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Operating Experience

with Nuclear Power Stations in Member States



2024 edition

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OPERATING EXPERIENCE
WITH NUCLEAR POWER STATIONS
IN MEMBER STATES (2024 EDITION)

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FOREWORD

This report is the fifty-fifth in the IAEA's series of annual reports on operating experience with nuclear power stations worldwide.

As in previous years, in addition to annual performance data and outage information, the report contains statistical information on electricity production and the overall performance of individual nuclear power plants that were in operation in the reporting year. In addition to annual information, the report contains a historical summary of performance during the lifetime of individual reactors and showcases worldwide performance data of the nuclear industry.

The intent behind this report, and all related IAEA publications, is to provide a useful tool for everyone concerned with nuclear power. Suggestions and queries from readers are most welcome.

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1. INTRODUCTION

The 2024 edition of this publication contains integrated reports combining nuclear reactor operating experience data with design characteristics and dashboards. The integrated report provides a general overview of each individual operating nuclear power reactor that was in operation in 2023.

The publication provides annual performance data and outage information for individual nuclear power plants. Summaries of historical performance and outages during the lifetimes of those plants are also included. In order to provide a broad picture of nuclear power usage, six figures illustrate global operational statistics up to and including 2023.

The data that form the basis of this publication are a direct output from the IAEA's Power Reactor Information System (PRIS), the database that contains all performance data published in the IAEA's operating experience annual reports since 1970, as well as basic information on power reactors, including design data. It presents operating experience data for all nuclear power plants worldwide from the start date of their commercial operation. The PRIS data is available free of charge to IAEA Member States through its public web site and on-line application, PRIS-Statistics. The web site www.iaea.org/pris contains publicly available information about reactor units and nuclear industry results. PRIS-Statistics (<http://pris.iaea.org>) provides direct access to the database. This application allows registered users to generate statistical outputs through predesigned reports and filters.

When analysing the performance of nuclear reactors, indicators such as energy production, load, operating and availability factors are often used. Energy unavailability factors, categorized separately for planned and unplanned unavailability (due either to causes under plant management control or to external causes out of plant management control), are used as a measure of energy loss when a unit is not available to the grid on full power. Despite efforts to properly classify unavailability data, some ambiguity remains in operator reports, as it is inherently difficult to find energy losses caused by load following operation and by grid limitation for externally facilitated unavailability. Therefore, for load, operation and unavailability factors, there may be differences between the data compiled in this report and data published elsewhere. For detailed information on data elements and performance indicators included in this publication, please refer to the definitions in Section 2.

Information and data received by the IAEA through 21 June 2024 are included in this publication. All commercially operating units reported data up to this date. Any modifications received at a later date, although not included in this publication, are available in the PRIS database.

The information contained in this publication was made available to the IAEA through designated national PRIS Data Providers and Liaison Officers. The IAEA appreciates the valuable assistance of the national authorities, official correspondents and various utilities in gathering the information for this report.

This publication was compiled by staff of the IAEA's Division of Nuclear Power, Nuclear Power Engineering Section. It is hoped that the publication will serve as a useful tool for nuclear power plant operators, nuclear system designers, nuclear power

planners, professional engineers, scientists and others concerned with the operating experience of nuclear power reactors. Suggestions and corrections from readers are most welcome.

2. DEFINITIONS

1. Reference unit power, RUP [$MW_{(e)}$]

The maximum (electrical) power that could be maintained continuously throughout a prolonged period of operation under reference ambient conditions.

It is specified that this value must remain constant for a given unit unless, following permanent modification, or a new permanent authorization, the management decides to amend the original value.

The reference unit power may be gross or net:

- The gross RUP (P_g , $MW_{(e)}$) is deemed to be measured at the output terminals of all generator sets in the station.
- The net RUP (P_n , $MW_{(e)}$), indicating the maximum power that can be supplied, is measured at the station outlet terminals, i.e. after deducting the power taken by station auxiliaries and the losses in the transformers that are considered integral parts of the station.

2. Design net capacity [$MW_{(e)}$]

The net reference unit power as specified in an original unit design.

3. Reference period, T [hours]

For units in power ascension at the end of the period, the clock hours from the beginning of the period or the first electrical production, whichever comes last, to the end of the period.

For units in commercial operation at the end of the period, the clock hours from the beginning of the period or of commercial operation, whichever comes last, to the end of the period or permanent shutdown, whichever comes first.

4. On-line hours, t [hours]

The total clock hours in the reference period during which the unit operated with breakers closed to the station bus.

5. Reference energy generation, REG [$MW_{(e)}h$]

Net electrical energy which would have been supplied to the grid if the unit were operated continuously at the reference unit power during the whole reference period.

6. Energy generated (net), EG [$GW_{(e)}h$]

Net electrical energy produced during the reference period as measured at the unit outlet terminals, i.e. after deducting the electrical energy taken by unit auxiliaries and the losses in transformers that are considered integral parts of the unit. If this quantity is less than zero, zero is reported.

7. Load factor, LF [%]

$$LF = \frac{EG}{REG} \times 100$$

EG = energy generated (net), [MW_(e)h]
REG = reference energy generation [MW_(e)h]

Load factor is the ratio of the energy that the power unit has produced over a given period to the energy it would have produced at its reference power capacity over that period.

8. Operation factor, OF [%]

$$OF = \frac{t}{T} \times 100$$

t = number of hours on-line [h]
T = number of hours in the reference period

Operation factor is the ratio of the number of hours the unit was on-line to the total number of hours in the reference period, expressed as a percentage. It is a measure of the unit time availability on the grid and does not depend on the operating power level.

9. Available capacity, P [MW_(e)]

Maximum net capacity at a given moment at which the unit or station is able or is authorized to be operated at a continuous rating under the prevailing conditions assuming unlimited transmission facilities.

10. Energy loss, EL [MW_(e)h]

Energy that could have been produced during the reference period by using the unavailable capacity; it is categorized into three types:

- PEL: planned energy loss
- UEL: unplanned energy loss
- XEL: energy loss due to causes external to the plant

UEL comprises shutdowns, unplanned load reductions or outage extensions.

11. Unavailability

A status when the plant is not able to operate at its maximum capacity (reference power). This condition, which may be under or beyond plant management control, should only reflect lack of availability of the plant itself, regardless of energy demand, transmission grid condition or political situation in the country.

Unavailability is classified as planned if it is foreseen at least four weeks in advance, generally at the time when the annual overhaul programme is established, and if the beginning of the unavailability period can be largely controlled and deferred by management. Unavailability is classified as unplanned if not scheduled at least four weeks in advance. Power plant operation at lower than maximum capacity because of lower demand from the grid but occurring while the plant is available to operate at the maximum capacity does not constitute unavailability, either planned or unplanned.

12. Energy availability factor, EAF [%]

$$EAF = \frac{REG - PEL - UEL - XEL}{REG} \times 100$$

The energy availability factor is the ratio of the energy that the available capacity could have produced over a specified period to the energy that the reference unit power could have produced during the same period.

13. Energy unavailability factor, EUF [%]

$$EUF = \frac{EL}{REG} \times 100$$

The unavailability factor is the ratio of the energy losses, EL, that have not been produced during a specified period due to the unavailable capacity, to the energy that the reference unit power could have produced during the same period.

The energy unavailability factor EUF over a specified period can be divided into:

PUF = planned unavailability factor

UUF = unplanned unavailability factor due to causes in the plant

XUF = unplanned unavailability factor due to causes external to the plant.

The unavailability factor can be expressed as: $EUF = 100 - EAF$

14. Unit capability factor, UCF [%]

$$UCF = \frac{REG - PEL - UEL}{REG} \times 100$$

Unit capability factor is defined as the ratio of the energy that the unit was capable of generating over a given time period considering only limitation under the plant management control to the reference energy generation over the same time period, expressed as a percentage. Both of these energy generation terms are determined relative to reference ambient conditions.

15. Unplanned capability loss factor, UCL [%]

$$UCF = \frac{UEL}{REG} \times 100$$

Unplanned capability loss factor is defined as the ratio of the unplanned energy losses during a given period of time to the reference energy generation, expressed as a percentage. Unplanned energy loss is energy that was not produced during the period because of unplanned shutdowns, outage extensions or unplanned load reductions due to causes under plant management control. Causes of energy losses are considered to be unplanned if they are not scheduled at least four weeks in advance.

16. Construction start

Date when first major placing of concrete, usually for the base mat of the reactor building, is carried out.

17. First criticality

Date when the reactor is made critical for the first time.

18. Grid connection

Date when the plant is first connected to the electrical grid to supply power.

19. Commercial operation

Date when the plant is handed over by the contractors to the owner and officially declared to be in commercial operation.

20. Permanent shutdown

Date when the plant is officially declared shut down by the owner and taken out of operation permanently.

21. Long term shutdown (Suspended operation)

A unit is considered to be in the long term shutdown status if it has been shut down for an extended period (usually several years) without initially having any firm recovery schedule but if there is the intention of re-starting the unit eventually.

22. Outages

For the purpose of PRIS coding, the outage is defined as any status of a reactor unit, when its actual output power is lower than the reference unit power for a period of time. By this definition, the outage includes both power reduction and unit shutdown. The outage is considered significant if the loss in the energy production corresponds to at least ten hours of continuous operation at the reference unit power or if it has been caused by an unplanned reactor scram (even if the unit is shut down for less than ten hours).

23. Outage duration [h]

The total clock hours of the outage measured from the beginning of the reference period or the outage, whichever comes last, to the end of the reference period or the outage, whichever comes first.

24. Factors refer to the plants which were in commercial operation during the whole of the reference period.

25. Cumulative factors are given for the plants which were in commercial operation during full calendar years.

26. A blank and three periods (...), if used in tables, denote information that is not applicable or not available.

27. Types of outages

The outage type is a three-character code. The third character is for unplanned outages only:

Code_1 description:

- (P) Planned outage due to causes under the plant management control
- (U) Unplanned outage due to causes under the plant management control
- (X) Outage due to causes beyond the plant management control ("external")

Code_2 description:

- (F) Full outage
- (P) Partial outage

Code_3 description:

- (1) Controlled shutdown or load reduction that could be deferred but had to be performed earlier than four weeks after the cause occurred or before the next refuelling outage, whichever comes first
- (2) Controlled shutdown or load reduction that had to be performed in the next 24 hours after the cause occurred
- (3) Extension of planned outage
- (4) Reactor scram, automatic
- (5) Reactor scram, manual

28. Main causes of outages

- (A) Plant equipment failure
- (B) Refuelling without maintenance

- (C) Inspection, maintenance or repair combined with refuelling
- (D) Inspection, maintenance or repair without refuelling
- (E) Testing of plant systems or components
- (F) Major back-fitting, refurbishment or upgrading activities with refuelling
- (G) Major back-fitting, refurbishment or upgrading activities without refuelling
- (H) Nuclear regulatory requirements
- (I) Grid limitation
- (J) Grid failure or grid unavailability
- (K) Load-following (frequency control, reserve shutdown due to reduced energy demand)
- (L) Human factor related
- (M) Governmental requirements or court decisions
- (N) Environmental conditions (flood, storm, lightning, lack of cooling water due to dry weather, cooling water temperature limits, etc.)
- (O) Load dispatching - prioritization
- (P) Fire
- (R) External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems, etc.)
- (S) Fuel management limitation (including high flux tilt, stretch out or coast-down operation)
- (T) Heat supply (on-site to support next unit or desalination and off-site distribution)
- (U) Security and access control and other preventive shutdown due to external threats
- (Z) Others

29. Plant systems affected

Nuclear Systems

- 11.00 Reactor and Accessories
- 11.01 Reactor vessel and main shielding (including penetrations and nozzles)
- 11.02 Reactor core (including fuel assemblies)
- 11.03 Reactor internals (including steam separators/dryers – BWR, graphite, pressure tubes)
- 11.04 Auxiliary shielding and heat insulation
- 11.05 Moderator and auxiliaries (PHWR)
- 11.06 Annulus gas system (PHWR/RBMK)
- 11.99 None of the above systems

- 12.00 Reactor I&C Systems
- 12.01 Control and safety rods (including drives and special power supply)
- 12.02 Neutron monitoring (in-core and ex-core)
- 12.03 Reactor instrumentation (except neutron)
- 12.04 Reactor control system
- 12.05 Reactor protection system
- 12.06 Process computer
- 12.07 Reactor recirculation control (BWR)
- 12.99 None of the above systems

- 13.00 Reactor Auxiliary Systems
- 13.01 Primary coolant treatment and clean-up system
- 13.02 Chemical and volume control system
- 13.03 Residual heat removal system (including heat exchangers)

- 13.04 Component cooling system
- 13.05 Gaseous, liquid and solid radwaste treatment systems
- 13.06 Nuclear building ventilation and containment inerting system
- 13.07 Nuclear equipment venting and drainage system (including room floor drainage)
- 13.08 Borated or refuelling water storage system
- 13.09 CO₂ injection and storage system (GCR)
- 13.10 Sodium heating system (FBR)
- 13.11 Primary pump oil system (including RCP or make-up pump oil)
- 13.12 D₂O leakage collection and dryer system (PHWR)
- 13.13 Essential auxiliary systems (GCR)
- 13.99 None of the above systems

- 14.00 Safety Systems
- 14.01 Emergency core cooling systems (including accumulators and core spray system)
- 14.02 High pressure safety injection and emergency poisoning system
- 14.03 Auxiliary and emergency feedwater system
- 14.04 Containment spray system (active)
- 14.05 Containment pressure suppression system (passive)
- 14.06 Containment isolation system (isolation valves, doors, locks and penetrations)
- 14.07 Containment structures
- 14.08 Fire protection system
- 14.99 None of the above systems

- 15.00 Reactor Cooling Systems
- 15.01 Reactor coolant pumps/blowers and drives
- 15.02 Reactor coolant piping (including associated valves)
- 15.03 Reactor coolant safety and relief valves (including relief tank)
- 15.04 Reactor coolant pressure control system
- 15.05 Main steam piping and isolation valves (BWR)
- 15.99 None of the above systems

- 16.00 Steam Generation Systems
- 16.01 Steam generator (PWR), boiler (PHWR, AGR), steam drum vessel (RBMK, BWR)
- 16.02 Steam generator blowdown system
- 16.03 Steam drum level control system (RBMK, BWR)
- 16.99 None of the above systems

- 17.00 Safety I&C Systems (excluding reactor I&C)
- 17.01 Engineered safeguard feature actuation system
- 17.02 Fire detection system
- 17.03 Containment isolation function
- 17.04 Main steam/feedwater isolation function
- 17.05 Main steam pressure emergency control system (turbine bypass and steam dump valve control)
- 17.06 Failed fuel detection system (DN monitoring system for PHWR)
- 17.07 RCS integrity monitoring system (RBMK)
- 17.99 None of the above systems

Fuel and Refuelling Systems

- 21.00 Fuel Handling and Storage Facilities
- 21.01 On-power refuelling machine
- 21.02 Fuel transfer system
- 21.03 Storage facilities, including treatment plant and final loading and cask handling facilities
- 21.99 None of the above systems

Secondary plant systems

- 31.00 Turbine and Auxiliaries
- 31.01 Turbine
- 31.02 Moisture separator and reheater
- 31.03 Turbine control valves and stop valves
- 31.04 Main condenser (including vacuum system)
- 31.05 Turbine by-pass valves
- 31.06 Turbine auxiliaries (lubricating oil, gland steam, steam extraction)
- 31.07 Turbine control and protection system
- 31.99 None of the above systems

- 32.00 Feedwater and Main Steam System
- 32.01 Main steam piping and valves
- 32.02 Main steam safety and relief valves
- 32.03 Feedwater system (including feedwater tank, piping, pumps and heaters)
- 32.04 Condensate system (including condensate pumps, piping and heaters)
- 32.05 Condensate treatment system
- 32.99 None of the above systems

- 33.00 Circulating Water System
- 33.01 Circulating water system (pumps and piping/ducts excluding heat sink system)
- 33.02 Cooling towers/heat sink system
- 33.03 Emergency ultimate heat sink system
- 33.99 None of the above systems

- 34.00 Miscellaneous systems
- 34.01 Compressed air (essential and non-essential/high-pressure and low-pressure)
- 34.02 Gas storage, supply and cleanup systems (nitrogen, hydrogen, carbon dioxide, etc.)
- 34.03 Service water/process water supply system (including water treatment)
- 34.04 Demineralized water supply system (including water treatment)
- 34.05 Auxiliary steam supply system (including boilers and pressure control equipment)
- 34.06 Non-nuclear area ventilation (including main control room)
- 34.07 Chilled water supply system
- 34.08 Chemical additive injection and makeup systems
- 34.09 Non-nuclear equipment venting and drainage system
- 34.10 Communication system
- 34.99 None of the above systems

- 35.00 All Other I&C Systems
- 35.01 Plant process monitoring systems (excluding process computer)
- 35.02 Leak monitoring systems
- 35.03 Alarm annunciation system
- 35.04 Plant radiation monitoring system
- 35.05 Plant process control systems
- 35.99 None of the above systems

Electrical Systems

- 41.00 Main Generator Systems
 - 41.01 Generator and exciter (including generator output breaker)
 - 41.02 Sealing oil system
 - 41.03 Rotor cooling gas system
 - 41.04 Stator cooling water system
 - 41.05 Main generator control and protection system
 - 41.99 None of the above systems

- 42.00 Electrical Power Supply Systems
 - 42.01 Main transformers
 - 42.02 Unit self-consumption transformers (station, auxiliary, house reserve, etc.)
 - 42.03 Vital AC and DC plant power supply systems (medium and low voltage)
 - 42.04 Non-vital AC plant power supply system (medium and low voltage)
 - 42.05 Emergency power generation system (e.g. emergency diesel generator and auxiliaries)
 - 42.06 Power supply system logics (including load shed logic, emergency bus transfer logic, load sequencer logic, breaker trip logic, etc.)
 - 42.07 Plant switchyard equipment
 - 42.99 None of the above systems

Note: Detailed definitions of performance indicators and PRIS related terms can be found in IAEA Technical Reports Series No. 428, The Power Reactor Information System (PRIS) and its Extension to Non-electrical Applications, Decommissioning and Delayed Projects Information, IAEA, Vienna (2005)

3. ABBREVIATIONS

COUNTRY CODES

| | |
|----|---------------------------|
| AE | UNITED ARAB EMIRATES |
| AM | ARMENIA |
| AR | ARGENTINA |
| BE | BELGIUM |
| BG | BULGARIA |
| BR | BRAZIL |
| BL | BELARUS |
| CA | CANADA |
| CH | SWITZERLAND |
| CN | CHINA |
| CZ | CZECH REPUBLIC |
| DE | GERMANY |
| ES | SPAIN |
| FI | FINLAND |
| FR | FRANCE |
| GB | UNITED KINGDOM |
| HU | HUNGARY |
| IN | INDIA |
| IR | IRAN, ISLAMIC REPUBLIC OF |
| JP | JAPAN |
| KR | KOREA, REPUBLIC OF |
| MX | MEXICO |
| NL | NETHERLANDS |
| PK | PAKISTAN |
| RO | ROMANIA |
| RU | RUSSIAN FEDERATION |
| SE | SWEDEN |
| SI | SLOVENIA |
| SK | SLOVAKIA |
| UA | UKRAINE |
| US | UNITED STATES OF AMERICA |
| ZA | SOUTH AFRICA |

Note: TW - Code for Taiwan, China.

REACTOR TYPES

| | |
|------|--|
| BWR | BOILING LIGHT WATER COOLED AND MODERATED REACTOR |
| FBR | FAST BREEDER REACTOR |
| GCR | GAS COOLED, GRAPHITE MODERATED REACTOR |
| LWGR | LIGHT WATER COOLED, GRAPHITE MODERATED REACTOR |
| PHWR | PRESSURIZED HEAVY WATER MODERATED AND COOLED REACTOR |
| PWR | PRESSURIZED LIGHT WATER MODERATED AND COOLED REACTOR |

OPERATORS

| | |
|----------|---|
| AEP | AMERICAN ELECTRIC POWER COMPANY, INC. |
| AmerenUE | AMEREN UE, UNION ELECTRIC COMPANY |
| ANAV | ASOCIACION NUCLEAR ASCO-VANDELLOS A.I.E. (ENDESA/ID) |
| ANPPCJSC | CLOSED JOINT STOCK COMPANY ARMENIAN NPP |
| APS | ARIZONA PUBLIC SERVICE CO. |
| Axpo AG | KERNKRAFTWERK BEZNAU |
| BKW | BKW ENERGIE AG |
| BRUCEPOW | BRUCE POWER |
| CCNPP | CALVERT CLIFFS NUCLEAR POWER PLANT INC. |
| CEZ | CZECH POWER CO., CEZ A.S. |
| CFE | COMISION FEDERAL DE ELECTRICIDAD |
| CHUBU | CHUBU ELECTRIC POWER CO., INC. |
| CHUGOKU | THE CHUGOKU ELECTRIC POWER CO., INC. |
| CIAE | CHINA INSTITUTE OF ATOMIC ENERGY |
| CNAT | CENTRALES NUCLEARES ALMARAZ-TRILLO |
| CNNO | CNNC NUCLEAR OPERARION MANAGEMENT COMPANY LIMITED. |
| DNMC | DAYA BAY NUCLEAR POWER OPERATIONS AND MANAGEMENT CO, LTD. |
| DOMINION | DOMINION ENERGY |
| DTEDISON | DETROIT EDISON CO. |
| DUKEENER | DUKE ENERGY CORP. |
| E.ON | E.ON KERNKRAFT GMBH |
| EDF | ELECTRICITE DE FRANCE |
| EDF UK | EDF ENERGY |
| ELECTRAB | ELECTRABEL |
| ELETRONU | ELETROBRAS ELETRONUCLEAR S.A. |
| ENERGYNW | ENERGY NORTHWEST |
| EnKK | ENBW KERNKRAFT GMBH |
| ENTERGY | ENTERGY NUCLEAR OPERATIONS, INC. |
| EPZ | N.V. ELEKTRICITEITS-PRODUKTIEMAATSCHAPPIJ ZUID-NEDERLAND |
| ESKOM | ESKOM |
| EXELON | EXELON GENERATION CO., LLC. |
| FENOC | FIRST ENERGY NUCLEAR OPERATING CO. |
| FKA | FORSMARK KRAFTGRUPP AB |
| FORTUMPH | FORTUM POWER AND HEAT OY (FORMER IVO) |
| FPL | FLORIDA POWER & LIGHT CO. |
| FQNP | CNNC FUJIAN FUQING NUCLEAR POWER CO., LTD. |
| GFNPC | GUANGXI FANGCHENGGANG NUCLEAR POWER COMPANY, LTD. |
| HEPCO | HOKKAIDO ELECTRIC POWER CO., INC. |
| HNPC | HAINAN NUCLEAR POWER COMPANY |
| HOKURIKU | HOKURIKU ELECTRIC POWER CO. |
| ID | IBERDROLA, S.A. |
| JAPCO | JAPAN ATOMIC POWER CO. |
| JNPC | JIANGSU NUCLEAR POWER CORPORATION |
| KEPCO | KANSAI ELECTRIC POWER CO. |
| KGG | KERNKRAFTWERK GUNDREMMINGEN GMBH |
| KHNP | KOREA HYDRO AND NUCLEAR POWER CO. |

| | |
|----------|---|
| KKG | KERNKRAFTWERK GOESGEN-DAENIKEN AG |
| KKL | KERNKRAFTWERK LEIBSTADT |
| KLE | KERNKRAFTWERKE LIPPE-EMS GMBH |
| KOZNPP | KOZLODUY NPP, PLC. |
| KWG | GEMEINSCHAFTSKERNKRAFTWERK GROHNDE GMBH & CO. OHG. |
| KYUSHU | KYUSHU ELECTRIC POWER CO., INC. |
| LHNPC | LIAONING HONGYANHE NUCLEAR POWER CO. LTD. (LHNPC) |
| LUMINANT | LUMINANT GENERATION COMPANY, LLC. |
| NASA | NUCLEOELECTRICA ARGENTINA, S.A. |
| NBEPIC | NEW BRUNSWICK ELECTRIC POWER COMMISSION |
| NDNP | FUJIAN NINGDE NUCLEAR POWER COMPANY, LTD. |
| NEK | NUKLERANA ELEKTRARNA KRŠKO |
| NEXTERA | NEXTERA ENERGY RESOURCES, LLC |
| NNEGCO | NATIONAL NUCLEAR ENERGY GENERATING COMPANY 'ENERGOATOM |
| NPCIL | NUCLEAR POWER CORPORATION OF INDIA, LTD. |
| NPPDCO | NUCLEAR POWER PRODUCTION & DEVELOPEMENT CO. OF IRAN |
| NPQJVC | NUCLEAR POWER PLANT QINSHAN JOINT VENTURE COMPANY, LTD. |
| NSP | NORTHERN STATES POWER CO. (SUBSIDIARY OF XCEL ENERGY) |
| OKG | OKG AKTIEBOLAG |
| OPG | ONTARIO POWER GENERATION |
| PAEC | PAKISTAN ATOMIC ENERGY COMMISSION |
| PAKS Zrt | PAKS NUCLEAR POWER PLANT, LTD. |
| PG&E | PACIFIC GAS AND ELECTRIC COMPANY |
| PPL_SUSQ | PPL SUSQUEHANNA, LLC. |
| PROGRESS | PROGRESS ENERGY |
| PSEG | PSEG NUCLEAR, LLC. |
| QNPC | QINSHAN NUCLEAR POWER COMPANY |
| RAB | RINGHALS, AB |
| REA | JOINT STOCK COMPANY 'CONCERN ROSENERGOATOM' |
| SCE&G | SOUTH CAROLINA ELECTRIC & GAS CO. |
| SE, plc | SLOVENSKÉ ELEKTRÁRNE, A.S. |
| SHIKOKU | SHIKOKU ELECTRIC POWER CO., INC. |
| SNN | SOCIETATEA NATIONALA NUCLEARELECTRICA S.A. |
| SOUTHERN | SOUTHERN NUCLEAR OPERATING COMPANY, INC. |
| STP | STP NUCLEAR OPERATING CO. |
| TEPCO | TOKYO ELECTRIC POWER COMPANY HOLDINGS, INC. |
| TOHOKU | TOHOKU ELECTRIC POWER CO., INC. |
| TPC | TAIWAN POWER CO. |
| TQNPC | THE THIRD QINSHAN JOINTED VENTURE COMPANY LTDA. |
| TVA | TENNESSEE VALLEY AUTHORITY |
| TVO | TEOLLISUUDEN VOIMA OYJ |
| WCNOC | WOLF CREEK NUCLEAR OPERATION CORP. |
| YJNPC | YANGJIANG NUCLEAR POWER COMPANY |

REACTOR SUPPLIERS

| | |
|----------|--|
| ABBATOM | ABBATOM (FORMERLY ASEA-ATOM) |
| ACECOWEN | ACECOWEN (ACEC-COCKERILL-WESTINGHOUSE) |
| ACLF | (ACECOWEN - CREUSOT LOIRE - FRAMATOME) |
| AECL | ATOMIC ENERGY OF CANADA, LTD. |
| AECL/DAE | ATOMIC ENERGY OF CANADA, LTD./DEPARTMENT OF ATOMIC ENERGY(INDIA) |
| AECL/DHI | ATOMIC ENERGY OF CANADA, LTD./DOOSAN HEAVY INDUSTRY & CONSTRUCTION |
| AEE | ATOMENERGOEXPORT |
| APC | ATOMIC POWER CONSTRUCTION, LTD. |
| ASE | JSC ATOMSTROYEXPORT |
| ASEASTAL | ASEA-ATOM/STAL-LAVAL |
| B&W | BABCOCK & WILCOX CO. |
| CE | COMBUSTION ENGINEERING CO. |
| CFHI | CHINA FIRST HEAVY INDUSTRIES |
| CGE | CANADIAN GENERAL ELECTRIC |
| CNNC | CHINA NATIONAL NUCLEAR CORPORATION |
| DEC | DONGFANG ELECTRIC CORPORATION DEC-NPIC-FANP |
| DHICKAEC | DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO., LTD./KOREA ATOMICENERGY RESEARCH INSTITUTE/COMBUSTIONENGINEERING |
| DHICKOPC | DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO., LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING |
| FAEA | FEDERAL ATOMIC ENERGY AGENCY |
| FRAM | FRAMATOME |
| FRAMACEC | FRAMACECO (FRAMATOME-ACEC-COCKERILL) |
| GE | GENERAL ELECTRIC CO. |
| GETSCO | GENERAL ELECTRIC TECHNICAL SERVICES CO. |
| HITACHI | HITACHI, LTD. |
| IZ | IZHORSKIYE ZAVODY |
| KWU | SIEMENS KRAFTWERK UNION AG |
| MAEP | MINATOMENERGOPROM, MINISTRY OF NUCLEAR POWER AND INDUSTRY |
| MHI | mitsubishi heavy industries, LTD. |
| NNC | NATIONAL NUCLEAR CORPORATION |
| NPC | NUCLEAR POWER CO., LTD. |
| NPCIL | NUCLEAR POWER CORPORATION OF INDIA, LTD. |
| NPIC | NUCLEAR POWER INSTITUTE OF CHINA |
| OH/AECL | ONTARIO HYDRO/ATOMIC ENERGY OF CANADA, LTD. |
| PAA | PRODUCTION AMALGAMATION 'ATOMMASH', VOLGODONSK |
| PAIP | PRODUCTION AMALGAMATION IZHORSKY PLANT ATOMMASH, VOLGODONSK, RUSSIA |
| PPC | PWR POWER PROJECTS, LTD. |
| ROSATOM | STATE ATOMIC ENERGY CORPORATION "ROSATOM" |
| S/KWU | SIEMENS/KRAFTWERK UNION AG |
| SHE | SHANGHAI ELECTRIC |
| SIEMENS | SIEMENS AG, POWER GENERATION |
| SKODA | SKODA CONCERN NUCLEAR POWER PLANT WORKS |
| TNPG | THE NUCLEAR POWER GROUP, LTD. |
| TOSHIBA | TOSHIBA CORPORATION |
| WH | WESTINGHOUSE ELECTRIC CORPORATION |
| WH/MHI | WESTINGHOUSE ELECTRIC CORPORATION/MITSUBISHI HEAVY INDUSTRIES, LTD. |

4. FIGURES

1. Years of operating experience of nuclear power reactors
2. Lifetime energy availability factors up to 2023
3. Reactors with high availability factors for years 1985–2023
4. Average energy availability factors for years 1985–2023
5. Number of reactors in operation (as of 31 December 2023)
6. Number of reactors by age (as of 31 December 2023)

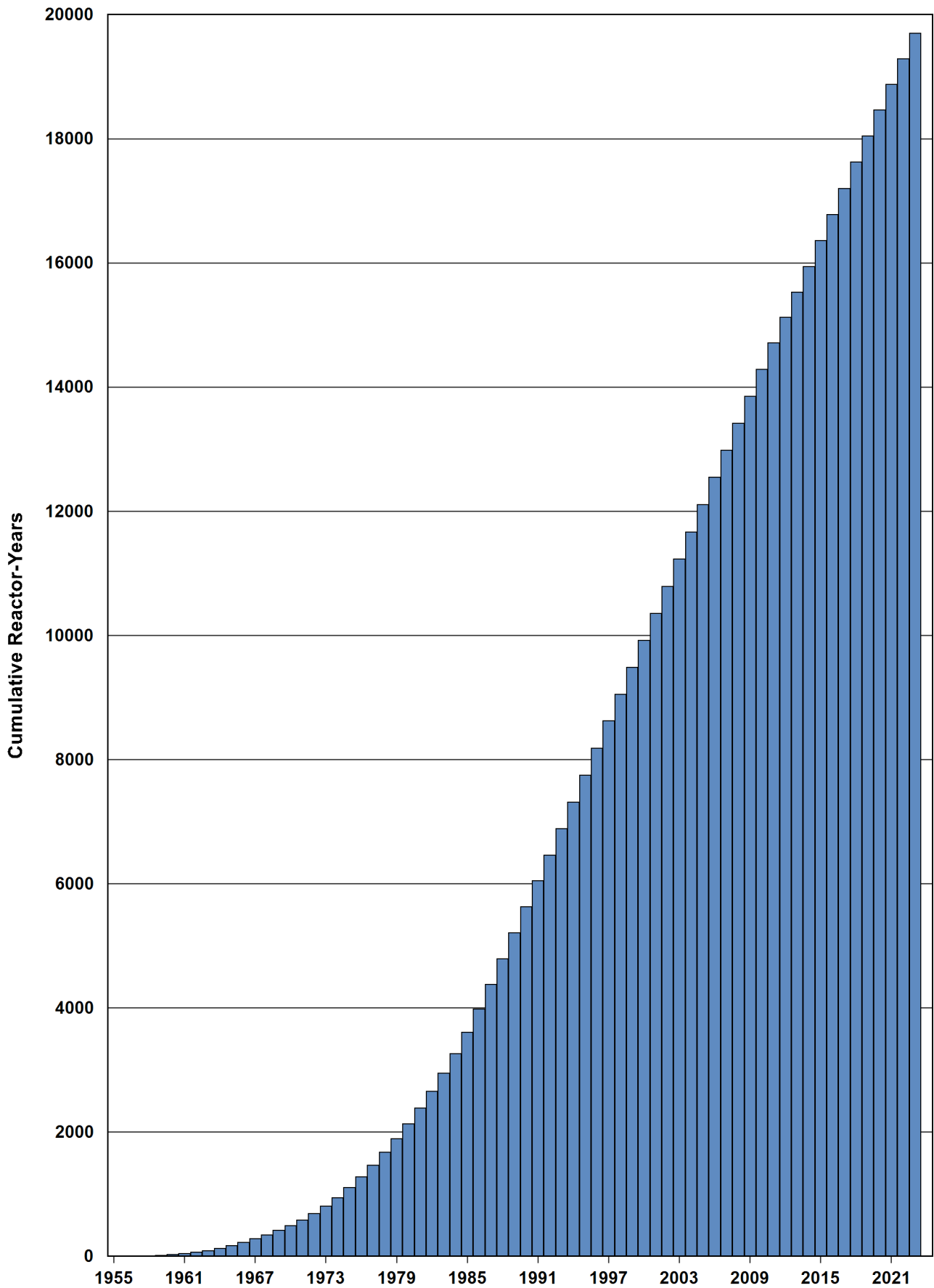


Figure 1 — Nuclear Power Reactors Operating Experience (1954-2023)

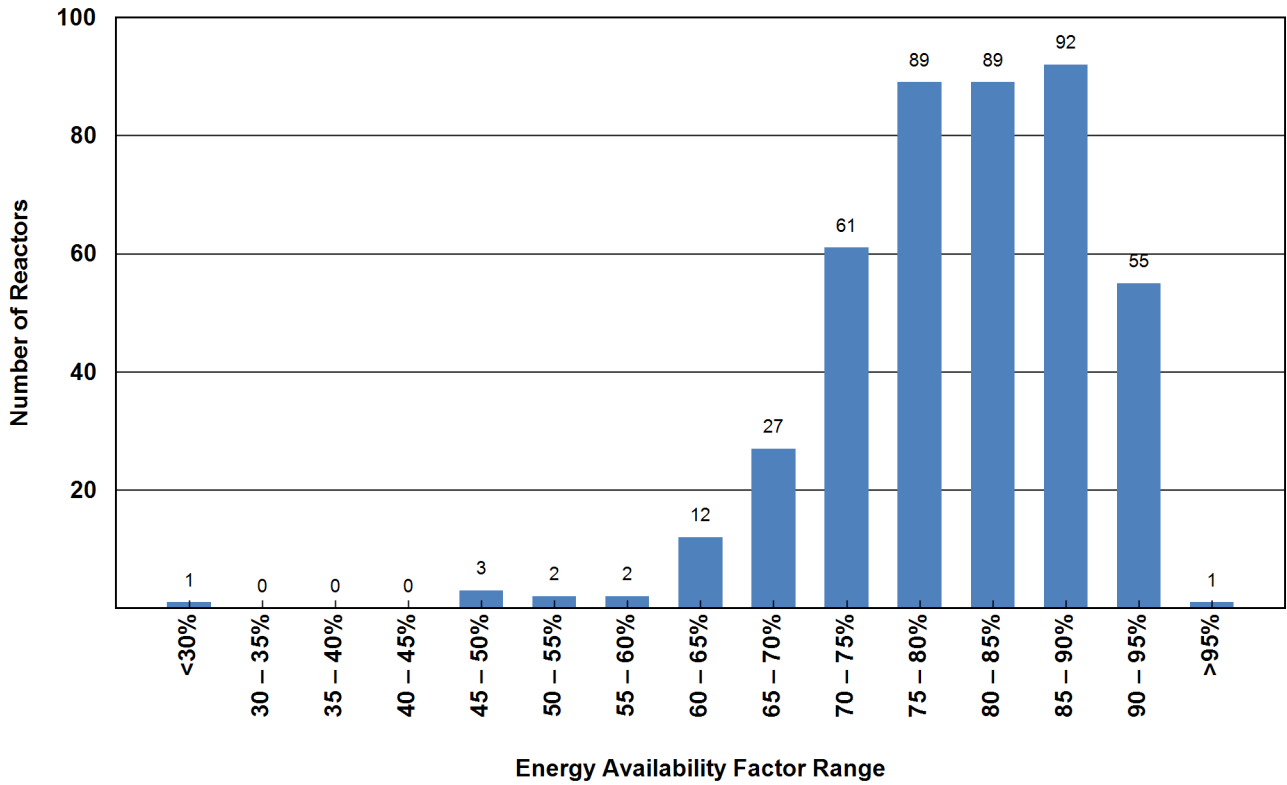


Figure 2 — Lifetime Energy Availability Factors up to 2023

(only reactors with capacity greater than 100 MW(e) and with more than one year of commercial operation)

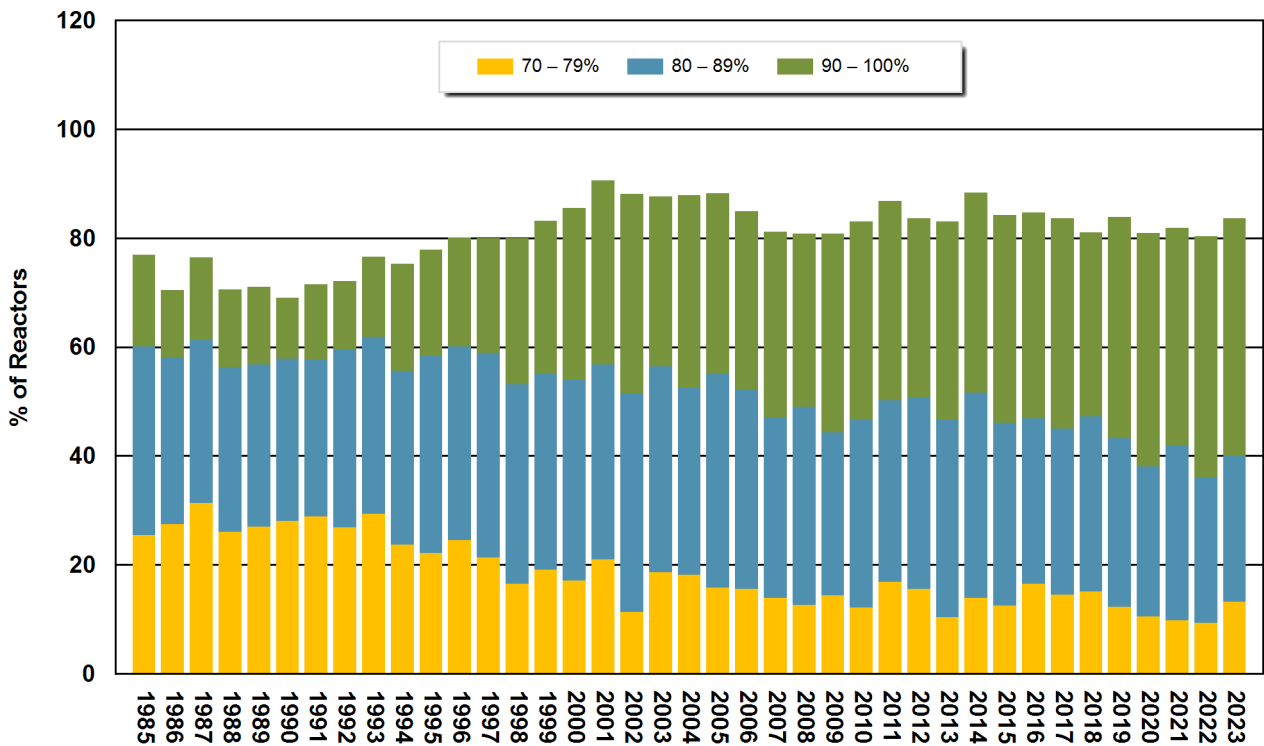


Figure 3 — Reactors with High Availability Factors

(only reactors with capacity greater than 100 MW(e) and with more than one year of commercial operation)

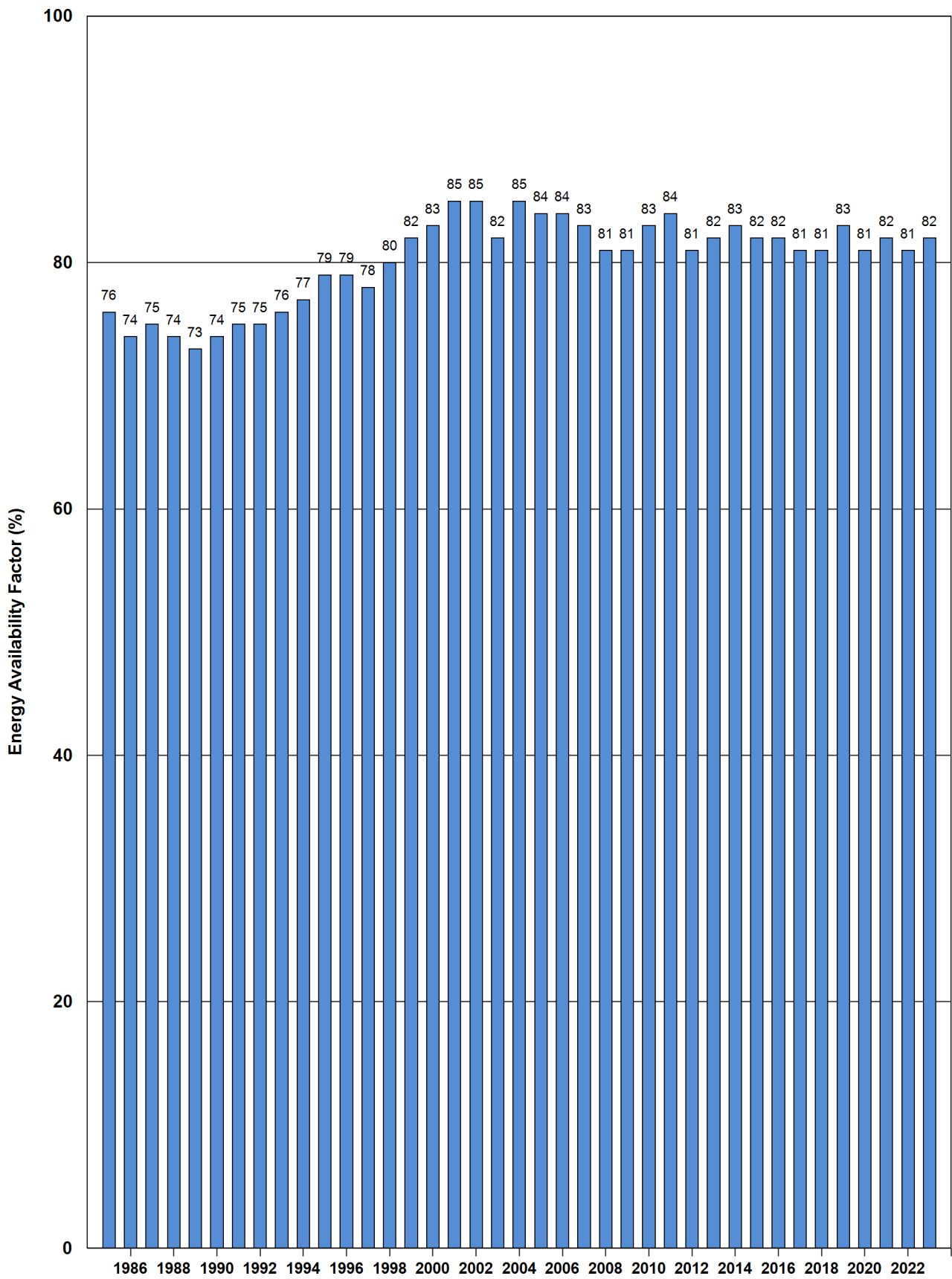


Figure 4 — Average Energy Availability Factors

(only reactors with capacity greater than 100 MW(e) and with more than one year of commercial operation)

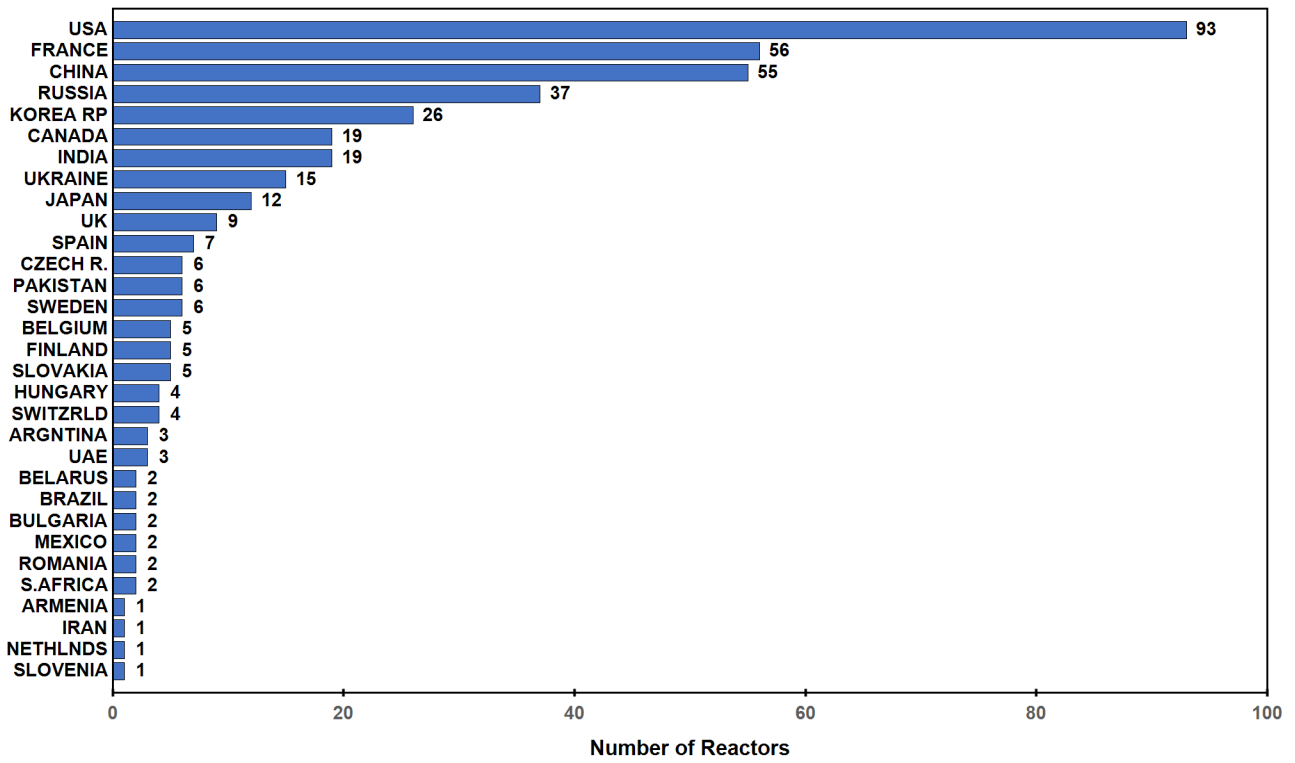


Figure 5 — Number of Reactors in Operation (as of 1 January 2024)

Note: There were 2 reactors in operation in Taiwan, China.

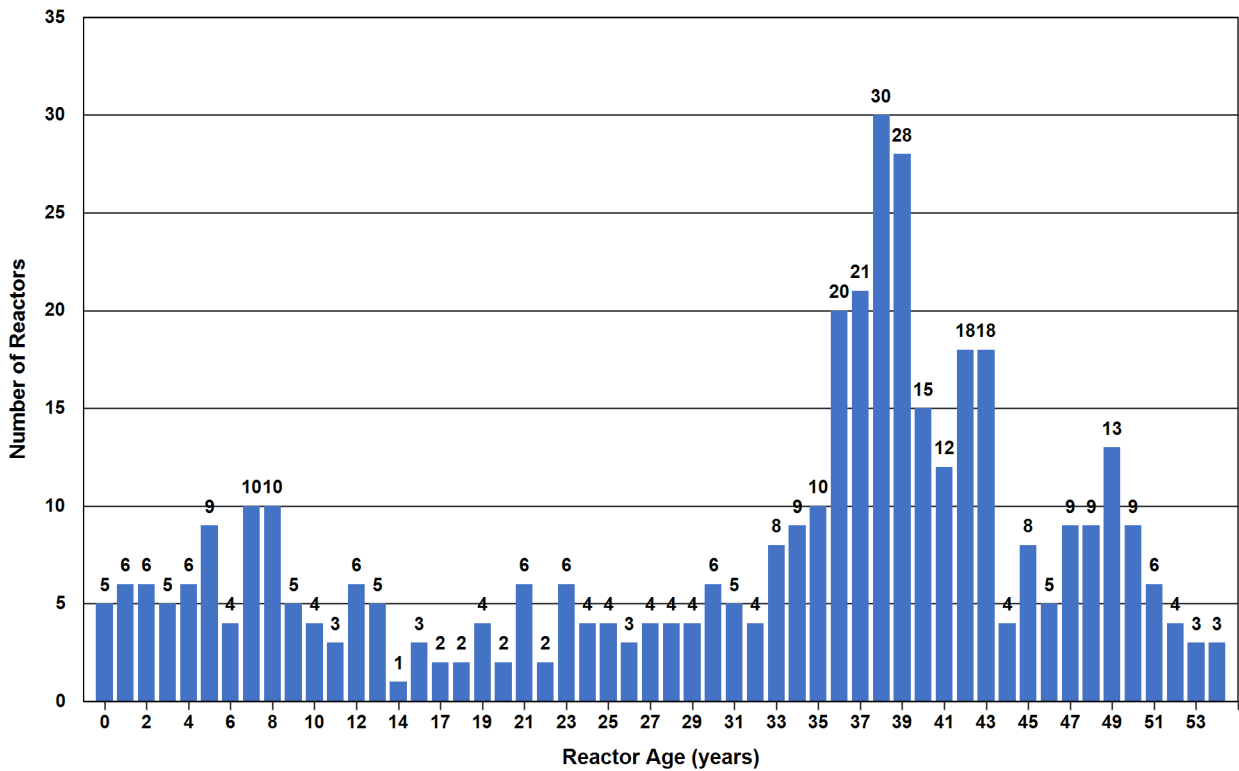


Figure 6 — Number of Reactors by Age (as of 1 January 2024)

5. OPERATING DATA SHEETS ON INDIVIDUAL NUCLEAR POWER STATIONS UNITS

| Country | NUMBER OF REACTORS OPERATED DURING 2023 |
|---------------------------|---|
| Argentina | 3 |
| Armenia | 1 |
| Belarus | 2 |
| Belgium | 6 |
| Brazil | 2 |
| Bulgaria | 2 |
| Canada | 19 |
| China | 55 |
| Czech Republic | 6 |
| Finland | 5 |
| France | 56 |
| Germany | 3 |
| Hungary | 4 |
| India | 19 |
| Iran, Islamic Republic of | 1 |
| Japan | 12 |
| Korea, Republic of | 26 |
| Mexico | 2 |
| Netherlands | 1 |
| Pakistan | 6 |
| Romania | 2 |
| Russia | 37 |
| Slovakia | 5 |
| Slovenia | 1 |
| South Africa | 2 |
| Spain | 7 |
| Sweden | 6 |
| Switzerland | 4 |
| United Arab Emirates | 3 |
| United Kingdom | 9 |
| Ukraine | 15 |
| United States of America | 93 |
| TOTAL REACTORS* | 418 |

* The total includes 3 reactors in Taiwan, China.

The total above does not include the 25 reactors (Japan 21 and India 4) in Suspended Operation.

2023 Operating Experience

AR-1

ATUCHA-1

ARGENTINA

Status at end of year : **Operational**
 Operator : NASA (NUCLEOELECTRICA ARGENTINA S.A.)
 Owner : NASA (NUCLEOELECTRICA ARGENTINA S.A.)
 Reactor Supplier : SIEMENS (Siemens AG, Power Generation)
 Turbine Supplier : SIEMENS (Siemens AG, Power Generation)



Reactor Unit Details

Reactor type and model : PHWR / PHWR KWU
 Thermal power : 1179 MWth
 Gross electrical power : 362 MWe
 Reference unit power (net) : 340 MWe

Key Dates

Construction Date : 1968-05-31
 Grid Date : 1974-03-18
 Commercial Date : 1974-06-23
 Age at end of year : 49 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : 0.85
 Refuelling frequency [month] : NA
 Part of the core refuelled [%] : NA
 Average discharge burnup [MWd/t] : 11140
 Active core diameter [m] : 4.51
 Active core height/length [m] : 5.3
 Number of fissile fuel assemblies/bundles : 250
 Fuel linear heat generation rate [kW/m] : 23.22
 Number of control rod assemblies : 29
 Number of external reactor coolant loops : 2
 Coolant type : D2O

Operating coolant pressure [MPa] : 11.5
 Reactor outlet temperature [°C] : 303.3
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.28

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 4.26
 Output voltage [kV] : 21
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

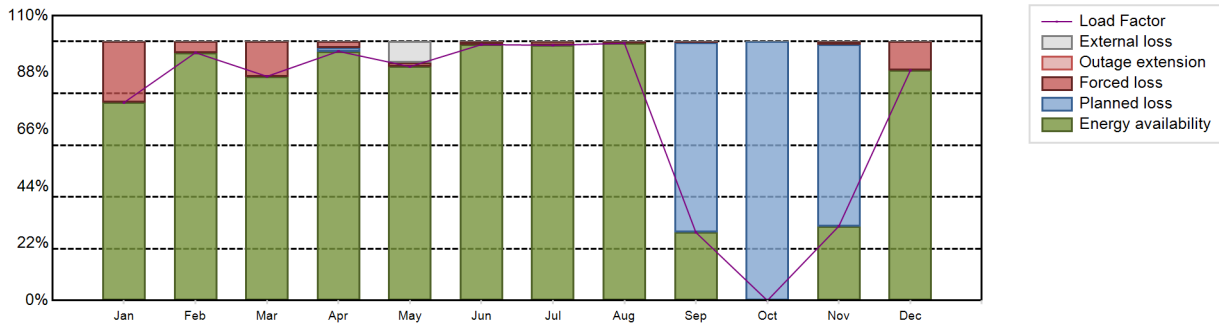
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 2197.12 GW(e).h
 Energy Availability Factor (EAF) : 73.77 %
 Unit Capability Factor (UCF) : 74.46 %
 Load Factor (LF) : 73.77 %
 Operating Factor (OF) : 78.25 %
 Forced Loss Rate (FLR) : 6.47 %
 Unplanned Capability Loss Factor (UCL) : 5.15 %
 Planned Unavailability Factor (PUF) : 20.4 %
 Externally cause unavailability (XUF) : 0.69 %
 Total off-line time : 1905 hours

Annual Summary

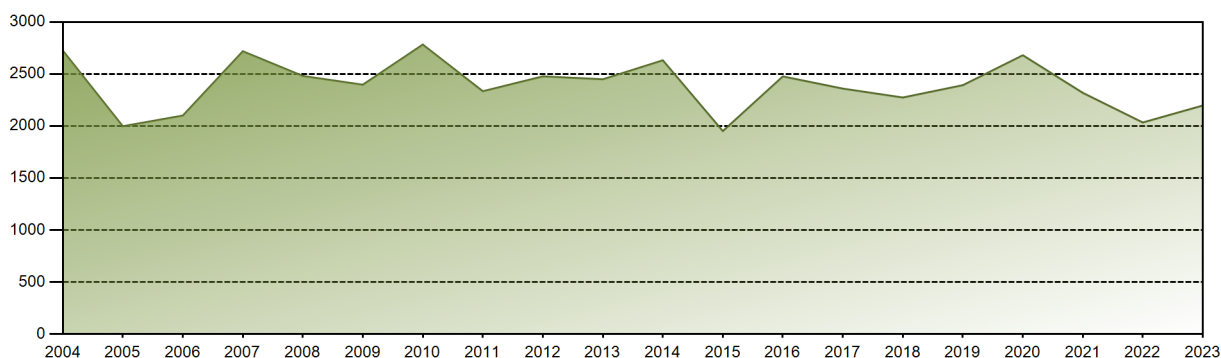


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|-------|--------|---------|
| GW(e)-h | 193.40 | 218.68 | 218.95 | 235.59 | 228.53 | 241.96 | 249.34 | 251.30 | 64.37 | 0.00 | 70.30 | 224.69 | 2197.12 |
| EAF [%] | 76.45 | 95.71 | 86.55 | 96.24 | 90.34 | 98.84 | 98.57 | 99.34 | 26.30 | 0.00 | 28.72 | 88.83 | 73.77 |
| UCF [%] | 76.45 | 95.71 | 86.55 | 96.24 | 98.45 | 98.84 | 98.57 | 99.34 | 26.30 | 0.00 | 28.72 | 88.83 | 74.46 |
| LF [%] | 76.45 | 95.71 | 86.55 | 96.24 | 90.34 | 98.84 | 98.57 | 99.34 | 26.30 | 0.00 | 28.72 | 88.83 | 73.77 |
| OF [%] | 100.00 | 100.00 | 93.82 | 100.00 | 93.68 | 100.00 | 100.00 | 100.00 | 26.67 | 0.00 | 31.67 | 93.55 | 78.25 |
| FLR [%] | 23.55 | 4.29 | 13.45 | 2.48 | 1.55 | 1.16 | 1.43 | 0.66 | 1.57 | 0.00 | 3.61 | 11.17 | 6.47 |
| UCL [%] | 23.55 | 4.29 | 13.45 | 2.44 | 1.55 | 1.16 | 1.43 | 0.66 | 0.42 | 0.00 | 1.08 | 11.17 | 5.15 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 1.32 | 0.00 | 0.00 | 0.00 | 0.00 | 73.29 | 100.00 | 70.21 | 0.00 | 20.40 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 8.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.69 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 105719.72 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 10.42 % |
| Cumulative Energy Availability Factor (EAF) | : 74.43 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 9.28 % |
| Cumulative Unit Capability Factor (UCF) | : 75.36 % | Cumulative Planned Unavailability Factor (PUF) | : 15.37 % |
| Cumulative Load Factor (LF) | : 72.54 % | Cumulative Externally cause unavailability (XUF) | : 0.93 % |
| Cumulative Operating Factor (OF) | : 77.87 % | | |

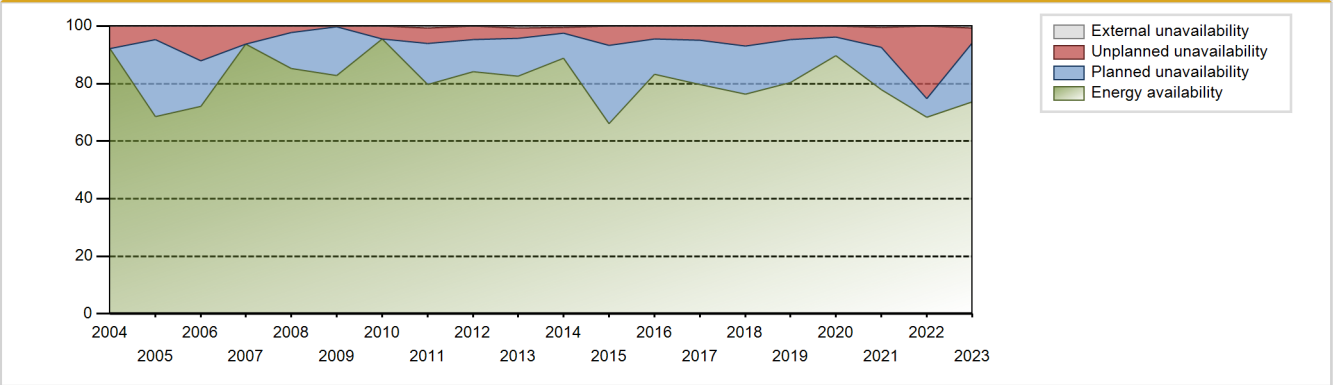
Electricity Production (net) [GWh]



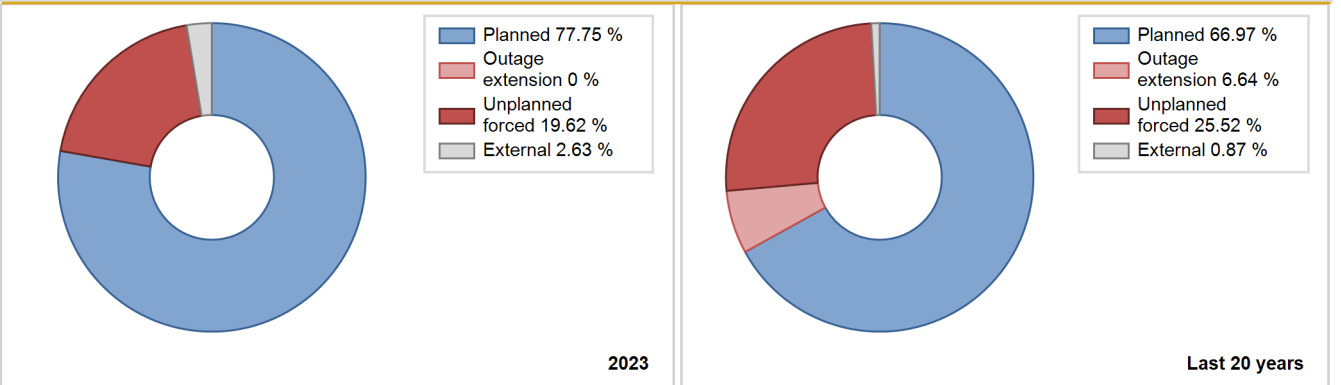
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|--------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1974 | 947.50 | 4458 | 321 | 50.27 | 51.01 | 50.29 | 65.96 | 16.06 | 9.76 | 39.23 | 0.73 |
| 1975 | 2357.80 | 7730 | 319 | 85.63 | 85.63 | 84.37 | 88.24 | 5.33 | 4.82 | 9.55 | 0.00 |
| 1976 | 2408.60 | 7808 | 319 | 86.89 | 86.89 | 85.96 | 88.89 | 10.93 | 10.66 | 2.45 | 0.00 |
| 1977 | 1537.00 | 4650 | 336 | 52.99 | 52.99 | 52.15 | 53.08 | 24.01 | 16.75 | 30.26 | 0.00 |
| 1978 | 2711.81 | 8026 | 345 | 90.89 | 90.89 | 89.73 | 91.62 | 8.88 | 8.85 | 0.26 | 0.00 |
| 1979 | 2503.70 | 7551 | 335 | 84.14 | 84.14 | 85.32 | 86.20 | 15.72 | 15.70 | 0.16 | 0.00 |
| 1980 | 2180.50 | 6947 | 335 | 73.51 | 73.51 | 74.10 | 79.09 | 8.40 | 6.74 | 19.74 | 0.00 |
| 1981 | 2647.60 | 8120 | 335 | 89.66 | 89.66 | 90.22 | 92.69 | 8.38 | 8.20 | 2.13 | 0.00 |
| 1982 | 1753.60 | 5600 | 335 | 59.17 | 59.17 | 59.76 | 63.93 | 13.18 | 8.98 | 31.85 | 0.00 |
| 1983 | 2356.00 | 8101 | 335 | 78.36 | 78.36 | 80.28 | 92.48 | 11.09 | 9.77 | 11.87 | 0.00 |
| 1984 | 1706.12 | 8678 | 335 | 98.74 | 98.74 | 57.98 | 98.79 | 1.26 | 1.26 | 0.00 | 0.00 |
| 1985 | 1470.45 | 7159 | 335 | 91.58 | 91.58 | 50.11 | 81.72 | 8.42 | 8.42 | 0.00 | 0.00 |
| 1986 | 2204.96 | 7532 | 335 | 75.83 | 75.83 | 75.14 | 85.98 | 10.36 | 8.76 | 15.40 | 0.00 |
| 1987 | 1405.80 | 4391 | 335 | 49.18 | 49.24 | 47.90 | 50.13 | 29.90 | 21.01 | 29.75 | 0.06 |
| 1988 | 808.10 | 2515 | 335 | 27.07 | 27.07 | 27.46 | 28.63 | 72.93 | 72.93 | 0.00 | 0.00 |
| 1989 | 0.00 | 0 | 335 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1990 | 1722.59 | 7201 | 335 | 58.70 | 84.89 | 58.70 | 82.20 | 6.76 | 6.15 | 8.96 | 26.19 |
| 1991 | 2721.89 | 8390 | 335 | 92.58 | 92.58 | 92.75 | 95.78 | 7.35 | 7.34 | 0.08 | 0.00 |
| 1992 | 2230.24 | 7089 | 335 | 76.33 | 76.33 | 75.79 | 80.70 | 7.71 | 6.38 | 17.29 | 0.00 |
| 1993 | 2403.66 | 7287 | 335 | 82.16 | 82.16 | 81.91 | 83.18 | 6.54 | 5.75 | 12.09 | 0.00 |
| 1994 | 2651.86 | 7916 | 335 | 90.37 | 90.37 | 90.37 | 90.37 | 1.19 | 1.08 | 8.55 | 0.00 |
| 1995 | 2671.71 | 8376 | 335 | 92.28 | 92.28 | 91.04 | 95.62 | 7.58 | 7.57 | 0.15 | 0.00 |
| 1996 | 2038.80 | 6990 | 335 | 70.62 | 70.62 | 69.28 | 79.58 | 6.80 | 5.15 | 24.23 | 0.00 |
| 1997 | 2720.14 | 8329 | 335 | 93.36 | 93.36 | 92.69 | 95.08 | 6.64 | 6.64 | 0.00 | 0.00 |
| 1998 | 2374.36 | 7242 | 335 | 81.32 | 81.40 | 80.91 | 82.67 | 6.76 | 5.90 | 12.69 | 0.08 |
| 1999 | 1395.50 | 4364 | 335 | 47.81 | 47.81 | 47.55 | 49.82 | 25.70 | 16.54 | 35.66 | 0.00 |
| 2000 | 1677.85 | 5038 | 335 | 56.85 | 72.76 | 57.02 | 57.35 | 27.24 | 27.24 | 0.00 | 15.92 |
| 2001 | 1425.96 | 4407 | 335 | 48.74 | 48.74 | 48.59 | 50.31 | 28.98 | 19.89 | 31.38 | 0.00 |
| 2002 | 1011.50 | 3030 | 335 | 34.58 | 34.58 | 34.47 | 34.59 | 16.39 | 6.78 | 58.64 | 0.00 |
| 2003 | 2020.60 | 6094 | 335 | 68.76 | 68.76 | 68.85 | 69.57 | 9.42 | 7.15 | 24.09 | 0.00 |
| 2004 | 2725.01 | 8250 | 335 | 92.17 | 92.17 | 92.60 | 93.92 | 7.83 | 7.83 | 0.00 | 0.00 |
| 2005 | 1997.96 | 7004 | 335 | 68.50 | 68.50 | 68.08 | 79.95 | 6.44 | 4.72 | 26.79 | 0.00 |
| 2006 | 2100.55 | 6403 | 335 | 72.10 | 72.10 | 71.58 | 73.09 | 14.45 | 12.18 | 15.72 | 0.00 |
| 2007 | 2718.74 | 8300 | 335 | 93.83 | 93.95 | 92.64 | 94.75 | 6.05 | 6.05 | 0.00 | 0.12 |
| 2008 | 2481.26 | 7562 | 335 | 85.27 | 85.27 | 84.32 | 86.09 | 2.49 | 2.18 | 12.55 | 0.00 |
| 2009 | 2397.18 | 7296 | 335 | 82.88 | 82.88 | 81.69 | 83.29 | 0.38 | 0.32 | 16.80 | 0.00 |
| 2010 | 2782.75 | 8560 | 335 | 95.52 | 95.52 | 94.83 | 97.72 | 4.48 | 4.48 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2011 | 2334.46 | 7289 | 335 | 79.63 | 80.28 | 79.55 | 83.21 | 4.07 | 5.45 | 14.27 | 0.65 |
| 2012 | 2477.36 | 7521 | 335 | 84.15 | 84.15 | 84.19 | 85.62 | 5.20 | 4.61 | 11.24 | 0.00 |
| 2013 | 2449.53 | 7310 | 340 | 82.55 | 83.29 | 82.75 | 83.45 | 2.94 | 3.49 | 13.22 | 0.73 |
| 2014 | 2631.71 | 7875 | 340 | 88.78 | 89.28 | 88.36 | 89.90 | 0.00 | 1.89 | 8.83 | 0.50 |
| 2015 | 1951.35 | 6109 | 340 | 66.00 | 66.03 | 65.52 | 69.74 | 6.26 | 6.69 | 27.28 | 0.03 |
| 2016 | 2476.82 | 7700 | 340 | 83.27 | 83.27 | 82.93 | 87.66 | 4.66 | 4.40 | 12.33 | 0.00 |
| 2017 | 2359.66 | 7832 | 340 | 79.70 | 79.70 | 79.23 | 89.41 | 5.87 | 4.97 | 15.33 | 0.00 |
| 2018 | 2274.09 | 7393 | 340 | 76.27 | 76.27 | 76.35 | 84.39 | 7.72 | 7.01 | 16.73 | 0.00 |
| 2019 | 2392.40 | 7341 | 340 | 80.33 | 80.33 | 80.33 | 83.80 | 5.48 | 4.66 | 15.01 | 0.00 |
| 2020 | 2680.41 | 8067 | 340 | 89.75 | 89.75 | 89.75 | 91.84 | 3.80 | 3.84 | 6.41 | 0.00 |
| 2021 | 2318.78 | 7243 | 340 | 77.85 | 78.38 | 77.85 | 82.68 | 7.80 | 6.90 | 14.72 | 0.53 |
| 2022 | 2034.01 | 6528 | 340 | 68.29 | 68.34 | 68.29 | 74.52 | 11.42 | 25.21 | 6.45 | 0.05 |
| 2023 | 2197.12 | 6855 | 340 | 73.77 | 74.46 | 73.77 | 78.25 | 6.47 | 5.15 | 20.40 | 0.69 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1974 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 94 | | | 614 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 27 | | |
| D. Inspection, maintenance or repair without refuelling | 1764 | | | 1125 | 11 | |
| E. Testing of plant systems or components | | | | 9 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 29 | | |
| H. Nuclear regulatory requirements | | | | | 60 | |
| J. Grid limitation, failure or grid unavailability | | | 47 | | | 17 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 20 |
| L. Human factor related | | | | | 38 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 2 |
| Subtotal | 1764 | 94 | 47 | 1190 | 723 | 39 |
| Total | | 1905 | | | 1952 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1974 to 2023 | |
|--|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 92 |
| 12. Reactor I&C Systems | | | 48 | 44 |
| 13. Reactor Auxiliary Systems | | | | 123 |
| 14. Safety Systems | | | | 37 |
| 15. Reactor Cooling Systems | | | 46 | 144 |
| 16. Steam generation systems | | | | 45 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 9 |
| 21. Fuel Handling and Storage Facilities | | | | 19 |
| 31. Turbine and auxiliaries | | | | 10 |
| 32. Feedwater and Main Steam System | | | | 21 |
| 33. Circulating Water System | | | | 10 |
| 35. All other I&C Systems | | | | 0 |
| 41. Main Generator Systems | | | | 7 |
| 42. Electrical Power Supply Systems | | | 47 | 84 |
| Total | | | 141 | 645 |

Highlights (2023)

01/01/2023 00:00 to 25/01/2023 00:00 - Power reduction due to a refueling machine intervention (80 %).
 25/01/2023 00:00 to 28/01/2023 23:19 - Power reduction due to a refueling machine intervention (90 %).
 28/01/2023 23:19 to 29/01/2023 21:50 - Power reduction due to a refueling machine intervention (95 %).
 29/01/2023 21:50 to 24/02/2023 07:44 - Normal Operation. Losses due to plant performance
 24/02/2023 07:44 to 24/02/2023 12:23 - Power reduction due to RM03D001 intervention.
 24/02/2023 12:23 to 01/03/2023 15:59 - Normal Operation. Losses due to plant performance.
 01/03/2023 15:59 to 03/03/2023 14:22 - Automatic Scram. Spurious trip of QF01D001.
 03/03/2023 14:22 to 05/03/2023 22:15 - Power ramp up.
 05/03/2023 22:15 to 23/04/2023 23:30 - Normal Operation. Losses due to plant performance.
 23/04/2023 23:30 to 24/04/2023 06:30 - Power ramp down.
 24/04/2023 06:30 to 25/04/2023 15:20 - Power reduction due to SD11W001 intervention.
 25/04/2023 15:20 to 25/04/2023 21:50 - Power ramp up.
 25/04/2023 21:50 to 25/05/2023 18:19 - Normal Operation. Losses due to plant performance.
 25/05/2023 18:19 to 27/05/2023 17:42 - Automatic Scram. Load rejection due to power grid unavailability.
 27/05/2023 17:42 to 29/05/2023 10:20 - Power ramp up.
 29/05/2023 10:20 to 09/09/2023 00:21 - Normal Operation. Losses due to plant performance.
 09/09/2023 00:21 to 21/11/2023 12:15 - 2023 programmed full maintenance.
 21/11/2023 12:15 to 23/11/2023 11:38 - Power ramp up.
 23/11/2023 11:38 to 02/12/2023 07:23 - Normal Operation. Losses due to plant performance.
 02/12/2023 07:23 to 04/12/2023 07:01 - Automatic turbine trip - manual Scram due to perturbation in JH02 rack.
 04/12/2023 07:01 to 05/12/2023 19:33 - Power Ramp up
 05/12/2023 19:33 to 01/01/2024 00:00 - Normal Operation. Losses due to plant performance.

2023 Operating Experience

AR-3

ATUCHA-2

ARGENTINA

Status at end of year : **Operational**
 Operator : NASA (NUCLEOELECTRICA ARGENTINA S.A.)
 Owner : NASA (NUCLEOELECTRICA ARGENTINA S.A.)
 Reactor Supplier : SIEMENS (Siemens AG, Power Generation)
 Turbine Supplier : KWU (KRAFTWERK UNION, AG)



Reactor Unit Details

Reactor type and model : PHWR / PHWR KWU
 Thermal power : 2160 MWth
 Gross electrical power : 745 MWe
 Reference unit power (net) : 693 MWe

Key Dates

Construction Date : 1981-07-13
 Grid Date : 2014-06-24
 Commercial Date : 2016-05-25
 Age at end of year : 9 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : 0.72
 Refuelling frequency [month] : NA
 Part of the core refuelled [%] : NA
 Average discharge burnup [MWd/t] : 7800
 Active core diameter [m] : 6.06
 Active core height/length [m] : 5.3
 Number of fissile fuel assemblies/bundles : 451
 Fuel linear heat generation rate [kW/m] : 23.2
 Number of control rod assemblies : 18
 Number of external reactor coolant loops : 2
 Coolant type : D2O

Operating coolant pressure [MPa] : 4.2
 Reactor outlet temperature [°C] : 312.3
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.48

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 5.59
 Output voltage [kV] : 21
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 4

Non-electrical applications

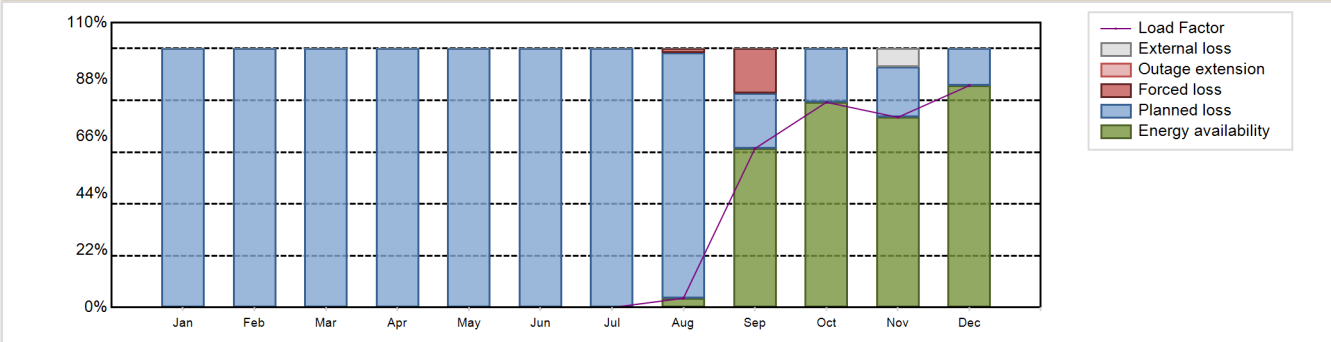
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 1541.93 GW(e).h
 Energy Availability Factor (EAF) : 25.4 %
 Unit Capability Factor (UCF) : 25.99 %
 Load Factor (LF) : 25.4 %
 Operating Factor (OF) : 33.77 %

Forced Loss Rate (FLR) : 5.7 %
 Unplanned Capability Loss Factor (UCL) : 1.57 %
 Planned Unavailability Factor (PUF) : 72.44 %
 Externally cause unavailability (XUF) : 0.59 %
 Total off-line time : 5802 hours

Annual Summary

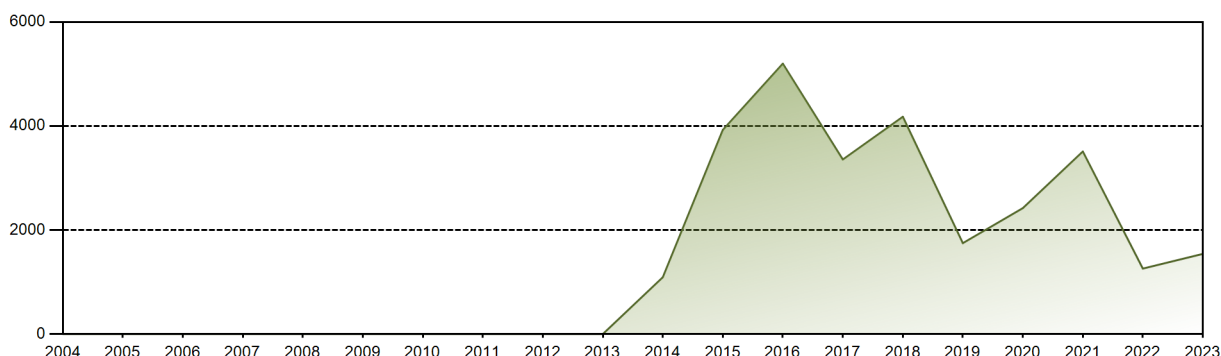


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.49 | 306.28 | 408.67 | 366.46 | 442.03 | 1541.93 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.59 | 61.38 | 79.26 | 73.45 | 85.73 | 25.40 |
| UCF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.59 | 61.38 | 79.26 | 80.61 | 85.73 | 25.99 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.59 | 61.38 | 79.26 | 73.45 | 85.73 | 25.40 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.08 | 100.00 | 100.00 | 93.75 | 100.00 | 33.77 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 32.30 | 22.03 | 0.00 | 0.00 | 0.00 | 5.70 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.71 | 17.35 | 0.00 | 0.00 | 0.00 | 1.57 |
| PUF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.70 | 21.27 | 20.74 | 19.39 | 14.27 | 72.44 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.16 | 0.00 | 0.59 |

Historical Summary

| | | | |
|---|-------------------|---|-----------|
| Lifetime energy generation | : 28237.1 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 37.75 % |
| Cumulative Energy Availability Factor (EAF) | : 45.78 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 31.67 % |
| Cumulative Unit Capability Factor (UCF) | : 45.86 % | Cumulative Planned Unavailability Factor (PUF) | : 22.48 % |
| Cumulative Load Factor (LF) | : 45.57 % | Cumulative Externally cause unavailability (XUF) | : 0.08 % |
| Cumulative Operating Factor (OF) | : 64.51 % | | |

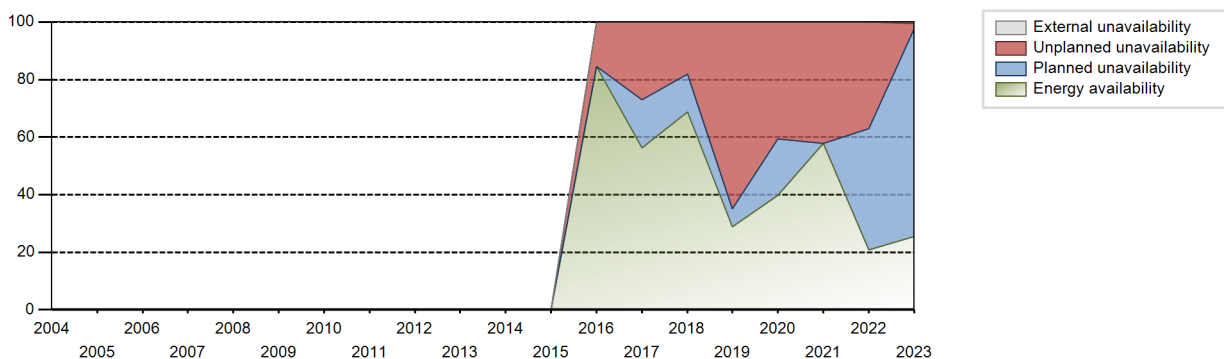
Electricity Production (net) [GWh]



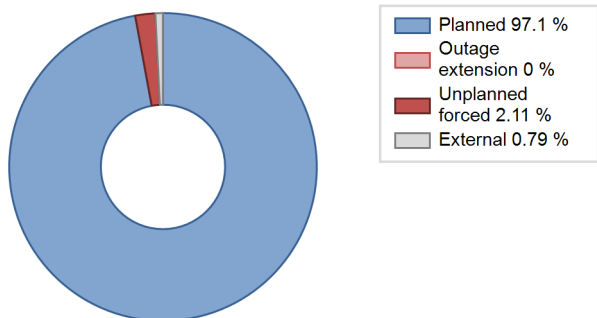
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 5200.54 | 8063 | 692 | 84.64 | 84.64 | 83.75 | 89.49 | 15.36 | 15.36 | 0.00 | 0.00 |
| 2017 | 3356.61 | 5130 | 693 | 56.27 | 56.27 | 55.29 | 58.56 | 7.12 | 27.04 | 16.68 | 0.00 |
| 2018 | 4178.88 | 6448 | 693 | 68.84 | 68.84 | 68.84 | 73.61 | 20.72 | 17.99 | 13.17 | 0.00 |
| 2019 | 1748.39 | 7001 | 693 | 28.85 | 28.85 | 28.80 | 79.92 | 68.93 | 64.83 | 6.32 | 0.00 |
| 2020 | 2421.87 | 6155 | 693 | 39.79 | 39.79 | 39.79 | 70.07 | 47.24 | 40.55 | 19.67 | 0.00 |
| 2021 | 3510.88 | 7217 | 693 | 57.83 | 57.83 | 57.83 | 82.39 | 41.72 | 42.16 | 0.00 | 0.00 |
| 2022 | 1259.03 | 3381 | 693 | 20.74 | 20.74 | 20.74 | 38.60 | 64.11 | 37.05 | 42.21 | 0.00 |
| 2023 | 1541.93 | 2958 | 693 | 25.40 | 25.99 | 25.40 | 33.77 | 5.70 | 1.57 | 72.44 | 0.59 |

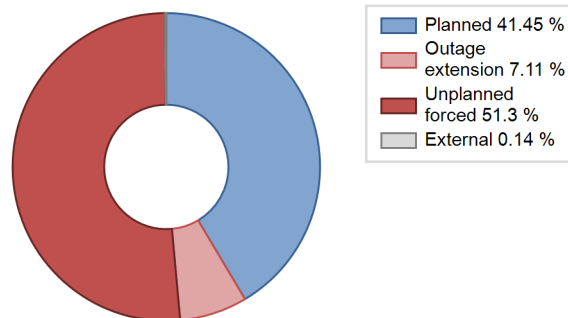
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 1322 | |
| D. Inspection, maintenance or repair without refuelling | 5757 | | | 1806 | | |
| J. Grid limitation, failure or grid unavailability | | | 45 | | | 6 |
| Subtotal | 5757 | | 45 | 1806 | 1322 | 6 |
| Total | | 5802 | | | 3134 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|--|------------|--|-------------------------------------|-------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 314 |
| 12. Reactor I&C Systems | | | | 62 |
| 13. Reactor Auxiliary Systems | | | | 33 |
| 14. Safety Systems | | | | 52 |
| 15. Reactor Cooling Systems | | | | 480 |
| 16. Steam generation systems | | | | 9 |
| 21. Fuel Handling and Storage Facilities | | | | 17 |
| 31. Turbine and auxiliaries | | | | 251 |
| 32. Feedwater and Main Steam System | | | | 26 |
| 41. Main Generator Systems | | | | 1 |
| 42. Electrical Power Supply Systems | | | | 7 |
| Total | | | | 1252 |

Highlights (2023)

01/01/2023 0:00 al 28/08/2023 21:16 – Programmed shutdown due to reactor intervention
 28/08/2023 21:16 al 28/09/2023 16:45 - Operation at reduced power due to reactor fill up.
 28/08/2023 21:16 al 28/09/2023 16:45 - Operation at reduced power. Debris removal strategy in the primary cooling system. (85%).
 28/09/2023 16:45 al 11/11/2023 01:41 - Operation at reduced power. Debris removal strategy in the primary cooling system. (85%).
 11/11/2023 01:41 al 12/11/2023 22:33 – Reactor and turbine automatic trip. scram due to low JFB10/30AP001 pumps flow as e result of a 500 kV. Atucha-Gral. Rodriguez line disconnection.
 12/11/2023 22:33 al 13/11/2023 13:10- Power ramp up.
 13/11/2023 13:10 al 13/12/2023 06:03 - Operation at reduced power. Debris removal strategy in the primary cooling system. (85 %).
 13/12/2023 06:03 al 01/01/2024 00:00 - Operation at reduced power. Debris removal strategy in the primary cooling system. (95 %).

2023 Operating Experience

AR-2

EMBALSE

ARGENTINA

Status at end of year : **Operational**
 Operator : NASA (NUCLEOELECTRICA ARGENTINA S.A.)
 Owner : NASA (NUCLEOELECTRICA ARGENTINA S.A.)
 Reactor Supplier : AECL (ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : AMN (ANSALDO/Asgen)



Reactor Unit Details

Reactor type and model : PHWR / CANDU 6
 Thermal power : 2064 MWth
 Gross electrical power : 656 MWe
 Reference unit power (net) : 608 MWe

Key Dates

Construction Date : 1974-03-31
 Grid Date : 1983-04-24
 Commercial Date : 1984-01-19
 Age at end of year : 40 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : 0.7
 Refuelling frequency [month] : NA
 Part of the core refuelled [%] : NA
 Average discharge burnup [MWd/t] : 7190
 Active core diameter [m] : 6.28
 Active core height/length [m] : 5.94
 Number of fissile fuel assemblies/bundles : 4560
 Fuel linear heat generation rate [kW/m] : 24.75
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 2
 Coolant type : D2O

Operating coolant pressure [MPa] : 10.2
 Reactor outlet temperature [°C] : 312
 Number of SG : 4
 Containment type : Confinement
 Containment design pressure [MPa] : 0.125

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 4.62
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 4

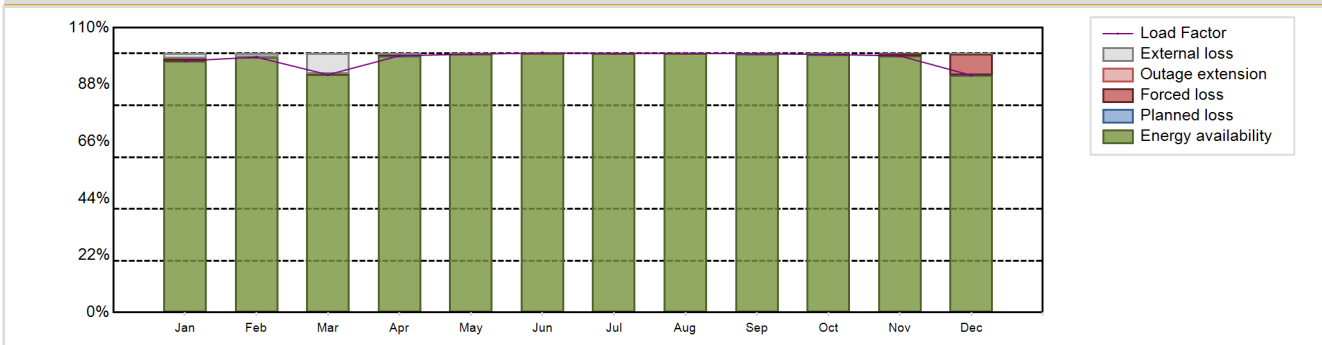
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5224.06 GW(e).h
 Energy Availability Factor (EAF) : 98.05 %
 Unit Capability Factor (UCF) : 99.04 %
 Load Factor (LF) : 98.08 %
 Operating Factor (OF) : 98.86 %
 Forced Loss Rate (FLR) : 0.95 %
 Unplanned Capability Loss Factor (UCL) : 0.95 %
 Planned Unavailability Factor (PUF) : 0.01 %
 Externally cause unavailability (XUF) : 0.98 %
 Total off-line time : 100 hours

Annual Summary

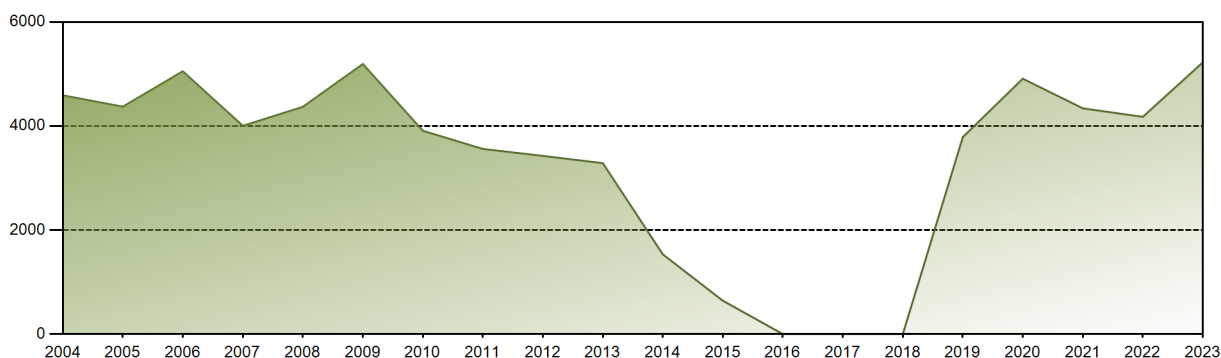


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 439.47 | 403.04 | 415.47 | 434.06 | 451.38 | 438.81 | 452.53 | 452.79 | 437.53 | 450.82 | 433.83 | 414.34 | 5224.06 |
| EAF [%] | 97.15 | 98.64 | 91.85 | 99.15 | 99.78 | 100.00 | 100.00 | 100.00 | 99.95 | 99.66 | 99.10 | 91.60 | 98.05 |
| UCF [%] | 99.02 | 100.00 | 99.73 | 99.58 | 99.78 | 100.00 | 100.00 | 100.00 | 99.95 | 99.66 | 99.10 | 91.81 | 99.04 |
| LF [%] | 97.15 | 98.64 | 91.85 | 99.15 | 99.78 | 100.24 | 100.04 | 100.10 | 99.95 | 99.66 | 99.10 | 91.60 | 98.08 |
| OF [%] | 99.87 | 100.00 | 93.41 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.28 | 98.86 |
| FLR [%] | 0.98 | 0.00 | 0.27 | 0.41 | 0.22 | 0.00 | 0.00 | 0.00 | 0.05 | 0.33 | 0.90 | 8.05 | 0.95 |
| UCL [%] | 0.98 | 0.00 | 0.27 | 0.41 | 0.22 | 0.00 | 0.00 | 0.00 | 0.05 | 0.33 | 0.90 | 8.04 | 0.95 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.14 | 0.01 |
| XUF [%] | 1.87 | 1.36 | 7.88 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.22 | 0.98 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 156061.92 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.96 % |
| Cumulative Energy Availability Factor (EAF) | : 79.14 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.45 % |
| Cumulative Unit Capability Factor (UCF) | : 79.5 % | Cumulative Planned Unavailability Factor (PUF) | : 18.05 % |
| Cumulative Load Factor (LF) | : 73.48 % | Cumulative Externally cause unavailability (XUF) | : 0.36 % |
| Cumulative Operating Factor (OF) | : 77.64 % | | |

Electricity Production (net) [GWh]

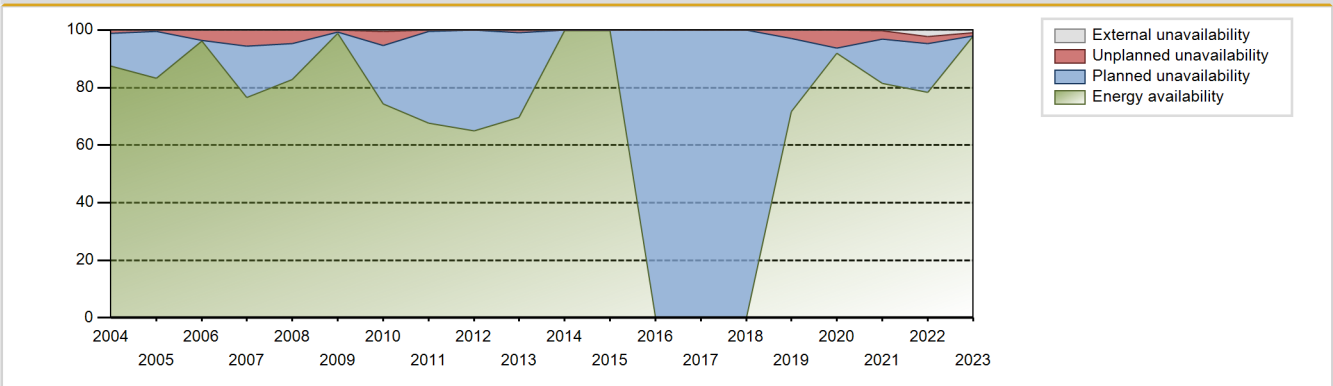


Performance for Years of Commercial Operation

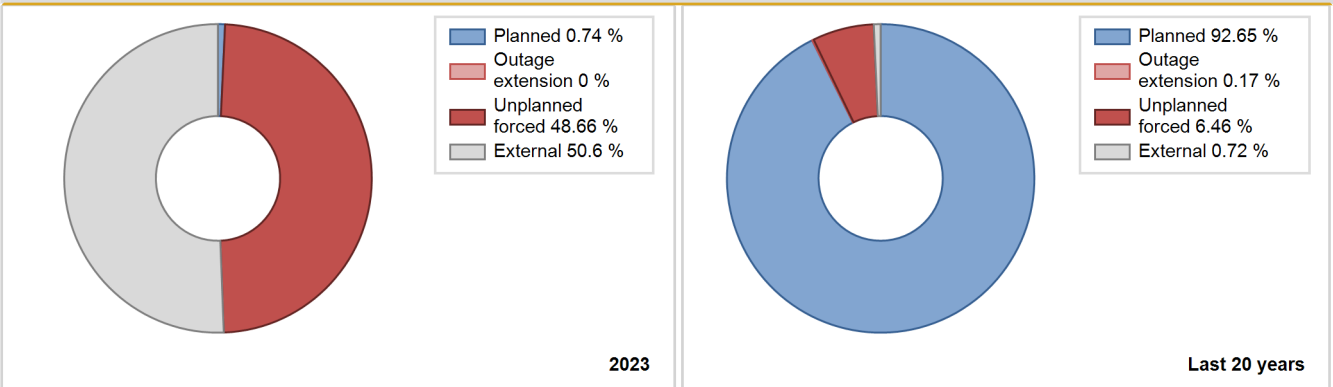
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 2527.07 | 6355 | 600 | 68.74 | 68.74 | 44.29 | 70.56 | 5.92 | 4.32 | 26.93 | 0.00 |
| 1985 | 3778.57 | 8170 | 600 | 93.44 | 93.44 | 71.89 | 93.26 | 6.15 | 6.13 | 0.43 | 0.00 |
| 1986 | 3061.67 | 5847 | 600 | 66.34 | 67.12 | 58.25 | 66.75 | 1.85 | 1.27 | 31.62 | 0.78 |
| 1987 | 4577.05 | 7951 | 600 | 87.92 | 87.92 | 87.08 | 90.76 | 5.89 | 5.50 | 6.58 | 0.00 |
| 1988 | 4560.58 | 7798 | 600 | 88.78 | 88.79 | 86.53 | 88.78 | 11.21 | 11.21 | 0.00 | 0.01 |
| 1989 | 4658.98 | 7804 | 600 | 89.11 | 90.09 | 88.64 | 89.09 | 1.00 | 0.91 | 9.00 | 0.98 |
| 1990 | 5000.74 | 8404 | 600 | 95.10 | 96.49 | 95.14 | 95.94 | 1.87 | 1.84 | 1.67 | 1.38 |
| 1991 | 4498.81 | 7855 | 600 | 85.76 | 89.68 | 85.59 | 89.67 | 0.00 | 0.00 | 10.32 | 3.92 |
| 1992 | 4353.98 | 7440 | 600 | 81.59 | 83.42 | 82.61 | 84.70 | 1.12 | 0.95 | 15.64 | 1.83 |
| 1993 | 4773.27 | 7956 | 600 | 90.60 | 90.68 | 90.82 | 90.82 | 0.73 | 0.67 | 8.65 | 0.08 |
| 1994 | 5157.89 | 8575 | 600 | 97.78 | 98.27 | 98.13 | 97.89 | 1.69 | 1.69 | 0.03 | 0.49 |
| 1995 | 3897.91 | 6541 | 600 | 74.34 | 74.34 | 74.16 | 74.67 | 5.54 | 4.36 | 21.30 | 0.00 |
| 1996 | 4891.97 | 8176 | 600 | 92.77 | 92.77 | 92.82 | 93.08 | 1.38 | 1.30 | 5.94 | 0.00 |
| 1997 | 4737.03 | 7821 | 600 | 89.27 | 89.27 | 90.13 | 89.28 | 0.54 | 0.48 | 10.25 | 0.00 |
| 1998 | 4555.43 | 7629 | 600 | 86.87 | 86.88 | 86.67 | 87.09 | 4.13 | 3.75 | 9.38 | 0.01 |
| 1999 | 5201.79 | 8700 | 598 | 99.14 | 99.14 | 99.30 | 99.32 | 0.73 | 0.73 | 0.14 | 0.00 |
| 2000 | 4064.48 | 6837 | 643 | 78.08 | 78.19 | 71.96 | 77.83 | 8.13 | 6.92 | 14.89 | 0.10 |
| 2001 | 5128.11 | 8564 | 600 | 97.45 | 97.47 | 97.57 | 97.76 | 2.29 | 2.28 | 0.25 | 0.02 |
| 2002 | 4385.52 | 7401 | 600 | 83.40 | 84.00 | 83.44 | 84.49 | 0.86 | 0.72 | 15.28 | 0.59 |
| 2003 | 5004.14 | 8367 | 600 | 95.07 | 95.13 | 95.21 | 95.51 | 4.58 | 4.57 | 0.30 | 0.05 |
| 2004 | 4589.57 | 7704 | 600 | 87.51 | 87.54 | 87.08 | 87.70 | 1.27 | 1.12 | 11.33 | 0.03 |
| 2005 | 4372.48 | 7341 | 600 | 83.32 | 83.32 | 83.19 | 83.80 | 0.00 | 0.43 | 16.25 | 0.00 |
| 2006 | 5052.10 | 8455 | 600 | 96.23 | 96.23 | 96.12 | 96.52 | 3.66 | 3.66 | 0.11 | 0.00 |
| 2007 | 4003.72 | 6771 | 600 | 76.51 | 76.51 | 76.17 | 77.29 | 6.19 | 5.53 | 17.96 | 0.00 |
| 2008 | 4368.61 | 7382 | 600 | 82.89 | 82.89 | 82.89 | 84.04 | 5.24 | 4.65 | 12.46 | 0.00 |
| 2009 | 5192.43 | 8705 | 600 | 98.79 | 98.79 | 98.78 | 99.36 | 0.78 | 0.78 | 0.44 | 0.00 |
| 2010 | 3908.69 | 6701 | 600 | 74.37 | 74.86 | 74.37 | 76.50 | 6.11 | 4.87 | 20.26 | 0.50 |
| 2011 | 3559.35 | 7405 | 600 | 67.72 | 67.72 | 67.72 | 84.53 | 0.69 | 0.47 | 31.81 | 0.00 |
| 2012 | 3425.53 | 7214 | 600 | 65.07 | 65.07 | 65.00 | 82.13 | 0.11 | 0.07 | 34.86 | 0.00 |
| 2013 | 3285.69 | 6841 | 600 | 69.65 | 69.65 | 62.51 | 78.09 | 1.31 | 0.92 | 29.43 | 0.00 |
| 2014 | 1533.11 | 3678 | 600 | 99.79 | 99.79 | 29.17 | 41.99 | 0.14 | 0.14 | 0.07 | 0.00 |
| 2015 | 641.36 | 1564 | 600 | 99.78 | 99.78 | 12.20 | 17.85 | 0.00 | 0.00 | 0.22 | 0.00 |
| 2016 | 0.00 | 0 | 600 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2017 | 0.00 | 0 | 600 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2018 | 0.00 | 0 | 600 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2019 | 3786.17 | 7051 | 608 | 71.76 | 71.76 | 71.09 | 80.49 | 3.80 | 2.83 | 25.41 | 0.00 |
| 2020 | 4910.14 | 8447 | 608 | 91.88 | 91.93 | 91.94 | 96.16 | 6.33 | 6.22 | 1.85 | 0.05 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 4340.06 | 7227 | 608 | 81.49 | 81.70 | 81.49 | 82.50 | 3.56 | 3.01 | 15.29 | 0.21 |
| 2022 | 4176.48 | 6993 | 608 | 78.42 | 80.73 | 78.42 | 79.83 | 2.96 | 2.46 | 16.81 | 2.32 |
| 2023 | 5224.06 | 8660 | 608 | 98.05 | 99.04 | 98.08 | 98.86 | 0.95 | 0.95 | 0.01 | 0.98 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 52 | | | 209 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 88 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 683 | | |
| E. Testing of plant systems or components | | | | 36 | 1 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 686 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | 49 | | | 16 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 16 |
| L. Human factor related | | | | | 2 | |
| M. Governmental requirements or court decisions | | | | | | 307 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 5 |
| Z. Other | | | | | 2 | |
| Subtotal | | 52 | 49 | 1493 | 215 | 345 |
| Total | | 101 | | | 2053 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 7 |
| 12. Reactor I&C Systems | 1 | 7 |
| 13. Reactor Auxiliary Systems | | 30 |
| 14. Safety Systems | | 3 |
| 15. Reactor Cooling Systems | | 10 |
| 16. Steam generation systems | | 58 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 2 |
| 31. Turbine and auxiliaries | 51 | 26 |
| 32. Feedwater and Main Steam System | | 20 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 3 |
| 41. Main Generator Systems | | 37 |
| 42. Electrical Power Supply Systems | | 8 |
| Total | 52 | 213 |

Highlights (2023)

R1 1/1/2023 00:00 a 9/1/2023 00:11 Environmental condition: seasonal variation in cooling water temperature
R2 9/1/2023 00:11 a 9/1/2023 20:58 4313 P531/P532 pumps out of service due to steam losses in 4313 P532
R3 9/1/2023 20:58 a 18/1/2023 1:22 Environmental condition: seasonal variation in cooling water temperature
S1 18/1/2023 1:22 a 18/1/2023 2:27 Spurious trip of channel E of the SP N°1 during execution of test. Activation of SP N°1
R4 18/1/2023 2:27 a 19/1/2023 23:11 Power ramp up due to full outage S1
R5 19/1/2023 23:11 a 1/3/2023 16:32 Environmental condition: seasonal variation in cooling water temperature
S2 1/3/2023 16:32 a 3/3/2023 17:19 Activation of SP N° 1 due to disturbances in the power grid
R6 3/3/2023 17:19 a 3/3/2023 20:47 Power ramp up due to full outage S2.
R7 3/3/2023 20:47 a 3/3/2023 22:15 Trip of Channel F of SP N° 1 during power ramp up due to low level in SG's.
R8 3/3/2023 22:15 a 5/3/2023 00:50 Power ramp up due to full outage S2
R9 5/3/2023 00:50 a 6/3/2023 16:20 Environmental condition: seasonal variation in cooling water temperature
R10 6/3/2023 16:20 a 6/3/2023 17:00 Failure 63611 FT3, Steam generator N° 3 flow transmitter.
R11 6/3/2023 17:00 a 23/3/2023 00:48 Environmental condition: seasonal variation in cooling water temperature
R12 23/3/2023 00:48 a 23/3/2023 17:27 4313 P103B pump out of service due to mechanic seal failure.
R13 23/3/2023 17:27 a 2/4/2023 8:15 Environmental condition: seasonal variation in cooling water temperature
R14 28/3/2023 00:30 a 2/4/2023 8:15 4313 P103B pump out of service due to mechanic seal failure.
R15 2/4/2023 8:15 a 2/4/2023 8:45 Turbine control valves test (PF-41100-08)
R16 2/4/2023 8:45 a 2/5/2023 00:00 Environmental condition: seasonal variation in cooling water temperature
R17 2/4/2023 8:45 a 31/5/2023 12:48 4313 P103B pump out of service due to mechanic seal failure.
R18 21/9/2023 7:38 a 21/9/2023 8:12 Turbine control valves test (PF-41100-08)
R19 25/9/2023 00:45 a 25/9/2023 8:02 4313 9531/9532 pumps F/S and Set back. during work protection application.
R20 1/10/2023 00:00 a 5/10/2023 8:15 Unknown internal causes
R21 5/10/2023 8:15 a 5/10/2023 17:45 Planned repair of 64113 LCV593
R22 5/10/2023 17:45 a 1/11/2023 00:27 Unknown internal causes
R23 1/11/2023 00:27 a 1/11/2023 16:50 Failure in 64312 LCV46, level control valve
R24 1/11/2023 16:50 a 5/12/2023 16:30 Unknown internal causes
R25 5/12/2023 16:30 a 6/12/2023 19:11 Maintenance in 64113 LCV594, level control valve
R26 6/12/2023 19:11 a 7/12/2023 8:15 Unknown internal causes
R27 7/12/2023 8:15 a 7/12/2023 8:30 Turbine control valves test (PF-14400-08)
R28 7/12/2023 8:30 a 19/12/2023 16:35 Unknown internal causes
R29 19/12/2023 16:35 a 21/12/2023 1:45 Planned repair of 64113 LCV593
R30 21/12/2023 1:45 a 21/12/2023 11:56 Environmental condition: seasonal variation in cooling water temperature
S3 21/12/2023 11:56 a 23/12/2023 14:27 Manual Scram of SP N°1 due to failure in DEHC system.
R31 23/12/2023 14:27 a 24/12/2023 7:46 Power ramp up
R32 24/12/2023 7:46 a 1/1/2024 00:00 Environmental condition: seasonal variation in cooling water temperature

2023 Operating Experience

AM-19

ARMENIAN-2

ARMENIA

Status at end of year : **Operational**
 Operator : ANPPC.JSC (Closed Joint Stock Company Armenian NPP)
 Owner : M.E. (Ministry of Territorial Administration and Infrastructure)
 Reactor Supplier : FAEA (Federal Atomic Energy Agency)
 Turbine Supplier : EITM ("Electrotiazhmash" Kharkiv)



Reactor Unit Details

Reactor type and model : PWR / VVER V-270
 Thermal power : 1375 MWth
 Gross electrical power : 448 MWe
 Reference unit power (net) : 416 MWe

Key Dates

Construction Date : 1975-07-01
 Grid Date : 1980-01-05
 Commercial Date : 1980-05-03
 Age at end of year : 43 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 28600
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.5
 Reactor outlet temperature [°C] : 295.8
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.4
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 4

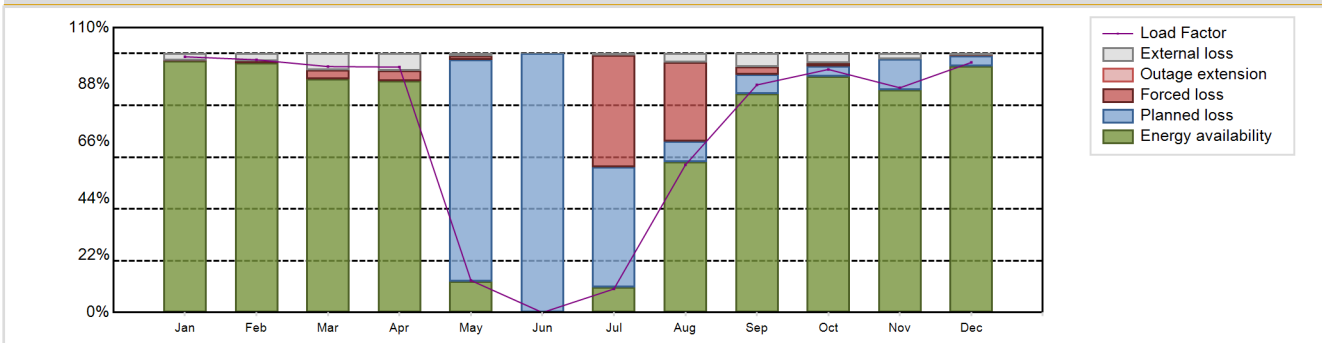
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 2512.03 GW(e).h
 Energy Availability Factor (EAF) : 67.31 %
 Unit Capability Factor (UCF) : 70.21 %
 Load Factor (LF) : 68.93 %
 Operating Factor (OF) : 74.09 %
 Forced Loss Rate (FLR) : 9.58 %
 Unplanned Capability Loss Factor (UCL) : 7.44 %
 Planned Unavailability Factor (PUF) : 22.35 %
 Externally cause unavailability (XUF) : 2.9 %
 Total off-line time : 2270 hours

Annual Summary

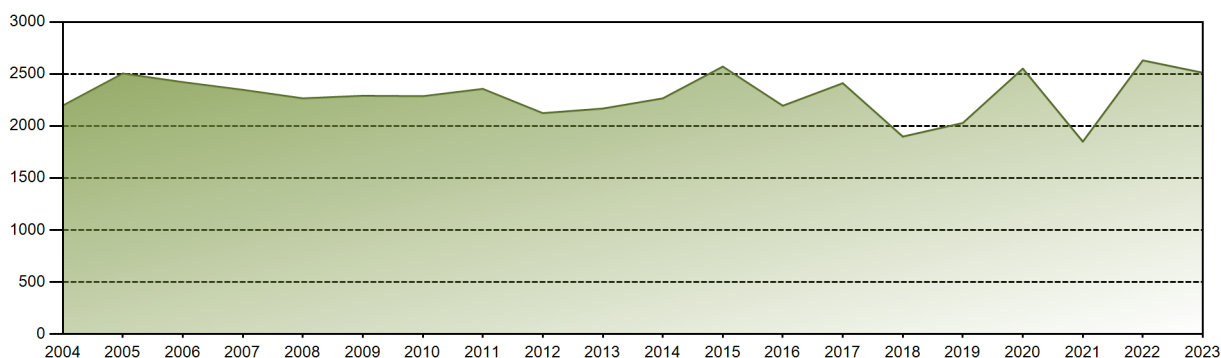


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|-------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 305.69 | 272.86 | 293.98 | 283.89 | 38.33 | 0.00 | 28.18 | 176.44 | 263.25 | 290.56 | 259.94 | 298.92 | 2512.03 |
| EAF [%] | 97.20 | 96.32 | 90.14 | 89.42 | 12.10 | 0.00 | 9.82 | 58.24 | 84.54 | 91.27 | 86.09 | 95.09 | 67.31 |
| UCF [%] | 99.77 | 99.29 | 96.39 | 96.03 | 12.90 | 0.00 | 10.51 | 61.70 | 89.60 | 94.88 | 88.33 | 95.73 | 70.21 |
| LF [%] | 98.77 | 97.61 | 94.98 | 94.78 | 12.38 | 0.00 | 9.10 | 57.01 | 87.89 | 93.88 | 86.78 | 96.58 | 68.93 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 13.17 | 0.00 | 11.42 | 67.07 | 100.00 | 100.00 | 100.00 | 100.00 | 74.09 |
| FLR [%] | 0.23 | 0.71 | 3.61 | 3.97 | 10.79 | 0.00 | 80.41 | 32.93 | 3.18 | 1.16 | 0.00 | 0.28 | 9.58 |
| UCL [%] | 0.23 | 0.71 | 3.61 | 3.97 | 1.56 | 0.00 | 43.15 | 30.30 | 2.94 | 1.12 | 0.00 | 0.27 | 7.44 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 85.54 | 100.00 | 46.34 | 8.00 | 7.47 | 4.00 | 11.67 | 4.00 | 22.35 |
| XUF [%] | 2.57 | 2.97 | 6.25 | 6.61 | 0.80 | 0.00 | 0.69 | 3.47 | 5.05 | 3.62 | 2.24 | 0.65 | 2.90 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 82950.68 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.4 % |
| Cumulative Energy Availability Factor (EAF) | : 65.28 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.45 % |
| Cumulative Unit Capability Factor (UCF) | : 67.45 % | Cumulative Planned Unavailability Factor (PUF) | : 29.09 % |
| Cumulative Load Factor (LF) | : 65.14 % | Cumulative Externally cause unavailability (XUF) | : 2.17 % |
| Cumulative Operating Factor (OF) | : 78.61 % | | |

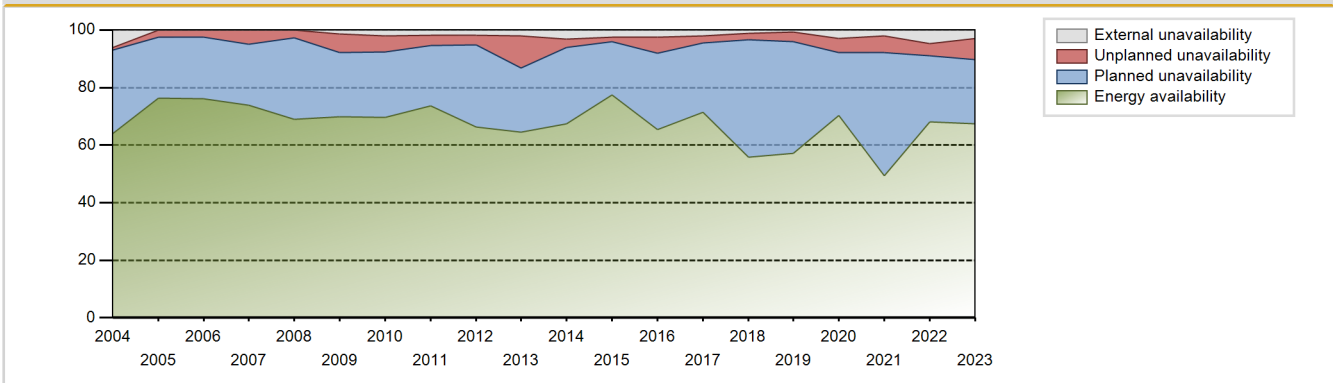
Electricity Production (net) [GWh]



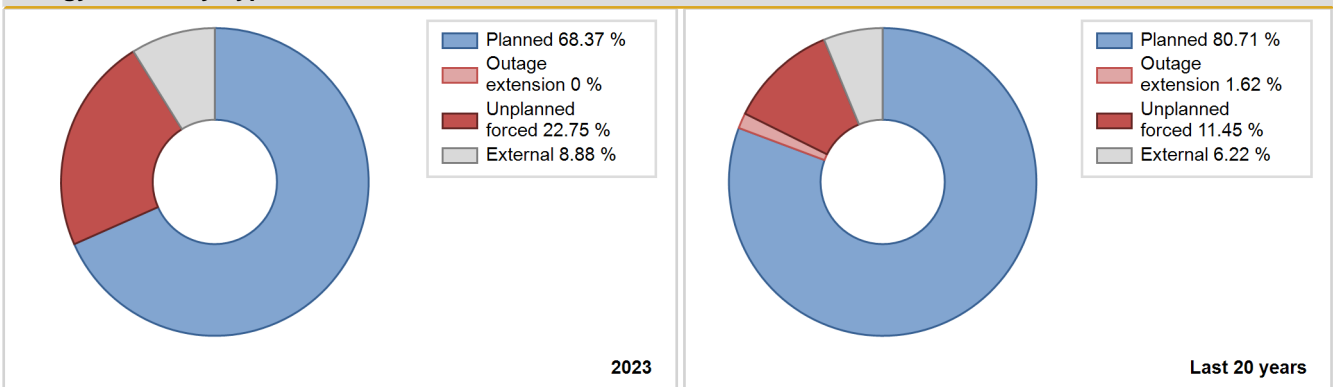
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|--|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | Data not provided | | | | | | | | | | |
| 1981 | | | | | | | | | | | |
| 1982 | | | | | | | | | | | |
| 1983 | | | | | | | | | | | |
| 1984 | | | | | | | | | | | |
| 1985 | | | | | | | | | | | |
| 1986 | | | | | | | | | | | |
| 1987 | 2629.08 | 7040 | 408 | 79.34 | 79.34 | 73.56 | 80.37 | 10.91 | 9.71 | 10.95 | 0.00 |
| 1988 | 2254.53 | 6741 | 376 | 73.40 | 73.40 | 68.26 | 76.74 | 7.07 | 5.58 | 21.02 | 0.00 |
| 1989 | 671.28 | 1838 | 376 | 99.58 | 99.58 | 82.69 | 85.13 | 0.42 | 0.42 | 0.00 | 0.00 |
| 1990 | Data not available - Suspended Operation | | | | | | | | | | |
| 1991 | | | | | | | | | | | |
| 1992 | | | | | | | | | | | |
| 1993 | | | | | | | | | | | |
| 1994 | | | | | | | | | | | |
| 1995 | Data not provided | | | | | | | | | | |
| 1996 | 2097.98 | 7561 | 376 | 63.60 | 86.25 | 63.52 | 86.08 | 0.42 | 0.37 | 13.39 | 22.64 |
| 1997 | 1429.96 | 5700 | 376 | 43.41 | 43.41 | 43.41 | 65.07 | 1.59 | 0.70 | 55.88 | 0.00 |
| 1998 | 1416.47 | 6408 | 376 | 44.62 | 44.62 | 43.00 | 73.15 | 0.11 | 0.05 | 55.33 | 0.00 |
| 1999 | 1890.37 | 6193 | 376 | 57.39 | 57.39 | 57.39 | 70.70 | 0.41 | 0.23 | 42.37 | 0.00 |
| 2000 | 1841.51 | 5699 | 376 | 55.77 | 55.78 | 55.76 | 64.88 | 2.17 | 1.24 | 42.99 | 0.01 |
| 2001 | 1815.41 | 5660 | 376 | 55.11 | 55.12 | 55.12 | 64.61 | 0.57 | 0.32 | 44.57 | 0.01 |
| 2002 | 2078.90 | 6961 | 376 | 63.20 | 63.31 | 63.12 | 79.46 | 0.87 | 0.56 | 36.13 | 0.11 |
| 2003 | 1997.55 | 6120 | 376 | 60.65 | 63.39 | 60.65 | 69.86 | 0.00 | 0.00 | 36.61 | 2.74 |
| 2004 | 2196.58 | 7135 | 376 | 64.18 | 70.29 | 66.51 | 81.23 | 0.75 | 0.89 | 28.82 | 6.11 |
| 2005 | 2504.49 | 7658 | 376 | 76.25 | 76.25 | 76.04 | 87.42 | 3.26 | 2.57 | 21.18 | 0.00 |
| 2006 | 2421.62 | 7632 | 376 | 76.13 | 76.13 | 73.52 | 87.12 | 3.15 | 2.48 | 21.39 | 0.00 |
| 2007 | 2347.83 | 7447 | 376 | 73.81 | 73.81 | 71.28 | 85.01 | 6.26 | 4.93 | 21.26 | 0.00 |
| 2008 | 2265.89 | 7013 | 376 | 69.01 | 69.01 | 68.61 | 79.84 | 3.79 | 2.72 | 28.27 | 0.00 |
| 2009 | 2290.42 | 7408 | 375 | 69.85 | 71.28 | 69.72 | 84.57 | 7.74 | 6.32 | 22.39 | 1.43 |
| 2010 | 2286.54 | 7535 | 375 | 69.70 | 71.78 | 69.61 | 86.02 | 7.26 | 5.62 | 22.61 | 2.08 |
| 2011 | 2356.84 | 7552 | 375 | 73.70 | 75.49 | 71.75 | 86.21 | 3.76 | 3.64 | 20.87 | 1.79 |
| 2012 | 2123.50 | 7052 | 375 | 66.39 | 68.31 | 64.47 | 80.28 | 4.50 | 3.22 | 28.47 | 1.92 |
| 2013 | 2167.63 | 7237 | 375 | 64.44 | 66.45 | 65.99 | 82.61 | 14.48 | 11.25 | 22.30 | 2.01 |
| 2014 | 2265.64 | 7542 | 375 | 67.32 | 70.51 | 68.97 | 86.10 | 3.94 | 2.89 | 26.60 | 3.19 |
| 2015 | 2571.10 | 7859 | 375 | 77.43 | 79.90 | 78.27 | 89.71 | 1.91 | 1.55 | 18.55 | 2.47 |
| 2016 | 2194.85 | 6756 | 375 | 65.45 | 67.82 | 66.63 | 76.91 | 1.76 | 5.72 | 26.45 | 2.37 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2017 | 2411.39 | 7341 | 375 | 71.41 | 73.43 | 73.41 | 83.80 | 3.19 | 2.42 | 24.15 | 2.02 |
| 2018 | 1898.08 | 7169 | 375 | 55.75 | 56.87 | 57.78 | 81.84 | 3.81 | 2.25 | 40.88 | 1.12 |
| 2019 | 2028.96 | 6252 | 375 | 57.15 | 57.76 | 61.76 | 71.37 | 5.62 | 3.44 | 38.80 | 0.60 |
| 2020 | 2551.80 | 7295 | 415 | 70.30 | 73.30 | 70.00 | 83.05 | 6.29 | 4.92 | 21.78 | 3.00 |
| 2021 | 1850.04 | 5028 | 448 | 49.46 | 51.55 | 50.22 | 57.40 | 2.74 | 5.78 | 42.67 | 2.09 |
| 2022 | 2630.85 | 7110 | 416 | 68.17 | 72.88 | 72.19 | 81.16 | 5.40 | 4.16 | 22.96 | 4.72 |
| 2023 | 2512.03 | 6490 | 416 | 67.31 | 70.21 | 68.93 | 74.09 | 9.58 | 7.44 | 22.35 | 2.90 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 566 | | | 112 | |
| C. Inspection, maintenance or repair combined with refuelling | 1704 | | | 1516 | 14 | |
| D. Inspection, maintenance or repair without refuelling | | | | 130 | | |
| E. Testing of plant systems or components | | | | | 2 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 52 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 9 |
| L. Human factor related | | | | | 2 | |
| Z. Other | | | | | 14 | |
| Subtotal | 1704 | 566 | | 1698 | 144 | 9 |
| Total | | 2270 | | | 1851 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1980 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 26 |
| 12. Reactor I&C Systems | | 11 |
| 13. Reactor Auxiliary Systems | | 8 |
| 15. Reactor Cooling Systems | 566 | 33 |
| 16. Steam generation systems | | 7 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 2 |
| 34. Miscellaneous Systems | | 22 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 1 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | 566 | 116 |

Highlights (2023)

Highlights for the year 2023

On May 5, 2023 at 01:45 the ANPP Unit 2 was shut down for annual outage-2023 which will last 75 days.

In addition to the scope of the annual outage, as part of outage-2023 a number of activities were implemented which were aimed at improving the safety of the plant operation. The employees of the main departments of the ANPP, as well as other experienced specialists from the Russian Federation, Croatia, the Czech Republic, Slovakia and other countries were involved in the work. The following main activities are scheduled to be performed during outage-2023.

- reactor intermediate maintenance with a complete core unloading,
- major overhaul of reactor coolant pumps ?2 and ?3,
- major overhaul of steam generators ?2 and ?3,
- routine maintenance of turbine generators,
- routine maintenance of steam turbines.
- activities on replacement of Unit 2 2RCP-1+6 pump units wraparound pipelines,
- improvement of reactor facility confinement leak-tightness,
- installation of a new system of boron unit air-cooling,
- installation/dismantling of the I and II channel ELCS pipelines and support & suspension system in the turbine hall,
- installation/dismantling of sections of the circulating water pipelines to cooling tower ?1 and other activities were performed.
- modernization of some of the safety systems will be carried out, such as replacing the pipelines of the Essential Load Cooling System.
- In the framework of the ANPP Unit 2 life extension project, during outage-2023 MAW type valves installed in the unit systems were replaced with valves of a new type and units 2?-1, 2?-2, 2?-4 of the air-cooling systems of the reactor facility confinement were replaced.
- installation of auxiliary equipment of turbine generators ?3 and ?4 was performed. Currently activities are underway to prepare Unit 2 for start-up after the outage.

All the activities included in outage schedule 2023 have been completed and the unit was connected to the grid on 15 of July, 2023, Unit 2 of the Armenian NPP was put into operation; activities of planned outage were finished 3 days before planned date.

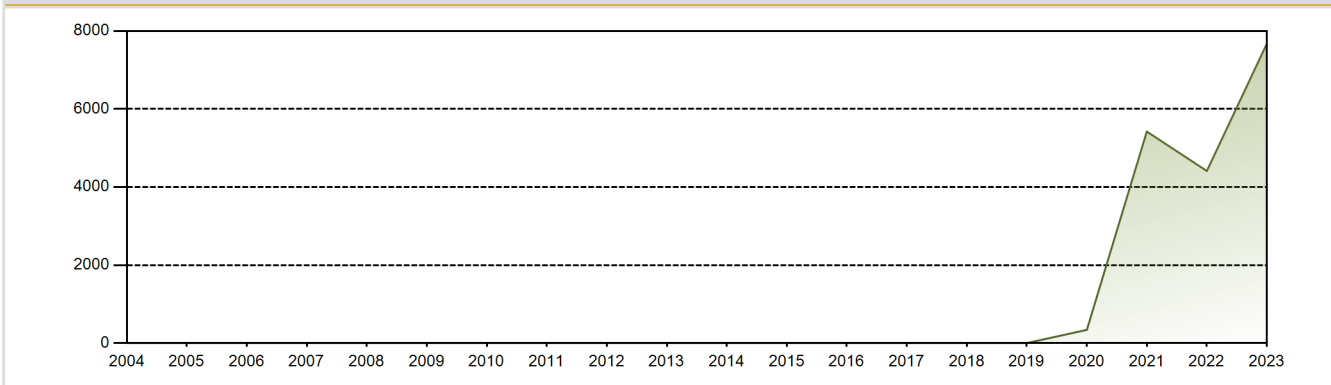
2023 Operating Experience

| BY-1 | | BELARUSIAN-1 | | BELARUS | | | | | | | | | |
|---|---|------------------|--|---------|----------------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : BelNPP (Republican Unitary Enterprise "Belarusian Nuclear Power Plant") | | | | | | | | | | | | |
| Owner | : BelNPP (Republican Unitary Enterprise "Belarusian Nuclear Power Plant") | | | | | | | | | | | | |
| Reactor Supplier | : JSC ASE (JSC "Atomstroyexport") | | | | | | | | | | | | |
| Turbine Supplier | : JSC ASE (JSC "Atomstroyexport") | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PWR / VVER V-491 | Construction Date | : | 2013-11-08 | | | | | | | | |
| Thermal power | : | 3200 MWth | Grid Date | : | 2020-11-03 | | | | | | | | |
| Gross electrical power | : | 1194 MWe | Commercial Date | : | 2021-06-10 | | | | | | | | |
| Reference unit power (net) | : | 1110 MWe | Age at end of year | : | 3 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | | | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Reactor outlet temperature [°C] | : | 328.6 | | | | | | | | |
| Fuel material | : | UO2 | Number of SG | : | 4 | | | | | | | | |
| Refuelling type | : | OFF-line | Containment type | : | Double | | | | | | | | |
| Moderator material | : | H2O | Containment design pressure [MPa] | : | 0.4 | | | | | | | | |
| Average fuel enrichment [% of U235] | : | - | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : | 12 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Part of the core refuelled [%] | : | - | Turbine speed [rpm] | : | 3000 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | 55500 | Number of LP cylinders per turbine | : | 4 | | | | | | | | |
| Active core diameter [m] | : | 3.16 | HP cylinder inlet steam pressure [MPa] | : | 6.8 | | | | | | | | |
| Active core height/length [m] | : | 3.73 | Output voltage [kV] | : | 24 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 163 | Primary means of condenser cooling | : | Cooling Towers | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 16.87 | Number of main condensate pumps | : | 6 | | | | | | | | |
| Number of control rod assemblies | : | 121 | Number of FW pumps for full power operation | : | 4 | | | | | | | | |
| Number of external reactor coolant loops | : | 4 | Number of on-site safety related diesel generators | : | 5 | | | | | | | | |
| Coolant type | : | H2O | Non-electrical applications | | | | | | | | | | |
| | | | | : | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 7675.4 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 79.03 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 80.37 % | Planned Unavailability Factor (PUF) | : | 19.63 % | | | | | | | | |
| Load Factor (LF) | : | 78.94 % | Externally cause unavailability (XUF) | : | 1.35 % | | | | | | | | |
| Operating Factor (OF) | : | 80.53 % | Total off-line time | : | 1706 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 824.81 | 747.65 | 822.41 | 785.96 | 809.73 | 778.55 | 801.02 | 795.24 | 773.81 | 136.08 | 0.00 | 400.15 | 7675.40 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 98.34 | 98.05 | 97.42 | 96.99 | 96.29 | 96.82 | 17.20 | 0.00 | 48.45 | 79.03 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 17.20 | 0.00 | 48.45 | 80.37 |
| LF [%] | 99.88 | 100.23 | 99.58 | 98.34 | 98.05 | 97.42 | 96.99 | 96.29 | 96.82 | 16.48 | 0.00 | 48.45 | 78.94 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 17.20 | 0.00 | 50.27 | 80.53 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 82.80 | 100.00 | 51.55 | 19.63 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 1.66 | 1.95 | 2.58 | 3.01 | 3.71 | 3.18 | 0.00 | 0.00 | 0.00 | 1.35 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 17847.28 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 13.03 % |
| Cumulative Energy Availability Factor (EAF) | : 61.42 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 22.27 % |
| Cumulative Unit Capability Factor (UCF) | : 61.94 % | Cumulative Planned Unavailability Factor (PUF) | : 15.8 % |
| Cumulative Load Factor (LF) | : 61.28 % | Cumulative Externally cause unavailability (XUF) | : 0.52 % |
| Cumulative Operating Factor (OF) | : 62.35 % | | |

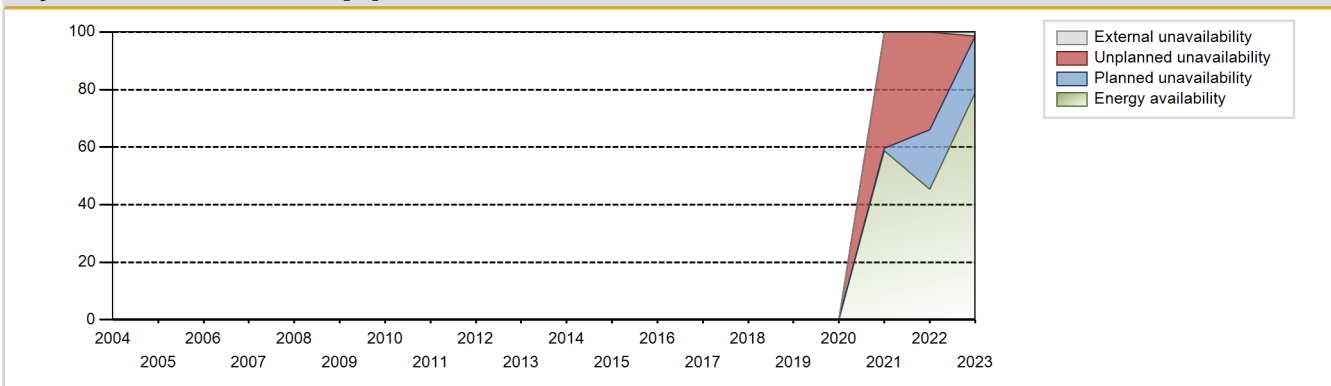
Electricity Production (net) [GWh]



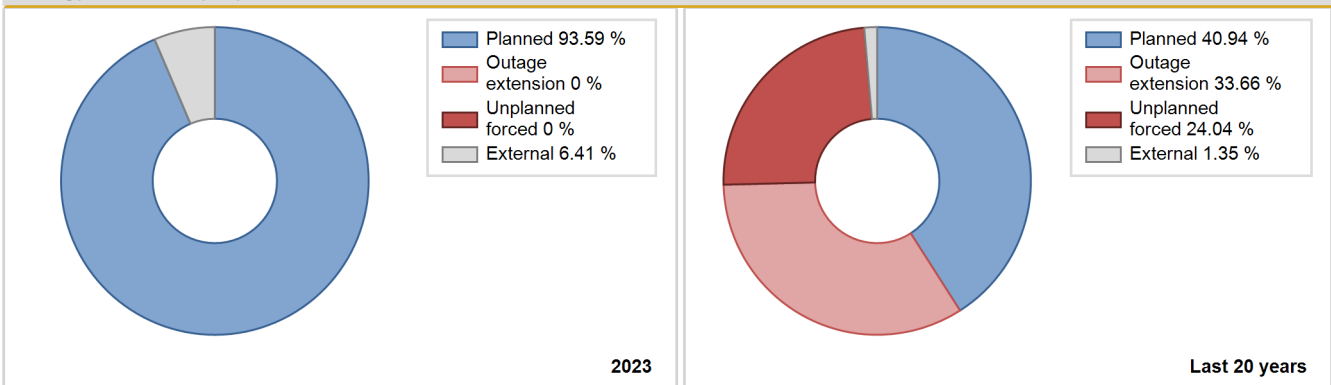
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2021 | 5422.11 | 5255 | 1110 | 58.75 | 58.75 | 58.32 | 59.66 | 40.71 | 40.34 | 0.91 | 0.00 |
| 2022 | 4411.35 | 4008 | 1110 | 45.38 | 45.38 | 45.37 | 45.75 | 0.74 | 33.93 | 20.69 | 0.00 |
| 2023 | 7675.40 | 7054 | 1110 | 79.03 | 80.37 | 78.94 | 80.53 | 0.00 | 0.00 | 19.63 | 1.35 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2021 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 806 | |
| C. Inspection, maintenance or repair combined with refuelling | 1706 | | | 1357 | | |
| Z. Other | | | | | 1139 | |
| Subtotal | 1706 | | | 1357 | 1945 | |
| Total | | 1706 | | | 3302 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2021 to 2023 | |
|-----------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 17 |
| 31. Turbine and auxiliaries | | | | 3 |
| 41. Main Generator Systems | | | | 674 |
| Total | | | | 694 |

Highlights (2023)

Scheduled overhaul

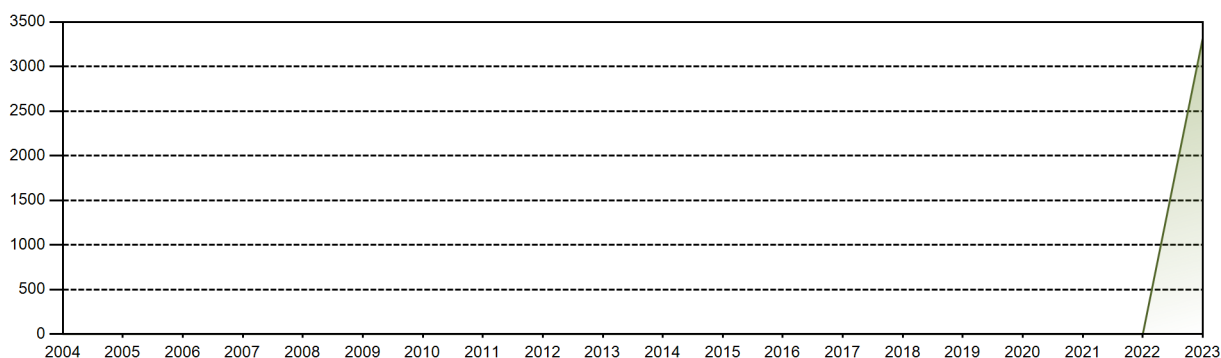
2023 Operating Experience

| BY-2 | | BELARUSIAN-2 | | BELARUS | | | | | | | | | |
|---|---|--|-------------------|---------|--------|-----|-----|-----|-----|-----|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : BelNPP (Republican Unitary Enterprise "Belarusian Nuclear Power Plant") | | | | | | | | | | | | |
| Owner | : BelNPP (Republican Unitary Enterprise "Belarusian Nuclear Power Plant") | | | | | | | | | | | | |
| Reactor Supplier | : JSC ASE (JSC "Atomstroyexport") | | | | | | | | | | | | |
| Turbine Supplier | : JSC ASE (JSC "Atomstroyexport") | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : PWR / VVER V-491 | Construction Date | : 2014-04-27 | | | | | | | | | | |
| Thermal power | : 3200 MWth | Grid Date | : 2023-05-13 | | | | | | | | | | |
| Gross electrical power | : 1194 MWe | Commercial Date | : 2023-11-01 | | | | | | | | | | |
| Reference unit power (net) | : 1110 MWe | Age at end of year | : 0 years | | | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Secondary systems | | | | | | | | | | |
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 16.2 | | | | | | | | | | |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 328.6 | | | | | | | | | | |
| Refuelling type | : OFF-line | Number of SG | : 4 | | | | | | | | | | |
| Moderator material | : H2O | Containment type | : Double | | | | | | | | | | |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 0.2 | | | | | | | | | | |
| Refuelling frequency [month] | : 12 | Secondary systems | | | | | | | | | | | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 | | | | | | | | | | |
| Average discharge burnup [MWd/t] | : 55500 | Turbine speed [rpm] | : 3000 | | | | | | | | | | |
| Active core diameter [m] | : 3.16 | Number of LP cylinders per turbine | : 4 | | | | | | | | | | |
| Active core height/length [m] | : 3.73 | HP cylinder inlet steam pressure [MPa] | : 6.8 | | | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : 163 | Output voltage [kV] | : 24 | | | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : 16.87 | Primary means of condenser cooling | : Cooling Towers | | | | | | | | | | |
| Number of control rod assemblies | : 121 | Number of main condensate pumps | : 6 | | | | | | | | | | |
| Number of external reactor coolant loops | : 4 | Number of FW pumps for full power operation | : 4 | | | | | | | | | | |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 5 | | | | | | | | | | |
| | | Non-electrical applications | | | : none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : 3321.12 GW(e).h | Forced Loss Rate (FLR) | : 15.42 % | | | | | | | | | | |
| Energy Availability Factor (EAF) | : 84.58 % | Unplanned Capability Loss Factor (UCL) | : 15.42 % | | | | | | | | | | |
| Unit Capability Factor (UCF) | : 84.58 % | Planned Unavailability Factor (PUF) | : 0 % | | | | | | | | | | |
| Load Factor (LF) | : 84.58 % | Externally cause unavailability (XUF) | : 0 % | | | | | | | | | | |
| Operating Factor (OF) | : 98.5 % | Total off-line time | : 1918 hours | | | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Oct | Feb | Mar | Apr | May | Jun | Jul | Sep | Aug | Nov | Dec | Annual |
| GW(e)-h | | | | | | | | | | | 578.77 | 795.69 | 1374.46 |
| EAF [%] | | | | | | | | | | | 72.42 | 96.35 | 84.58 |
| UCF [%] | | | | | | | | | | | 72.42 | 96.35 | 84.58 |
| LF [%] | | | | | | | | | | | 72.42 | 96.35 | 84.58 |
| OF [%] | | | | | | | | | | | 96.94 | 100.00 | 98.50 |
| FLR [%] | | | | | | | | | | | 27.58 | 3.65 | 15.42 |
| UCL [%] | | | | | | | | | | | 27.58 | 3.65 | 15.42 |
| PUF [%] | | | | | | | | | | | 0.00 | 0.00 | 0.00 |
| XUF [%] | | | | | | | | | | | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|-------------------|---|-----------|
| Lifetime energy generation | : 3321.12 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 15.42 % |
| Cumulative Energy Availability Factor (EAF) | : 84.58 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 15.42 % |
| Cumulative Unit Capability Factor (UCF) | : 84.58 % | Cumulative Planned Unavailability Factor (PUF) | : 0 % |
| Cumulative Load Factor (LF) | : 84.58 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 98.5 % | | |

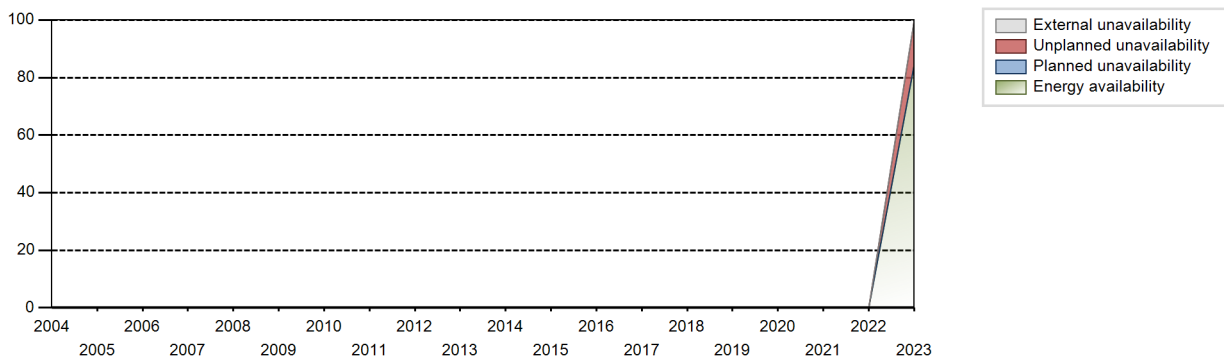
Electricity Production (net) [GWh]



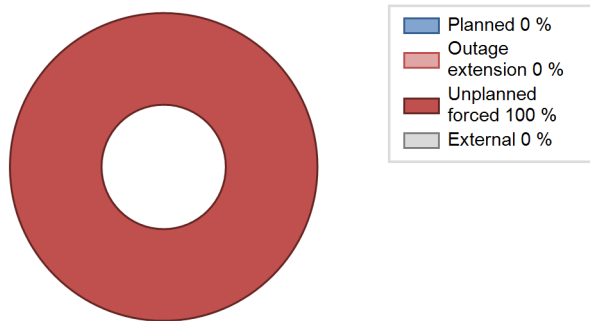
Performance for Years of Commercial Operation

| Year | Energy | Time Online | Reference Unit Power | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------|-------------|----------------------|-------|-------|-------|-------|-------|-------|------|------|
| | [GW-h] | [Hours] | [MW] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2023 | 3321.12 | 3674 | 1110 | 84.58 | 84.58 | 84.58 | 98.50 | 15.42 | 15.42 | 0.00 | 0.00 |

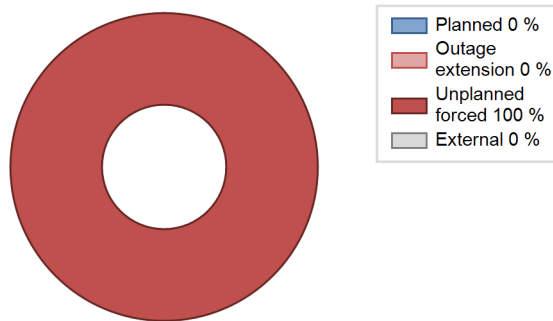
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2023 to 2023 | | |
|------------------------------------|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 22 | | | 132 | |
| Subtotal | | 22 | | | 132 | |
| Total | | 22 | | | 132 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2023 to 2023 |
|-----------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 31. Turbine and auxiliaries | 22 | 33 |
| Total | 22 | 33 |

Highlights (2023)

First connection grid - 05/13/2023
Start commercial operation - 11/01/2023

2023 Operating Experience

BE-2

DOEL-1

BELGIUM

Status at end of year : **Operational**
 Operator : EBL+EDF (ENGIE ELECTRABEL + EDF BELGIUM + EDF LUMINUS)
 Owner : IND.DOEL (INDIVISION DOEL (EBES , INTERCOM , UNERG))
 Reactor Supplier : ACECOWEN (ACECOWEN (ACEC-COCKERILL-WESTINGHOUSE))
 Turbine Supplier : COC/ACEC (TURBINE: COCKERILL-TOSI ; ALTERNATOR: ACEC)



Reactor Unit Details

Reactor type and model : PWR / WH 2LP
 Thermal power : 1311 MWth
 Gross electrical power : 454 MWe
 Reference unit power (net) : 445 MWe

Key Dates

Construction Date : 1969-07-01
 Grid Date : 1974-08-28
 Commercial Date : 1975-02-15
 Age at end of year : 49 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 2.46
 Active core height/length [m] : 2.44
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 22.22
 Number of control rod assemblies : 21
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.73
 Reactor outlet temperature [°C] : 315.08
 Number of SG : 2
 Containment type : Double
 Containment design pressure [MPa] : 2.9

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.8
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

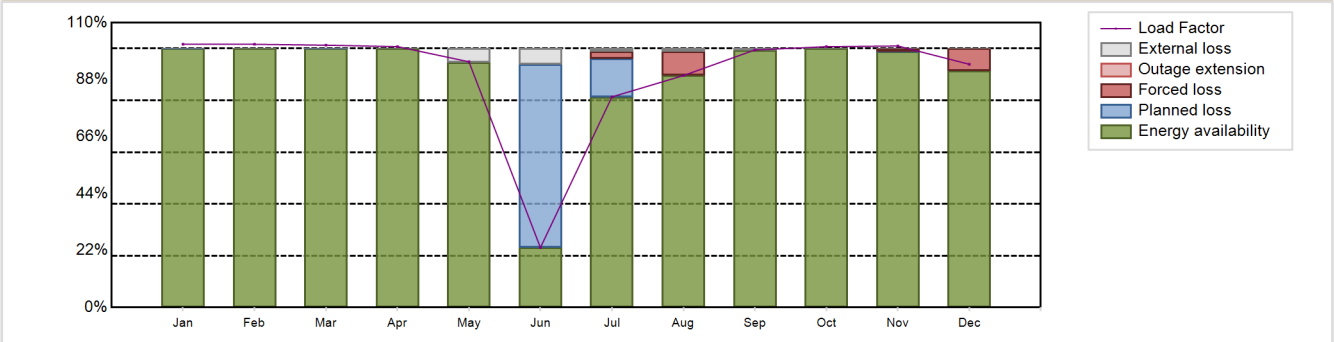
: none

Annual Production Results (2023)

Net Energy Production : 3540.07 GW(e).h
 Energy Availability Factor (EAF) : 89.9 %
 Unit Capability Factor (UCF) : 91.08 %
 Load Factor (LF) : 90.81 %
 Operating Factor (OF) : 92.18 %

Forced Loss Rate (FLR) : 1.98 %
 Unplanned Capability Loss Factor (UCL) : 1.84 %
 Planned Unavailability Factor (PUF) : 7.09 %
 Externally cause unavailability (XUF) : 1.17 %
 Total off-line time : 685 hours

Annual Summary

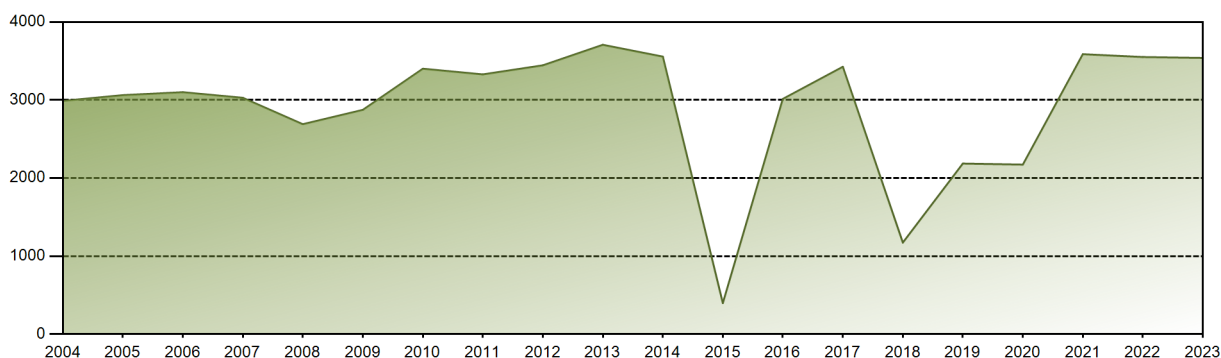


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 336.59 | 304.02 | 334.98 | 322.86 | 314.24 | 74.14 | 269.31 | 296.57 | 318.73 | 333.97 | 323.66 | 311.00 | 3540.07 |
| EAF [%] | 99.99 | 100.00 | 100.00 | 100.00 | 94.72 | 23.14 | 81.34 | 89.58 | 99.48 | 100.00 | 98.83 | 91.50 | 89.90 |
| UCF [%] | 99.99 | 100.00 | 100.00 | 100.00 | 100.00 | 29.14 | 82.57 | 90.59 | 100.00 | 100.00 | 98.83 | 91.50 | 91.08 |
| LF [%] | 101.66 | 101.67 | 101.31 | 100.77 | 94.91 | 23.14 | 81.34 | 89.58 | 99.48 | 100.74 | 101.02 | 93.93 | 90.81 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 29.44 | 85.48 | 98.12 | 100.00 | 100.00 | 100.00 | 92.61 | 92.18 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.05 | 9.41 | 0.00 | 0.00 | 1.15 | 8.50 | 1.98 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.60 | 9.41 | 0.00 | 0.00 | 1.15 | 8.50 | 1.84 |
| PUF [%] | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 70.86 | 14.83 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 7.09 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 5.28 | 6.00 | 1.23 | 1.01 | 0.52 | 0.00 | 0.00 | 0.00 | 1.17 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 143911.9 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.04 % |
| Cumulative Energy Availability Factor (EAF) | : 83.87 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.01 % |
| Cumulative Unit Capability Factor (UCF) | : 84.69 % | Cumulative Planned Unavailability Factor (PUF) | : 12.3 % |
| Cumulative Load Factor (LF) | : 82.35 % | Cumulative Externally cause unavailability (XUF) | : 0.82 % |
| Cumulative Operating Factor (OF) | : 83.88 % | | |

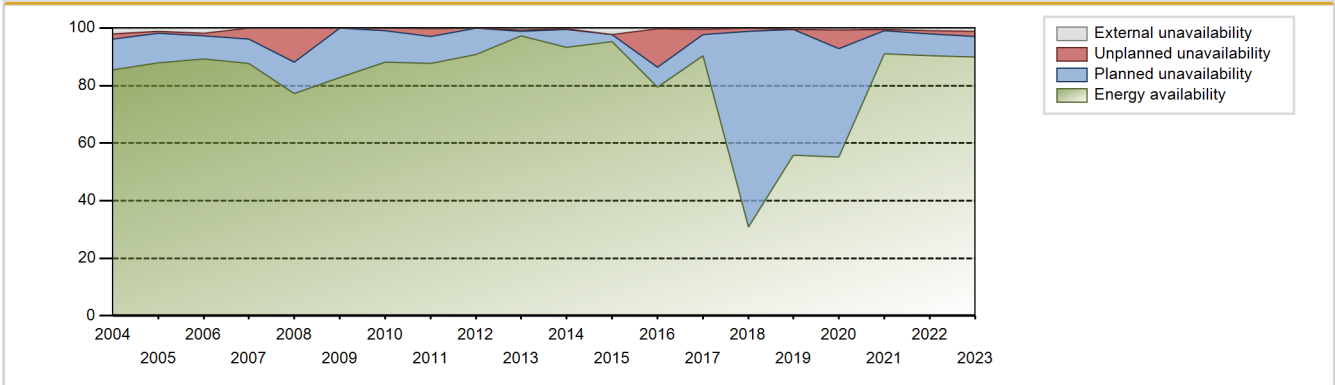
Electricity Production (net) [GWh]



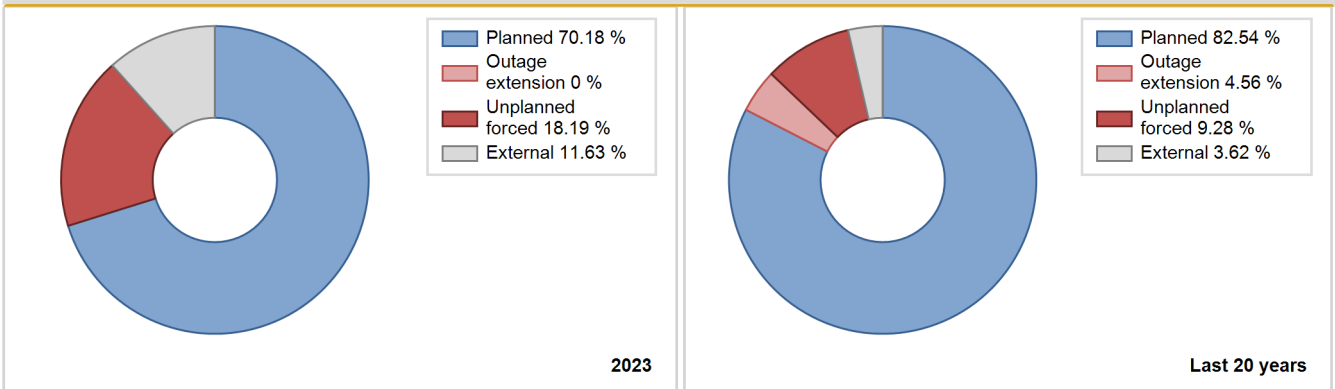
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 2557.60 | 7257 | 392 | 75.78 | 75.78 | 75.77 | 81.78 | 24.22 | 24.22 | 0.00 | 0.00 |
| 1976 | 2667.10 | 6928 | 395 | 75.48 | 75.48 | 76.87 | 78.87 | 12.67 | 10.95 | 13.57 | 0.00 |
| 1977 | 2830.00 | 7332 | 395 | 81.77 | 81.77 | 81.79 | 83.70 | 8.45 | 7.55 | 10.67 | 0.00 |
| 1978 | 2731.20 | 7071 | 395 | 78.89 | 78.89 | 78.93 | 80.72 | 0.99 | 0.78 | 20.33 | 0.00 |
| 1979 | 3037.00 | 7812 | 395 | 86.38 | 86.38 | 87.77 | 89.18 | 1.45 | 1.27 | 12.35 | 0.00 |
| 1980 | 2901.00 | 7596 | 395 | 84.36 | 84.36 | 83.61 | 86.48 | 2.96 | 2.57 | 13.07 | 0.00 |
| 1981 | 2946.00 | 7644 | 395 | 85.00 | 85.00 | 85.14 | 87.26 | 0.00 | 0.00 | 15.00 | 0.00 |
| 1982 | 3184.50 | 8103 | 395 | 91.24 | 91.24 | 92.03 | 92.50 | 1.45 | 1.34 | 7.42 | 0.00 |
| 1983 | 2823.00 | 7316 | 393 | 81.78 | 81.78 | 82.00 | 83.52 | 17.98 | 17.92 | 0.30 | 0.00 |
| 1984 | 3129.00 | 7988 | 393 | 90.22 | 90.22 | 90.64 | 90.94 | 1.88 | 1.73 | 8.06 | 0.00 |
| 1985 | 2896.32 | 7330 | 392 | 82.44 | 82.44 | 84.34 | 83.68 | 2.58 | 2.18 | 15.38 | 0.00 |
| 1986 | 2685.93 | 7040 | 392 | 78.85 | 79.15 | 78.22 | 80.37 | 3.69 | 3.03 | 17.82 | 0.30 |
| 1987 | 2928.35 | 7306 | 400 | 85.44 | 85.45 | 83.57 | 83.40 | 3.59 | 3.18 | 11.37 | 0.01 |
| 1988 | 2694.15 | 7686 | 400 | 81.28 | 86.59 | 76.68 | 87.50 | 1.53 | 1.35 | 12.06 | 5.31 |
| 1989 | 2513.10 | 6475 | 400 | 71.87 | 73.57 | 71.72 | 73.92 | 9.59 | 7.81 | 18.63 | 1.70 |
| 1990 | 2859.89 | 7380 | 400 | 83.54 | 85.62 | 81.62 | 84.25 | 0.84 | 0.73 | 13.65 | 2.07 |
| 1991 | 3061.38 | 7860 | 400 | 89.20 | 89.48 | 87.37 | 89.73 | 1.12 | 1.02 | 9.51 | 0.28 |
| 1992 | 2990.54 | 7741 | 400 | 86.52 | 87.69 | 85.11 | 88.13 | 1.18 | 1.05 | 11.26 | 1.17 |
| 1993 | 2908.89 | 7580 | 400 | 84.38 | 86.00 | 83.02 | 86.53 | 3.84 | 3.43 | 10.57 | 1.62 |
| 1994 | 2921.78 | 7635 | 400 | 84.32 | 88.72 | 83.38 | 87.16 | 0.38 | 0.34 | 10.94 | 4.40 |
| 1995 | 2791.52 | 7342 | 392 | 80.96 | 82.67 | 81.29 | 83.81 | 3.45 | 2.95 | 14.37 | 1.72 |
| 1996 | 3169.35 | 8141 | 392 | 91.25 | 91.48 | 92.04 | 92.68 | 0.48 | 0.44 | 8.08 | 0.23 |
| 1997 | 3113.83 | 7899 | 392 | 88.92 | 88.97 | 90.68 | 90.17 | 2.08 | 1.89 | 9.14 | 0.05 |
| 1998 | 3292.46 | 8277 | 392 | 93.74 | 94.05 | 95.88 | 94.49 | 0.17 | 0.16 | 5.78 | 0.31 |
| 1999 | 3196.84 | 8123 | 392 | 91.12 | 92.58 | 93.10 | 92.73 | 0.27 | 0.25 | 7.16 | 1.46 |
| 2000 | 3264.77 | 8317 | 392 | 92.34 | 94.25 | 94.81 | 94.68 | 0.39 | 0.37 | 5.39 | 1.91 |
| 2001 | 3157.62 | 8098 | 392 | 90.47 | 91.37 | 91.94 | 92.43 | 3.11 | 2.93 | 5.70 | 0.90 |
| 2002 | 3260.70 | 8308 | 392 | 93.33 | 93.44 | 94.96 | 94.84 | 0.39 | 0.37 | 6.19 | 0.11 |
| 2003 | 3024.60 | 7953 | 392 | 86.35 | 90.29 | 88.08 | 90.79 | 0.23 | 0.58 | 9.13 | 3.94 |
| 2004 | 2989.10 | 7742 | 392 | 85.54 | 87.55 | 86.81 | 88.14 | 1.66 | 1.72 | 10.72 | 2.02 |
| 2005 | 3062.65 | 7849 | 392 | 87.95 | 89.14 | 89.18 | 89.59 | 0.78 | 0.70 | 10.16 | 1.18 |
| 2006 | 3100.48 | 8030 | 392 | 89.19 | 91.10 | 90.29 | 91.67 | 0.89 | 0.82 | 8.08 | 1.91 |
| 2007 | 3028.97 | 7709 | 392 | 87.64 | 87.72 | 88.21 | 88.00 | 0.00 | 3.70 | 8.58 | 0.08 |
| 2008 | 2690.32 | 6847 | 392 | 77.29 | 77.29 | 78.13 | 77.95 | 12.89 | 11.96 | 10.75 | 0.00 |
| 2009 | 2874.05 | 7266 | 392 | 82.89 | 82.90 | 83.70 | 82.95 | 0.00 | 0.00 | 17.09 | 0.01 |
| 2010 | 3401.38 | 7801 | 433 | 88.25 | 88.25 | 89.67 | 89.05 | 1.09 | 0.97 | 10.78 | 0.01 |
| 2011 | 3328.53 | 7740 | 433 | 87.77 | 87.94 | 87.75 | 88.36 | 0.34 | 2.72 | 9.34 | 0.17 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2012 | 3444.69 | 8019 | 433 | 90.91 | 90.91 | 90.57 | 91.29 | 0.08 | 0.07 | 9.02 | 0.00 |
| 2013 | 3707.93 | 8595 | 433 | 97.23 | 97.93 | 97.76 | 98.12 | 0.37 | 0.36 | 1.71 | 0.70 |
| 2014 | 3556.42 | 8230 | 433 | 93.35 | 93.62 | 93.76 | 93.95 | 0.32 | 0.30 | 6.08 | 0.27 |
| 2015 | 396.78 | 1143 | 433 | 95.33 | 97.63 | 10.46 | 13.05 | 0.00 | 0.00 | 2.37 | 2.30 |
| 2016 | 3014.51 | 7056 | 433 | 79.41 | 79.64 | 79.26 | 80.33 | 13.14 | 13.44 | 6.92 | 0.23 |
| 2017 | 3426.38 | 8019 | 433 | 90.28 | 90.68 | 90.33 | 91.54 | 0.61 | 1.85 | 7.46 | 0.40 |
| 2018 | 1172.49 | 2700 | 433 | 30.81 | 30.81 | 30.91 | 30.82 | 3.61 | 1.15 | 68.04 | 0.00 |
| 2019 | 2185.67 | 4968 | 445 | 55.84 | 56.39 | 56.31 | 56.71 | 0.05 | 0.03 | 43.58 | 0.55 |
| 2020 | 2172.18 | 4946 | 445 | 55.19 | 55.81 | 55.57 | 56.31 | 0.00 | 6.55 | 37.64 | 0.62 |
| 2021 | 3587.85 | 8045 | 445 | 91.05 | 91.44 | 92.04 | 91.84 | 0.51 | 0.47 | 8.10 | 0.39 |
| 2022 | 3551.15 | 8045 | 445 | 90.40 | 91.39 | 91.10 | 91.84 | 1.13 | 1.04 | 7.56 | 0.99 |
| 2023 | 3540.07 | 8075 | 445 | 89.90 | 91.08 | 90.81 | 92.18 | 1.98 | 1.84 | 7.09 | 1.17 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 87 | | | 189 | |
| C. Inspection, maintenance or repair combined with refuelling | 598 | | | 717 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 6 | | |
| E. Testing of plant systems or components | | | | 44 | 2 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 266 | | |
| H. Nuclear regulatory requirements | | | | | 5 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 5 |
| L. Human factor related | | | | | 25 | |
| M. Governmental requirements or court decisions | | | | | | 152 |
| P. Fire | | | | | 1 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 17 | 32 | |
| Z. Other | | | | | 1 | |
| Subtotal | 598 | 87 | | 1050 | 255 | 157 |
| Total | | 685 | | | 1462 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 8 |
| 12. Reactor I&C Systems | | 29 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 12 |
| 15. Reactor Cooling Systems | | 32 |
| 16. Steam generation systems | | 30 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | 73 | 57 |
| 32. Feedwater and Main Steam System | 14 | 17 |
| 33. Circulating Water System | | 0 |
| 41. Main Generator Systems | | 6 |
| 42. Electrical Power Supply Systems | | 0 |
| Total | 87 | 195 |

Highlights (2023)

27-04-2023: start Stretch-out
 09-06-2023: Refuelling outage
 04-07-2023: startup cycle 48
 05-07-2023: scram automatic
 26-08-2023: scram automatic
 05-12-2023: scram automatic

2023 Operating Experience

BE-4

DOEL-2

BELGIUM

Status at end of year : **Operational**
 Operator : EBL+EDF (ENGIE ELECTRABEL + EDF BELGIUM + EDF LUMINUS)
 Owner : IND.DOEL (INDIVISION DOEL (EBES , INTERCOM , UNERG))
 Reactor Supplier : ACECOWEN (ACECOWEN (ACEC-COCKERILL-WESTINGHOUSE))
 Turbine Supplier : COC/ACEC (TURBINE: COCKERILL-TOSI ; ALTERNATOR: ACEC)



Reactor Unit Details

Reactor type and model : PWR / WH 2LP
 Thermal power : 1311 MWth
 Gross electrical power : 454 MWe
 Reference unit power (net) : 445 MWe

Key Dates

Construction Date : 1971-09-01
 Grid Date : 1975-08-21
 Commercial Date : 1975-12-01
 Age at end of year : 48 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 2.46
 Active core height/length [m] : 2.44
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 22.22
 Number of control rod assemblies : 21
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.73
 Reactor outlet temperature [°C] : 315.08
 Number of SG : 2
 Containment type : -
 Containment design pressure [MPa] : 2.9

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.8
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

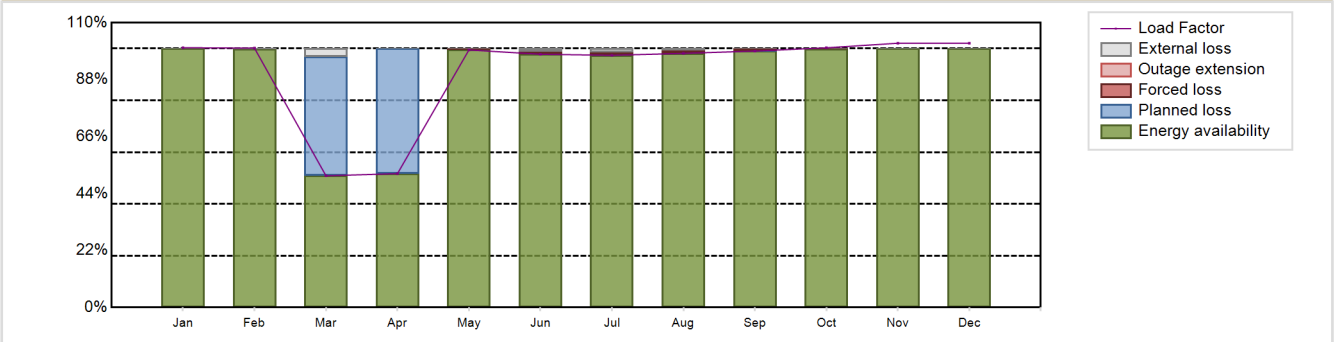
: none

Annual Production Results (2023)

Net Energy Production : 3570.58 GW(e).h
 Energy Availability Factor (EAF) : 91.16 %
 Unit Capability Factor (UCF) : 91.7 %
 Load Factor (LF) : 91.6 %
 Operating Factor (OF) : 92.36 %

Forced Loss Rate (FLR) : 0.45 %
 Unplanned Capability Loss Factor (UCL) : 0.41 %
 Planned Unavailability Factor (PUF) : 7.89 %
 Externally cause unavailability (XUF) : 0.54 %
 Total off-line time : 669 hours

Annual Summary

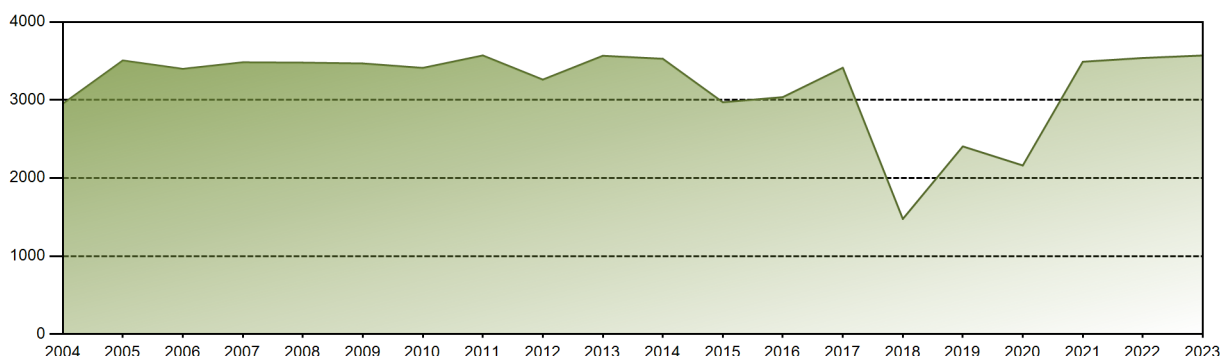


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 332.23 | 299.57 | 168.22 | 165.69 | 329.36 | 313.39 | 322.50 | 324.93 | 317.32 | 332.54 | 327.02 | 337.82 | 3570.58 |
| EAF [%] | 100.00 | 99.90 | 50.88 | 51.61 | 99.50 | 97.81 | 97.41 | 98.14 | 99.04 | 99.86 | 100.00 | 100.00 | 91.16 |
| UCF [%] | 100.00 | 100.00 | 53.90 | 51.61 | 99.50 | 98.89 | 98.88 | 98.90 | 99.04 | 99.86 | 100.00 | 100.00 | 91.70 |
| LF [%] | 100.35 | 100.18 | 50.88 | 51.71 | 99.48 | 97.81 | 97.41 | 98.14 | 99.04 | 100.31 | 102.07 | 102.04 | 91.60 |
| OF [%] | 100.00 | 100.00 | 54.37 | 54.17 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.36 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 1.11 | 1.12 | 1.10 | 0.94 | 0.14 | 0.00 | 0.00 | 0.45 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 1.11 | 1.12 | 1.10 | 0.94 | 0.14 | 0.00 | 0.00 | 0.41 |
| PUF [%] | 0.00 | 0.00 | 46.10 | 48.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 7.89 |
| XUF [%] | 0.00 | 0.10 | 3.02 | 0.00 | 0.00 | 1.08 | 1.47 | 0.76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.54 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 142247.64 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.37 % |
| Cumulative Energy Availability Factor (EAF) | : 81.57 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.25 % |
| Cumulative Unit Capability Factor (UCF) | : 82.33 % | Cumulative Planned Unavailability Factor (PUF) | : 14.42 % |
| Cumulative Load Factor (LF) | : 81.82 % | Cumulative Externally cause unavailability (XUF) | : 0.76 % |
| Cumulative Operating Factor (OF) | : 82.66 % | | |

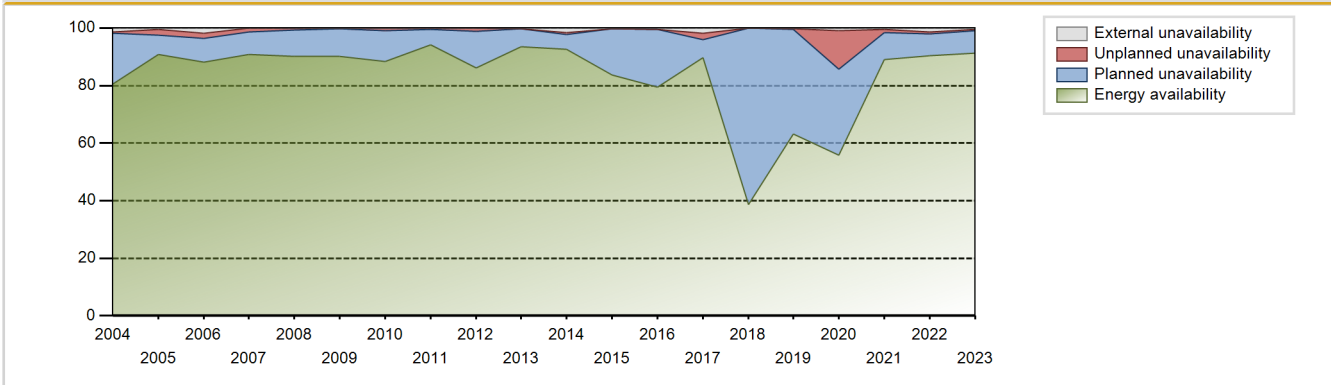
Electricity Production (net) [GWh]



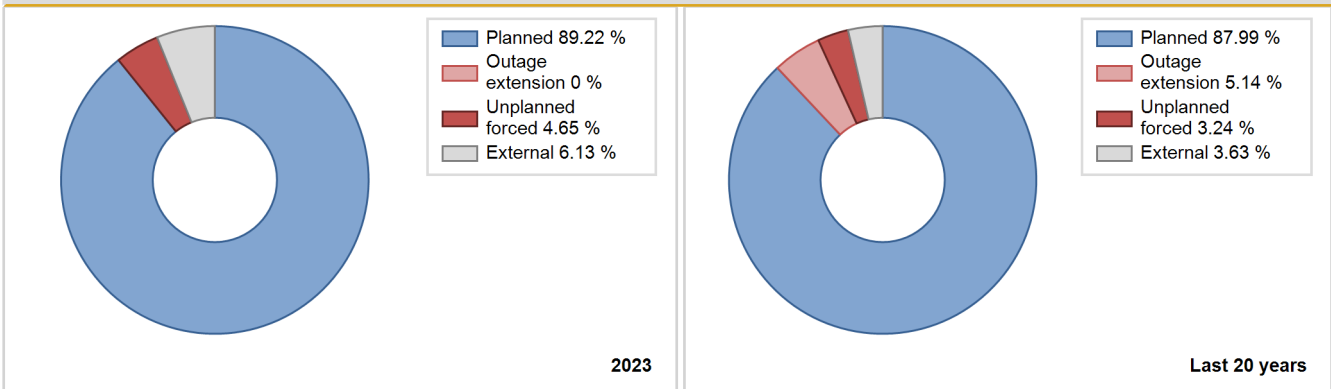
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 711.50 | 2305 | 392 | 91.30 | 91.30 | 91.34 | 93.28 | 8.70 | 8.70 | 0.00 | 0.00 |
| 1976 | 2462.80 | 6519 | 395 | 71.64 | 71.64 | 70.98 | 74.21 | 6.58 | 5.05 | 23.31 | 0.00 |
| 1977 | 2576.80 | 6649 | 395 | 74.30 | 74.30 | 74.47 | 75.90 | 15.58 | 13.71 | 11.99 | 0.00 |
| 1978 | 2750.60 | 7114 | 395 | 79.53 | 79.53 | 79.49 | 81.21 | 8.68 | 7.56 | 12.91 | 0.00 |
| 1979 | 2593.30 | 6639 | 395 | 74.56 | 74.56 | 74.95 | 75.79 | 2.02 | 1.54 | 23.90 | 0.00 |
| 1980 | 2782.00 | 7111 | 395 | 79.75 | 79.75 | 80.18 | 80.95 | 0.36 | 0.29 | 19.96 | 0.00 |
| 1981 | 2841.70 | 7226 | 395 | 81.36 | 81.36 | 82.13 | 82.49 | 2.77 | 2.32 | 16.33 | 0.00 |
| 1982 | 2582.00 | 6598 | 395 | 73.82 | 73.82 | 74.62 | 75.32 | 19.44 | 17.82 | 8.37 | 0.00 |
| 1983 | 2017.00 | 5190 | 393 | 58.02 | 58.02 | 58.59 | 59.25 | 0.06 | 0.03 | 41.95 | 0.00 |
| 1984 | 2916.00 | 7508 | 393 | 84.15 | 84.15 | 84.47 | 85.47 | 3.08 | 2.67 | 13.18 | 0.00 |
| 1985 | 2908.66 | 7341 | 392 | 83.04 | 83.04 | 84.70 | 83.80 | 7.64 | 6.86 | 10.10 | 0.00 |
| 1986 | 2282.63 | 5891 | 392 | 69.76 | 69.85 | 66.47 | 67.25 | 5.08 | 3.74 | 26.41 | 0.09 |
| 1987 | 2616.44 | 6612 | 400 | 76.77 | 77.75 | 74.67 | 75.48 | 8.61 | 7.32 | 14.92 | 0.99 |
| 1988 | 2906.68 | 7408 | 400 | 82.60 | 83.20 | 82.73 | 84.34 | 5.39 | 4.74 | 12.06 | 0.60 |
| 1989 | 2479.80 | 6436 | 400 | 70.79 | 71.79 | 70.77 | 73.47 | 11.54 | 9.36 | 18.85 | 1.00 |
| 1990 | 1982.58 | 5170 | 400 | 56.58 | 66.48 | 56.58 | 59.02 | 19.63 | 16.23 | 17.29 | 9.90 |
| 1991 | 2779.83 | 7136 | 400 | 81.02 | 81.17 | 79.33 | 81.46 | 2.08 | 1.72 | 17.10 | 0.15 |
| 1992 | 2971.94 | 7617 | 400 | 86.12 | 86.33 | 84.58 | 86.71 | 0.88 | 0.76 | 12.91 | 0.21 |
| 1993 | 2949.55 | 7551 | 400 | 85.68 | 85.94 | 84.18 | 86.20 | 2.40 | 2.12 | 11.94 | 0.27 |
| 1994 | 2982.45 | 7810 | 392 | 86.22 | 87.28 | 86.85 | 89.16 | 0.54 | 0.48 | 12.24 | 1.06 |
| 1995 | 2867.54 | 7342 | 392 | 82.70 | 82.92 | 83.51 | 83.81 | 5.02 | 4.38 | 12.70 | 0.23 |
| 1996 | 2888.76 | 7390 | 392 | 83.13 | 83.39 | 83.89 | 84.13 | 7.17 | 6.44 | 10.18 | 0.25 |
| 1997 | 2935.03 | 7749 | 392 | 84.50 | 87.71 | 85.47 | 88.46 | 2.97 | 2.68 | 9.61 | 3.21 |
| 1998 | 3145.01 | 7987 | 392 | 90.13 | 90.18 | 91.59 | 91.18 | 2.50 | 2.31 | 7.51 | 0.05 |
| 1999 | 3091.67 | 7875 | 392 | 88.88 | 89.57 | 90.03 | 89.90 | 3.65 | 3.39 | 7.04 | 0.70 |
| 2000 | 3135.59 | 8022 | 392 | 89.81 | 90.43 | 91.06 | 91.33 | 3.57 | 3.34 | 6.23 | 0.62 |
| 2001 | 3150.54 | 8060 | 392 | 90.30 | 90.89 | 91.75 | 92.01 | 2.41 | 2.25 | 6.87 | 0.58 |
| 2002 | 3104.45 | 8076 | 392 | 89.51 | 91.39 | 90.41 | 92.19 | 1.37 | 1.27 | 7.34 | 1.89 |
| 2003 | 3142.62 | 8184 | 392 | 90.13 | 93.09 | 91.52 | 93.42 | 0.47 | 0.59 | 6.32 | 2.96 |
| 2004 | 2951.91 | 7174 | 433 | 80.50 | 81.92 | 81.35 | 81.67 | 0.37 | 0.30 | 17.77 | 1.43 |
| 2005 | 3506.72 | 8036 | 433 | 90.79 | 91.26 | 92.44 | 91.72 | 2.11 | 1.97 | 6.77 | 0.47 |
| 2006 | 3399.32 | 7954 | 433 | 88.18 | 90.10 | 89.62 | 90.80 | 1.86 | 1.71 | 8.19 | 1.91 |
| 2007 | 3483.14 | 7985 | 433 | 90.76 | 90.77 | 91.83 | 91.15 | 0.09 | 1.43 | 7.80 | 0.01 |
| 2008 | 3478.91 | 8000 | 433 | 90.26 | 90.26 | 91.47 | 91.07 | 0.68 | 0.61 | 9.12 | 0.00 |
| 2009 | 3468.52 | 7941 | 433 | 90.11 | 90.11 | 91.44 | 90.65 | 0.39 | 0.36 | 9.54 | 0.00 |
| 2010 | 3411.40 | 7823 | 433 | 88.29 | 88.40 | 89.95 | 89.31 | 0.70 | 0.90 | 10.70 | 0.11 |
| 2011 | 3570.91 | 8292 | 433 | 94.12 | 94.12 | 94.14 | 94.66 | 0.49 | 0.47 | 5.41 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|-------|-------|------|
| 2012 | 3261.59 | 7605 | 433 | 86.06 | 86.14 | 85.75 | 86.58 | 1.34 | 1.17 | 12.68 | 0.09 |
| 2013 | 3566.80 | 8238 | 433 | 93.52 | 93.77 | 94.03 | 94.04 | 0.02 | 0.02 | 6.21 | 0.26 |
| 2014 | 3528.42 | 8291 | 433 | 92.67 | 94.33 | 93.02 | 94.65 | 0.59 | 0.56 | 5.10 | 1.66 |
| 2015 | 2971.43 | 6883 | 433 | 83.77 | 83.98 | 78.34 | 78.57 | 0.02 | 0.02 | 16.01 | 0.20 |
| 2016 | 3037.09 | 7056 | 433 | 79.47 | 79.90 | 79.85 | 80.33 | 0.07 | 0.05 | 20.05 | 0.43 |
| 2017 | 3413.43 | 8071 | 433 | 89.78 | 91.54 | 89.99 | 92.13 | 0.30 | 2.35 | 6.11 | 1.76 |
| 2018 | 1475.20 | 3400 | 433 | 38.68 | 38.70 | 38.89 | 38.81 | 0.24 | 0.09 | 61.21 | 0.02 |
| 2019 | 2405.33 | 5653 | 433 | 63.12 | 63.46 | 63.41 | 64.53 | 0.23 | 0.14 | 36.39 | 0.34 |
| 2020 | 2161.14 | 5003 | 445 | 55.74 | 56.73 | 55.91 | 56.96 | 0.26 | 13.38 | 29.89 | 0.99 |
| 2021 | 3490.70 | 7901 | 445 | 89.11 | 89.66 | 89.55 | 90.19 | 1.05 | 0.95 | 9.39 | 0.55 |
| 2022 | 3538.97 | 8105 | 445 | 90.46 | 91.80 | 90.78 | 92.52 | 0.88 | 0.81 | 7.39 | 1.34 |
| 2023 | 3570.58 | 8091 | 445 | 91.16 | 91.70 | 91.60 | 92.36 | 0.45 | 0.41 | 7.89 | 0.54 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 226 | |
| C. Inspection, maintenance or repair combined with refuelling | 670 | | | 770 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 137 | | |
| E. Testing of plant systems or components | | | | 62 | 10 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 226 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 15 |
| L. Human factor related | | | | | 42 | |
| M. Governmental requirements or court decisions | | | | | | 11 |
| P. Fire | | | | | 1 | |
| Z. Other | | | | | 7 | |
| Subtotal | 670 | | | 1195 | 286 | 26 |
| Total | | 670 | | | 1507 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 9 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | | 10 |
| 15. Reactor Cooling Systems | | 19 |
| 16. Steam generation systems | | 62 |
| 21. Fuel Handling and Storage Facilities | | 20 |
| 31. Turbine and auxiliaries | | 63 |
| 32. Feedwater and Main Steam System | | 13 |
| 34. Miscellaneous Systems | | 18 |
| 41. Main Generator Systems | | 20 |
| 42. Electrical Power Supply Systems | | 6 |
| Total | | 249 |

Highlights (2023)

14-02-2023: start stretch-out
 17-03-2023: refuelling outage
 14-04-2023: startup cycle 48

2023 Operating Experience

BE-7

DOEL-4

BELGIUM

Status at end of year : **Operational**
 Operator : EBL+EDF (ENGIE ELECTRABEL + EDF BELGIUM + EDF LUMINUS)
 Owner : EBES (SOCIETES REUNIES D'ENERGIE DU BASSIN DE L'ESCAUT SA)
 Reactor Supplier : ACECOWEN (ACECOWEN (ACEC-COCKERILL-WESTINGHOUSE))
 Turbine Supplier : AA/BB/AC ((ALSTHOM - BBC / ACEC))



Reactor Unit Details

Reactor type and model : PWR / WH 3LP
 Thermal power : 2988 MWth
 Gross electrical power : 1090 MWe
 Reference unit power (net) : 1026 MWe

Key Dates

Construction Date : 1978-12-01
 Grid Date : 1985-04-08
 Commercial Date : 1985-07-01
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 4.27
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 16.47
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.73
 Reactor outlet temperature [°C] : 315.08
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 3.5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 7.28
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

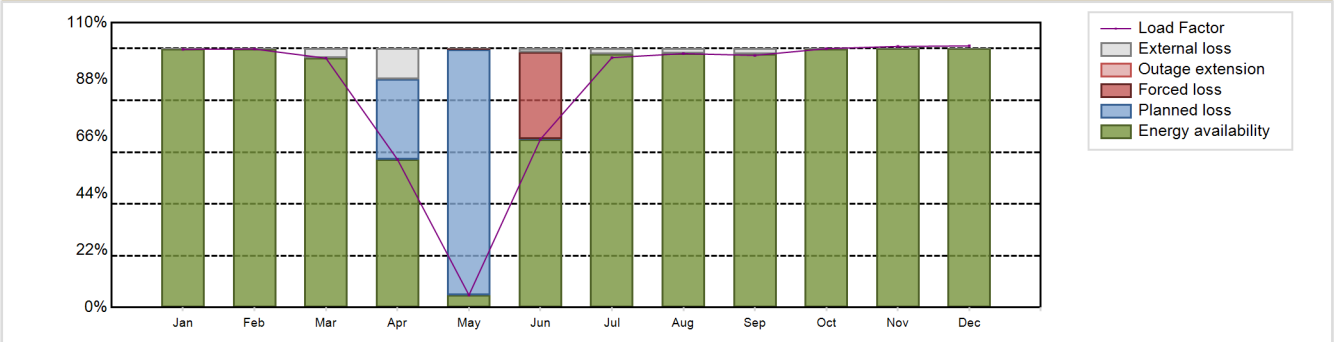
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7670.06 GW(e).h
 Energy Availability Factor (EAF) : 84.58 %
 Unit Capability Factor (UCF) : 86.55 %
 Load Factor (LF) : 84.6 %
 Operating Factor (OF) : 87.16 %

Forced Loss Rate (FLR) : 3.13 %
 Unplanned Capability Loss Factor (UCL) : 2.8 %
 Planned Unavailability Factor (PUF) : 10.65 %
 Externally cause unavailability (XUF) : 1.97 %
 Total off-line time : 1125 hours

Annual Summary

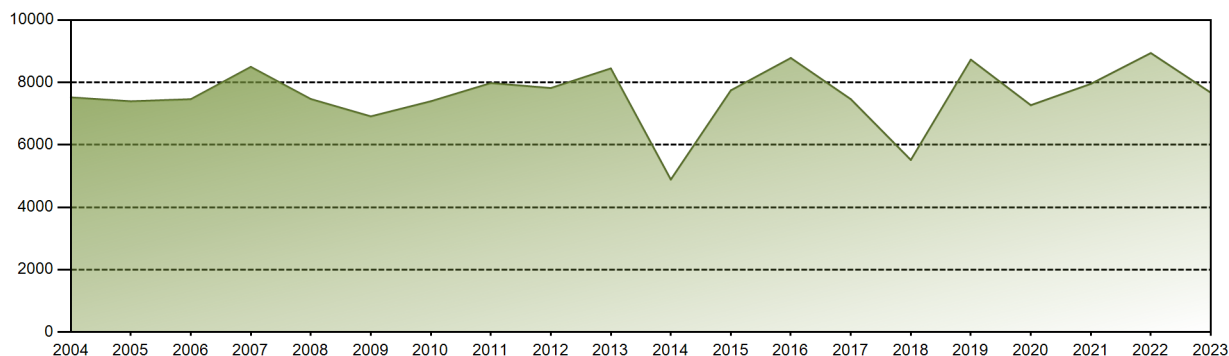


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 770.21 | 696.27 | 742.62 | 427.45 | 37.14 | 485.66 | 745.27 | 757.23 | 727.76 | 764.18 | 744.88 | 771.38 | 7670.06 |
| EAF [%] | 99.74 | 99.80 | 96.28 | 57.19 | 4.81 | 64.98 | 97.99 | 98.05 | 97.76 | 99.76 | 100.00 | 100.00 | 84.58 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 68.97 | 4.81 | 66.29 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.55 |
| LF [%] | 99.73 | 99.82 | 96.29 | 57.19 | 4.81 | 64.98 | 96.50 | 98.05 | 97.38 | 99.98 | 100.83 | 101.05 | 84.60 |
| OF [%] | 100.00 | 100.00 | 100.00 | 69.03 | 8.87 | 68.89 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.16 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 6.51 | 33.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.13 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 33.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.80 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 31.03 | 94.86 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.65 |
| XUF [%] | 0.26 | 0.20 | 3.72 | 11.77 | 0.00 | 1.30 | 2.01 | 1.95 | 2.24 | 0.24 | 0.00 | 0.00 | 1.97 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 286537.37 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.85 % |
| Cumulative Energy Availability Factor (EAF) | : 83.9 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.55 % |
| Cumulative Unit Capability Factor (UCF) | : 84.58 % | Cumulative Planned Unavailability Factor (PUF) | : 9.87 % |
| Cumulative Load Factor (LF) | : 83.61 % | Cumulative Externally cause unavailability (XUF) | : 0.67 % |
| Cumulative Operating Factor (OF) | : 85.88 % | | |

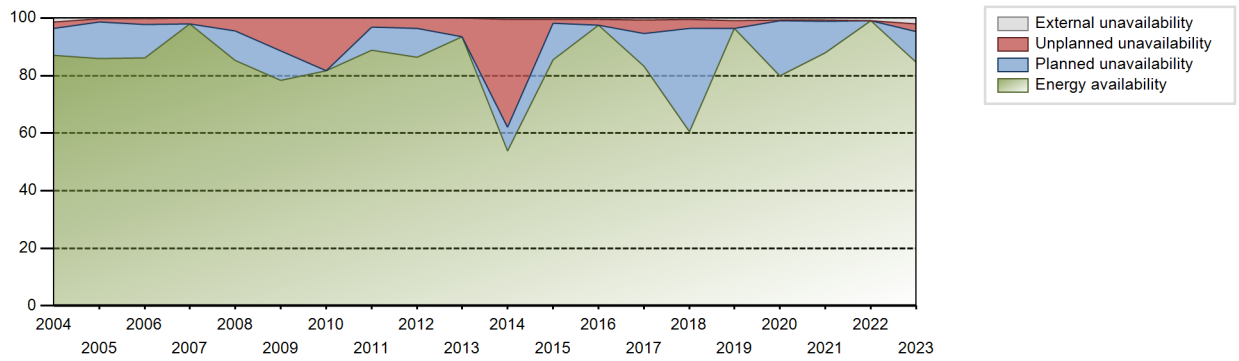
Electricity Production (net) [GWh]



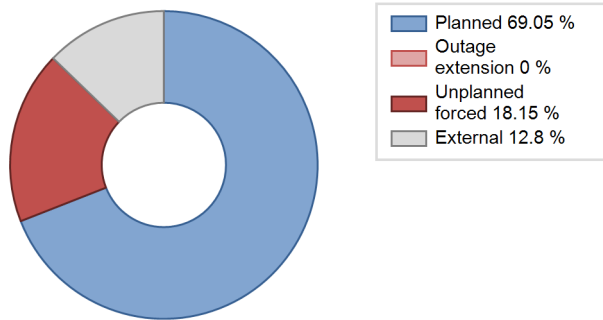
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 4282.13 | 5263 | 981 | 82.56 | 82.56 | 82.59 | 87.93 | 17.44 | 17.44 | 0.00 | 0.00 |
| 1986 | 7722.89 | 7973 | 1006 | 87.77 | 87.77 | 87.64 | 91.02 | 0.00 | 0.00 | 12.23 | 0.00 |
| 1987 | 6809.26 | 7448 | 1006 | 77.04 | 81.42 | 77.27 | 85.02 | 4.33 | 3.69 | 14.89 | 4.38 |
| 1988 | 7551.97 | 7784 | 1000 | 85.90 | 87.60 | 85.97 | 88.62 | 2.34 | 2.10 | 10.30 | 1.70 |
| 1989 | 7445.90 | 7737 | 1010 | 84.43 | 87.37 | 84.16 | 88.32 | 5.46 | 5.05 | 7.59 | 2.94 |
| 1990 | 7535.84 | 7790 | 1010 | 85.25 | 88.23 | 85.17 | 88.93 | 2.53 | 2.29 | 9.48 | 2.97 |
| 1991 | 7425.40 | 7673 | 1010 | 84.07 | 84.76 | 83.93 | 87.59 | 3.04 | 2.66 | 12.59 | 0.69 |
| 1992 | 7418.56 | 7481 | 1010 | 85.93 | 86.73 | 83.62 | 85.17 | 5.16 | 4.72 | 8.55 | 0.80 |
| 1993 | 6980.93 | 7112 | 1010 | 78.90 | 79.63 | 78.90 | 81.19 | 12.71 | 11.59 | 8.78 | 0.74 |
| 1994 | 3462.74 | 3637 | 1001 | 39.18 | 39.18 | 39.49 | 41.52 | 52.92 | 44.04 | 16.78 | 0.00 |
| 1995 | 6769.69 | 7381 | 1001 | 76.83 | 76.93 | 77.20 | 84.26 | 5.55 | 4.52 | 18.55 | 0.10 |
| 1996 | 6186.80 | 6565 | 1001 | 69.86 | 70.57 | 70.36 | 74.74 | 1.92 | 1.38 | 28.05 | 0.72 |
| 1997 | 7548.66 | 7653 | 1001 | 86.99 | 87.10 | 86.09 | 87.36 | 6.16 | 5.72 | 7.19 | 0.11 |
| 1998 | 7844.02 | 7998 | 985 | 89.99 | 89.99 | 90.91 | 91.30 | 1.51 | 1.38 | 8.63 | 0.00 |
| 1999 | 8008.40 | 8150 | 985 | 92.41 | 92.51 | 92.81 | 93.04 | 0.08 | 0.08 | 7.42 | 0.10 |
| 2000 | 7992.87 | 8323 | 985 | 91.98 | 92.01 | 92.38 | 94.75 | 2.75 | 2.60 | 5.40 | 0.03 |
| 2001 | 8098.91 | 8264 | 985 | 93.25 | 93.30 | 93.86 | 94.34 | 0.81 | 0.77 | 5.93 | 0.05 |
| 2002 | 7831.93 | 8017 | 985 | 90.45 | 90.61 | 90.77 | 91.52 | 1.97 | 1.82 | 7.57 | 0.16 |
| 2003 | 7781.23 | 8015 | 985 | 90.55 | 91.06 | 90.18 | 91.50 | 0.52 | 0.47 | 8.47 | 0.51 |
| 2004 | 7519.82 | 7843 | 985 | 86.98 | 88.35 | 86.90 | 89.28 | 0.81 | 2.24 | 9.40 | 1.37 |
| 2005 | 7394.83 | 7647 | 985 | 85.86 | 86.08 | 85.69 | 87.28 | 1.24 | 1.08 | 12.83 | 0.22 |
| 2006 | 7461.97 | 7633 | 1008 | 86.21 | 86.53 | 84.51 | 87.13 | 2.14 | 1.89 | 11.58 | 0.32 |
| 2007 | 8496.87 | 8608 | 1008 | 98.06 | 98.09 | 96.22 | 98.25 | 1.91 | 1.91 | 0.00 | 0.04 |
| 2008 | 7466.73 | 7534 | 1008 | 85.22 | 85.22 | 84.33 | 85.77 | 0.10 | 4.40 | 10.38 | 0.00 |
| 2009 | 6910.95 | 6946 | 1047 | 78.29 | 78.32 | 77.76 | 79.29 | 8.59 | 11.42 | 10.26 | 0.03 |
| 2010 | 7395.39 | 7192 | 1038 | 81.59 | 81.59 | 81.27 | 82.10 | 18.41 | 18.41 | 0.00 | 0.00 |
| 2011 | 7978.47 | 7832 | 1039 | 88.78 | 88.78 | 87.66 | 89.41 | 3.38 | 3.11 | 8.11 | 0.00 |
| 2012 | 7818.70 | 7659 | 1039 | 86.44 | 86.52 | 85.67 | 87.19 | 3.89 | 3.62 | 9.86 | 0.08 |
| 2013 | 8447.48 | 8192 | 1039 | 93.48 | 93.48 | 92.81 | 93.52 | 6.51 | 6.51 | 0.00 | 0.00 |
| 2014 | 4886.99 | 4796 | 1039 | 53.72 | 54.19 | 53.69 | 54.75 | 40.90 | 37.50 | 8.30 | 0.48 |
| 2015 | 7743.88 | 7568 | 1033 | 85.53 | 85.91 | 85.58 | 86.39 | 0.20 | 1.43 | 12.66 | 0.38 |
| 2016 | 8782.01 | 8630 | 1033 | 97.49 | 98.03 | 96.78 | 98.25 | 1.97 | 1.97 | 0.00 | 0.54 |
| 2017 | 7461.43 | 7326 | 1038 | 83.17 | 83.82 | 82.19 | 83.63 | 5.25 | 4.65 | 11.54 | 0.65 |
| 2018 | 5514.68 | 5479 | 1038 | 60.56 | 60.98 | 60.65 | 62.55 | 4.86 | 3.12 | 35.90 | 0.42 |
| 2019 | 8730.31 | 8760 | 1038 | 96.30 | 97.16 | 96.01 | 100.00 | 2.84 | 2.84 | 0.00 | 0.87 |
| 2020 | 7270.15 | 7147 | 1038 | 79.80 | 80.60 | 79.74 | 81.36 | 0.28 | 0.23 | 19.17 | 0.81 |
| 2021 | 7952.78 | 7802 | 1038 | 87.82 | 88.54 | 87.46 | 89.06 | 0.14 | 0.33 | 11.12 | 0.73 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|--------|------|------|-------|------|
| 2022 | 8940.45 | 8760 | 1038 | 99.03 | 99.98 | 98.32 | 100.00 | 0.02 | 0.02 | 0.00 | 0.95 |
| 2023 | 7670.06 | 7635 | 1026 | 84.58 | 86.55 | 84.60 | 87.16 | 3.13 | 2.80 | 10.65 | 1.97 |

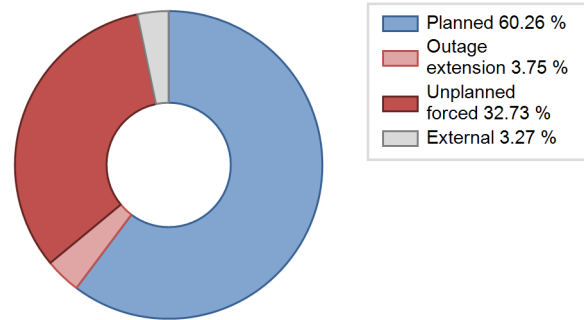
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 224 | | | 345 | |
| C. Inspection, maintenance or repair combined with refuelling | 901 | | | 708 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 43 | | |
| E. Testing of plant systems or components | | | | 1 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 84 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 24 | |
| P. Fire | | | | | 23 | |
| Z. Other | | | | | 30 | |
| Subtotal | 901 | 224 | | 836 | 424 | 4 |
| Total | | 1125 | | | 1264 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 0 |
| 12. Reactor I&C Systems | | 4 |
| 13. Reactor Auxiliary Systems | | 4 |
| 14. Safety Systems | | 9 |
| 15. Reactor Cooling Systems | | 15 |
| 16. Steam generation systems | | 132 |
| 31. Turbine and auxiliaries | | 153 |
| 32. Feedwater and Main Steam System | | 12 |
| 33. Circulating Water System | | 5 |
| 41. Main Generator Systems | 224 | 50 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | 224 | 388 |

Highlights (2023)

25-02-2023: start stretch-out
 21-04-2023: refuelling outage
 29-05-2023: start up cycle 33
 02-06-2023 to 12-06-2023: shutdown for an oil leak generator

2023 Operating Experience

BE-3

TIHANGE-1

BELGIUM

Status at end of year : **Operational**
 Operator : EBL (ENGIE ELECTRABEL)
 Owner : EBL (ENGIE ELECTRABEL)
 Reactor Supplier : ACLF ((ACECOWEN - CREUSOT LOIRE - FRAMATOME))
 Turbine Supplier : AAJSCH ((ALSTOM - ACEC - JEUMONT - SCHNEIDER))



Reactor Unit Details

Reactor type and model : PWR / Framatome 3 loops reactor
 Thermal power : 2873 MWth
 Gross electrical power : 1009 MWe
 Reference unit power (net) : 962 MWe

Key Dates

Construction Date : 1970-06-01
 Grid Date : 1975-03-07
 Commercial Date : 1975-10-01
 Age at end of year : 48 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.6
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 23.8
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.41
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Double
 Containment design pressure [MPa] : 0.41

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 5.65
 Output voltage [kV] : 18
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 6
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 2

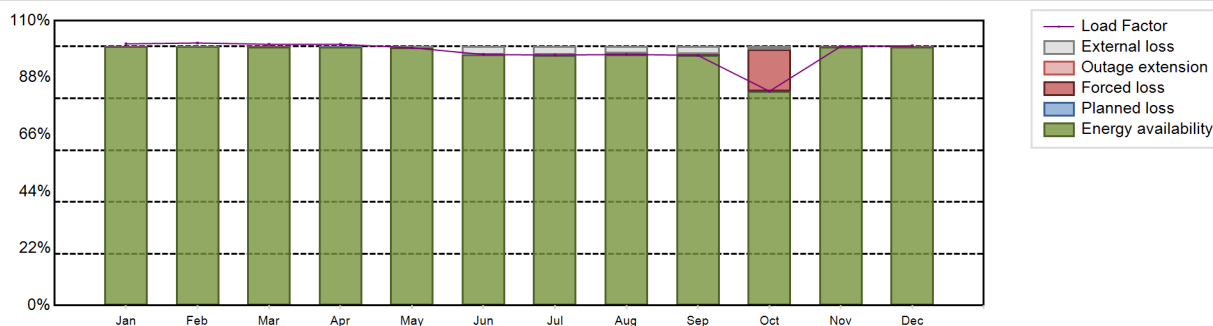
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8242.06 GW(e).h
 Energy Availability Factor (EAF) : 97.4 %
 Unit Capability Factor (UCF) : 98.5 %
 Load Factor (LF) : 97.8 %
 Operating Factor (OF) : 100 %
 Forced Loss Rate (FLR) : 1.47 %
 Unplanned Capability Loss Factor (UCL) : 1.47 %
 Planned Unavailability Factor (PUF) : 0.03 %
 Externally cause unavailability (XUF) : 1.1 %
 Total off-line time : 0 hours

Annual Summary

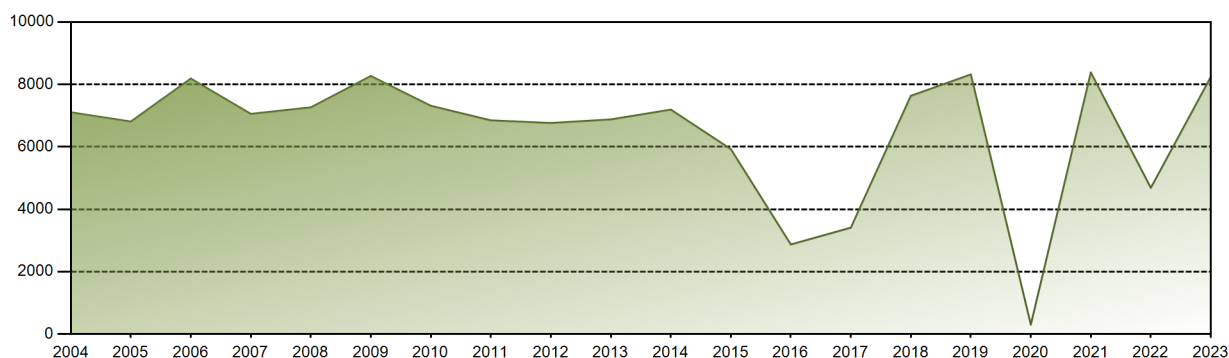


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 723.25 | 655.44 | 721.10 | 698.58 | 712.41 | 671.49 | 692.28 | 694.03 | 669.17 | 593.13 | 693.18 | 717.99 | 8242.06 |
| EAF [%] | 100.00 | 100.00 | 99.90 | 99.97 | 99.55 | 96.95 | 96.74 | 96.97 | 96.61 | 82.76 | 99.95 | 99.83 | 97.40 |
| UCF [%] | 100.00 | 100.00 | 99.90 | 99.97 | 99.95 | 99.97 | 99.98 | 99.56 | 99.50 | 83.78 | 99.95 | 99.83 | 98.50 |
| LF [%] | 101.05 | 101.39 | 100.89 | 100.86 | 99.54 | 96.95 | 96.72 | 96.97 | 96.61 | 82.76 | 100.08 | 100.32 | 97.80 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.01 | 0.40 | 0.44 | 16.19 | 0.03 | 0.11 | 1.47 |
| UCL [%] | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.01 | 0.40 | 0.44 | 16.19 | 0.03 | 0.11 | 1.47 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.03 | 0.05 | 0.03 | 0.01 | 0.04 | 0.06 | 0.03 | 0.02 | 0.06 | 0.03 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 3.03 | 3.24 | 2.59 | 2.89 | 1.02 | 0.00 | 0.00 | 1.10 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 314563.68 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.15 % |
| Cumulative Energy Availability Factor (EAF) | : 80.11 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.31 % |
| Cumulative Unit Capability Factor (UCF) | : 82.1 % | Cumulative Planned Unavailability Factor (PUF) | : 11.59 % |
| Cumulative Load Factor (LF) | : 80.02 % | Cumulative Externally cause unavailability (XUF) | : 1.99 % |
| Cumulative Operating Factor (OF) | : 83.65 % | | |

Electricity Production (net) [GWh]

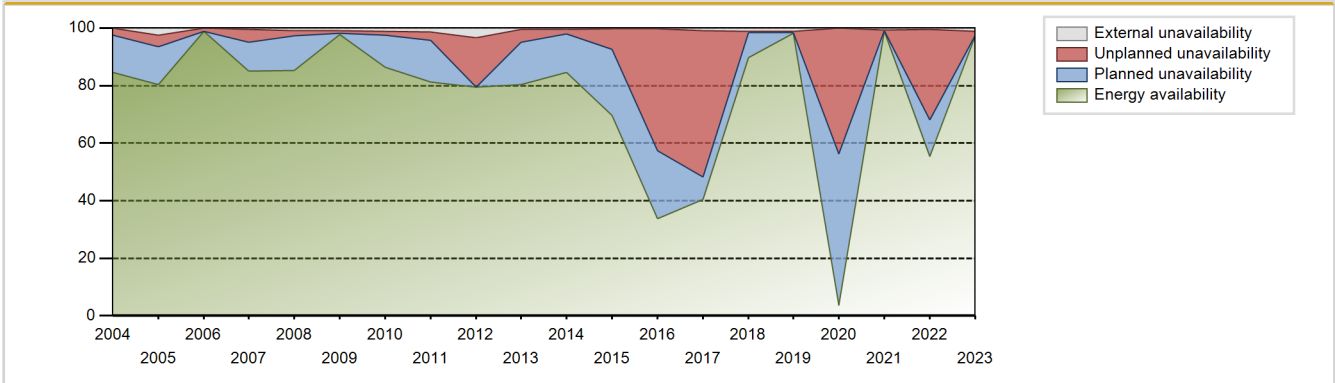


Performance for Years of Commercial Operation

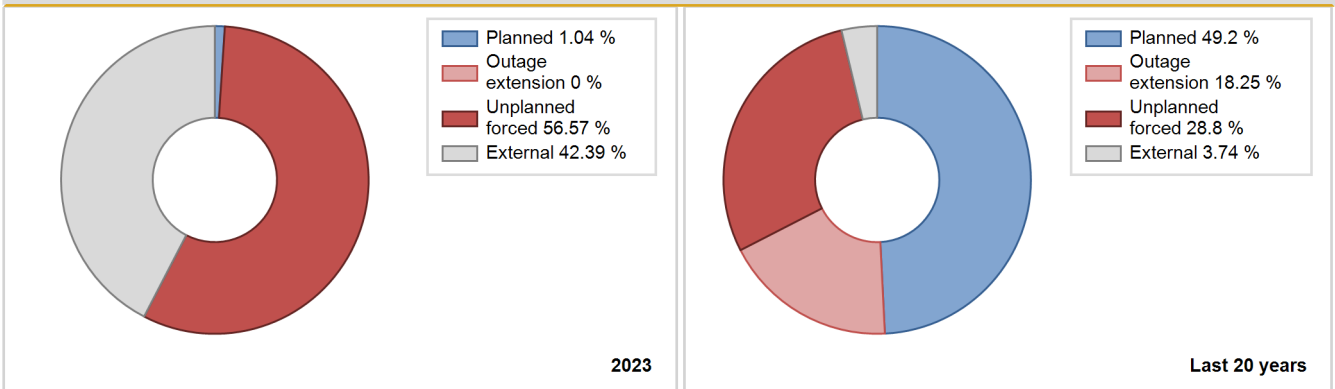
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 3096.30 | 5360 | 885 | 76.15 | 76.15 | 76.16 | 94.52 | 23.85 | 23.85 | 0.00 | 0.00 |
| 1976 | 4409.50 | 6354 | 870 | 57.54 | 89.78 | 57.70 | 72.34 | 3.70 | 3.45 | 6.76 | 32.24 |
| 1977 | 5842.30 | 7234 | 870 | 76.67 | 76.67 | 76.66 | 82.58 | 1.49 | 1.16 | 22.17 | 0.00 |
| 1978 | 6371.00 | 7582 | 870 | 84.31 | 84.31 | 83.60 | 86.55 | 0.51 | 0.43 | 15.26 | 0.00 |
| 1979 | 5159.00 | 6121 | 870 | 67.58 | 67.58 | 67.69 | 69.87 | 0.00 | 0.00 | 32.42 | 0.00 |
| 1980 | 6173.00 | 7337 | 870 | 80.70 | 80.71 | 80.78 | 83.53 | 8.46 | 7.46 | 11.83 | 0.01 |
| 1981 | 6414.20 | 7762 | 870 | 83.80 | 83.80 | 84.16 | 88.61 | 0.54 | 0.45 | 15.75 | 0.00 |
| 1982 | 6164.80 | 7269 | 870 | 80.80 | 80.80 | 80.89 | 82.98 | 2.21 | 1.82 | 17.38 | 0.00 |
| 1983 | 5843.00 | 7135 | 870 | 76.50 | 76.50 | 76.67 | 81.45 | 14.43 | 12.90 | 10.60 | 0.00 |
| 1984 | 6374.00 | 7774 | 870 | 83.44 | 83.44 | 83.41 | 88.50 | 4.99 | 4.38 | 12.18 | 0.00 |
| 1985 | 5979.00 | 8077 | 870 | 81.07 | 90.80 | 78.45 | 92.20 | 1.13 | 1.04 | 8.16 | 9.72 |
| 1986 | 4005.00 | 5429 | 870 | 54.78 | 59.15 | 52.55 | 61.97 | 5.05 | 3.15 | 37.70 | 4.37 |
| 1987 | 7337.00 | 8733 | 870 | 97.57 | 98.50 | 96.27 | 99.69 | 1.50 | 1.50 | 0.00 | 0.93 |
| 1988 | 6310.00 | 7520 | 870 | 83.89 | 84.93 | 82.57 | 85.61 | 8.66 | 8.05 | 7.01 | 1.05 |
| 1989 | 6508.00 | 7854 | 870 | 87.85 | 88.40 | 85.39 | 89.66 | 1.29 | 1.16 | 10.44 | 0.54 |
| 1990 | 6683.00 | 8082 | 870 | 88.40 | 90.85 | 87.69 | 92.26 | 1.09 | 1.00 | 8.15 | 2.45 |
| 1991 | 6163.00 | 7714 | 870 | 80.98 | 86.71 | 80.87 | 88.06 | 2.10 | 1.86 | 11.43 | 5.73 |
| 1992 | 6059.00 | 7807 | 870 | 79.10 | 80.45 | 79.28 | 88.88 | 5.88 | 5.02 | 14.52 | 1.35 |
| 1993 | 7317.00 | 8459 | 870 | 96.37 | 99.80 | 96.01 | 96.56 | 0.20 | 0.20 | 0.00 | 3.44 |
| 1994 | 6737.00 | 8018 | 863 | 89.97 | 90.66 | 89.12 | 91.53 | 0.66 | 0.60 | 8.74 | 0.69 |
| 1995 | 5442.00 | 6488 | 882 | 69.96 | 72.88 | 70.36 | 74.06 | 2.38 | 1.77 | 25.35 | 2.92 |
| 1996 | 7210.66 | 7823 | 931 | 88.22 | 88.40 | 88.18 | 89.07 | 1.71 | 1.54 | 10.06 | 0.18 |
| 1997 | 7942.57 | 8385 | 962 | 94.30 | 95.50 | 94.25 | 95.72 | 1.16 | 1.12 | 3.38 | 1.20 |
| 1998 | 7264.00 | 7777 | 962 | 86.32 | 87.44 | 86.20 | 88.78 | 2.68 | 2.41 | 10.15 | 1.12 |
| 1999 | 7272.00 | 7905 | 962 | 85.53 | 86.91 | 86.29 | 90.24 | 3.34 | 3.00 | 10.09 | 1.38 |
| 2000 | 8457.00 | 8782 | 962 | 99.28 | 99.28 | 100.08 | 99.98 | 0.02 | 0.02 | 0.70 | 0.00 |
| 2001 | 6969.00 | 7481 | 962 | 82.52 | 91.20 | 82.70 | 85.40 | 0.24 | 0.22 | 8.58 | 8.69 |
| 2002 | 7047.15 | 7631 | 962 | 83.92 | 85.98 | 83.62 | 87.11 | 0.96 | 0.83 | 13.19 | 2.06 |
| 2003 | 7990.42 | 8552 | 962 | 95.11 | 95.54 | 94.81 | 97.61 | 4.46 | 4.46 | 0.00 | 0.44 |
| 2004 | 7106.47 | 7456 | 962 | 84.50 | 84.50 | 84.10 | 84.88 | 2.05 | 2.41 | 13.09 | 0.00 |
| 2005 | 6810.95 | 7403 | 962 | 80.24 | 82.67 | 80.82 | 84.51 | 2.72 | 4.08 | 13.25 | 2.43 |
| 2006 | 8186.91 | 8693 | 962 | 98.79 | 98.79 | 97.15 | 99.24 | 1.21 | 1.21 | 0.00 | 0.00 |
| 2007 | 7055.90 | 7627 | 962 | 85.07 | 85.58 | 83.73 | 87.07 | 4.93 | 4.44 | 9.98 | 0.50 |
| 2008 | 7264.54 | 7650 | 962 | 85.25 | 86.24 | 85.97 | 87.09 | 1.60 | 1.68 | 12.09 | 0.98 |
| 2009 | 8269.54 | 8679 | 962 | 97.83 | 98.68 | 98.13 | 99.08 | 1.04 | 1.03 | 0.29 | 0.85 |
| 2010 | 7316.10 | 7752 | 962 | 86.35 | 87.47 | 86.82 | 88.49 | 1.64 | 1.46 | 11.07 | 1.12 |
| 2011 | 6848.28 | 7333 | 962 | 81.20 | 82.59 | 81.26 | 83.71 | 1.97 | 2.96 | 14.45 | 1.40 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|--------|-------|-------|-------|------|
| 2012 | 6763.30 | 8784 | 962 | 79.44 | 82.88 | 80.04 | 100.00 | 17.12 | 17.12 | 0.00 | 3.44 |
| 2013 | 6878.12 | 7203 | 962 | 80.40 | 80.90 | 81.62 | 82.23 | 1.20 | 4.40 | 14.70 | 0.49 |
| 2014 | 7192.76 | 7503 | 962 | 84.51 | 85.06 | 85.35 | 85.65 | 0.32 | 1.57 | 13.37 | 0.55 |
| 2015 | 5927.29 | 6211 | 962 | 69.69 | 69.84 | 70.34 | 70.90 | 7.56 | 7.34 | 22.82 | 0.15 |
| 2016 | 2871.03 | 3026 | 962 | 33.69 | 33.85 | 33.98 | 34.45 | 52.16 | 42.50 | 23.65 | 0.16 |
| 2017 | 3409.97 | 3675 | 962 | 40.36 | 41.23 | 40.46 | 41.95 | 55.23 | 50.86 | 7.90 | 0.87 |
| 2018 | 7633.87 | 8024 | 962 | 89.79 | 91.05 | 90.59 | 91.60 | 0.40 | 0.36 | 8.59 | 1.26 |
| 2019 | 8319.24 | 8714 | 962 | 98.19 | 99.28 | 98.72 | 99.47 | 0.43 | 0.43 | 0.29 | 1.10 |
| 2020 | 303.85 | 434 | 962 | 3.57 | 3.57 | 3.60 | 4.94 | 30.28 | 43.82 | 52.61 | 0.00 |
| 2021 | 8384.09 | 8760 | 962 | 98.96 | 99.75 | 99.49 | 100.00 | 0.23 | 0.23 | 0.02 | 0.79 |
| 2022 | 4685.63 | 4940 | 962 | 55.27 | 55.67 | 55.60 | 56.39 | 6.80 | 31.55 | 12.78 | 0.40 |
| 2023 | 8242.06 | 8760 | 962 | 97.40 | 98.50 | 97.80 | 100.00 | 1.47 | 1.47 | 0.03 | 1.10 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 333 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 874 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 22 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 41 | | |
| L. Human factor related | | | | | 82 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 59 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 6 |
| Z. Other | | | | | 6 | |
| Subtotal | | | | 937 | 421 | 65 |
| Total | | 0 | | | 1423 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 88 |
| 13. Reactor Auxiliary Systems | | 5 |
| 14. Safety Systems | | 22 |
| 15. Reactor Cooling Systems | | 57 |
| 16. Steam generation systems | | 12 |
| 31. Turbine and auxiliaries | | 9 |
| 32. Feedwater and Main Steam System | | 188 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 12 |
| 42. Electrical Power Supply Systems | | 14 |
| Total | | 410 |

2023 Operating Experience

BE-6

TIHANGE-2

BELGIUM

Status at end of year : **Permanent Shutdown**
 Operator : EBL (ENGIE ELECTRABEL)
 Owner : EBL (ENGIE ELECTRABEL)
 Reactor Supplier : FRAMACEC (FRAMACECO (FRAMATOME-ACEC-COCKERILL))
 Turbine Supplier : ALS/ACEC (TURBINE: ALSTOM; ALTERNATOR: ACEC)



Reactor Unit Details

Reactor type and model : PWR / WH 3LP
 Thermal power : 3064 MWth
 Gross electrical power : 1055 MWe
 Reference unit power (net) : 1008 MWe

Key Dates

Construction Date : 1976-04-01
 Grid Date : 1982-10-13
 Commercial Date : 1983-06-01
 Age at end of year : 41 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.35
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.85
 Number of control rod assemblies : 32
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.52
 Reactor outlet temperature [°C] : 324.7
 Number of SG : 3
 Containment type : Double
 Containment design pressure [MPa] : 0.35

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.4
 Output voltage [kV] : 24
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 6

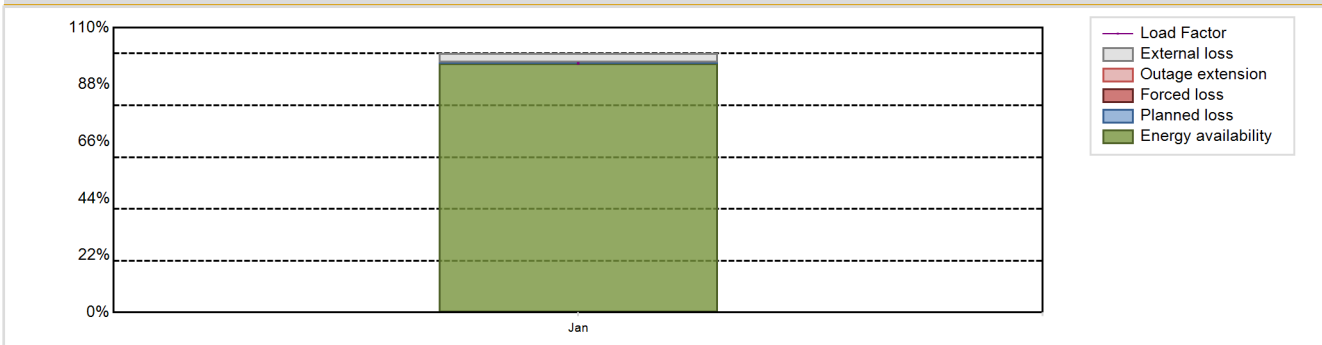
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 721.74 GW(e).h
 Energy Availability Factor (EAF) : 96.24 %
 Unit Capability Factor (UCF) : 99.61 %
 Load Factor (LF) : 96.24 %
 Operating Factor (OF) : 99.87 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.39 %
 Externally cause unavailability (XUF) : 3.37 %
 Total off-line time : 25 hours

Annual Summary

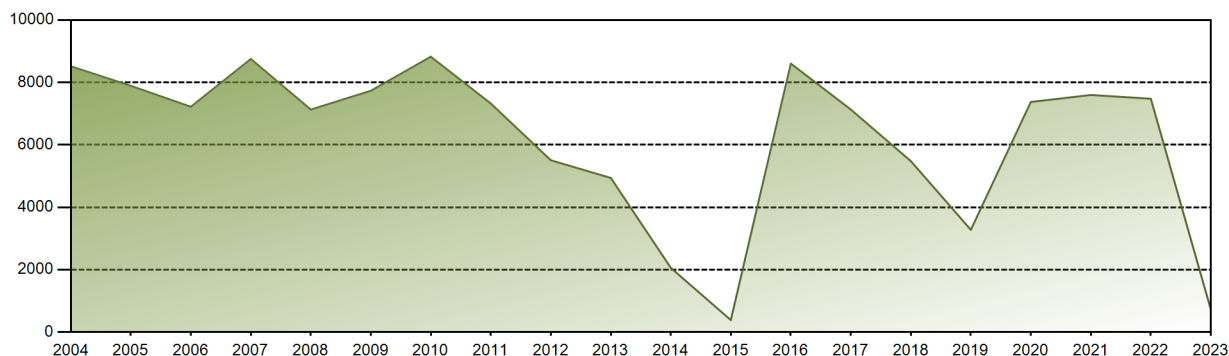


| | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Jan | Annual |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|--------|
| GW(e)-h | | | | | | | | | | | | 721.74 | 721.74 |
| EAF [%] | | | | | | | | | | | | 96.24 | 96.24 |
| UCF [%] | | | | | | | | | | | | 99.61 | 99.61 |
| LF [%] | | | | | | | | | | | | 96.24 | 96.24 |
| OF [%] | | | | | | | | | | | | 99.87 | 99.87 |
| FLR [%] | | | | | | | | | | | | 0.00 | 0.00 |
| UCL [%] | | | | | | | | | | | | 0.00 | 0.00 |
| PUF [%] | | | | | | | | | | | | 0.39 | 0.39 |
| XUF [%] | | | | | | | | | | | | 3.37 | 3.37 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 270828.36 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.2 % |
| Cumulative Energy Availability Factor (EAF) | : 80.06 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 10.47 % |
| Cumulative Unit Capability Factor (UCF) | : 80.91 % | Cumulative Planned Unavailability Factor (PUF) | : 8.62 % |
| Cumulative Load Factor (LF) | : 80.06 % | Cumulative Externally cause unavailability (XUF) | : 0.85 % |
| Cumulative Operating Factor (OF) | : 81.86 % | | |

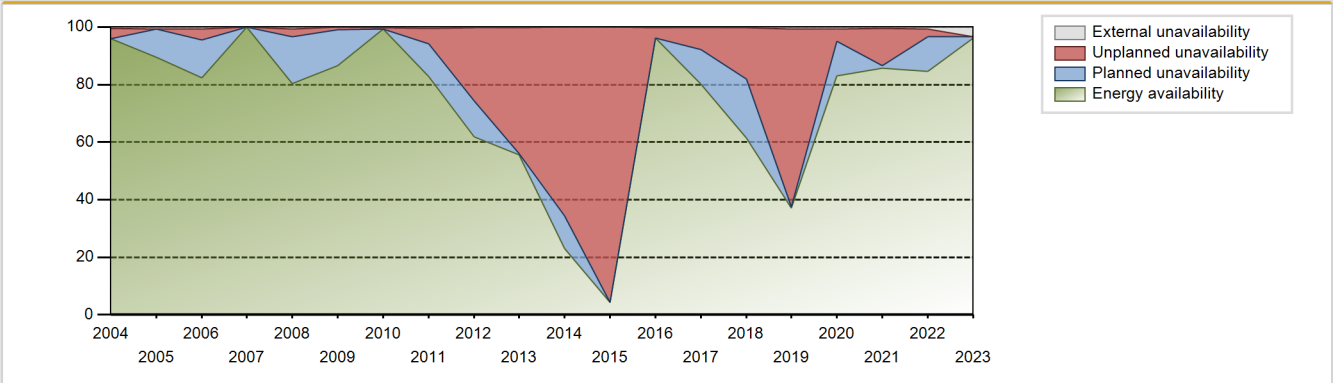
Electricity Production (net) [GWh]



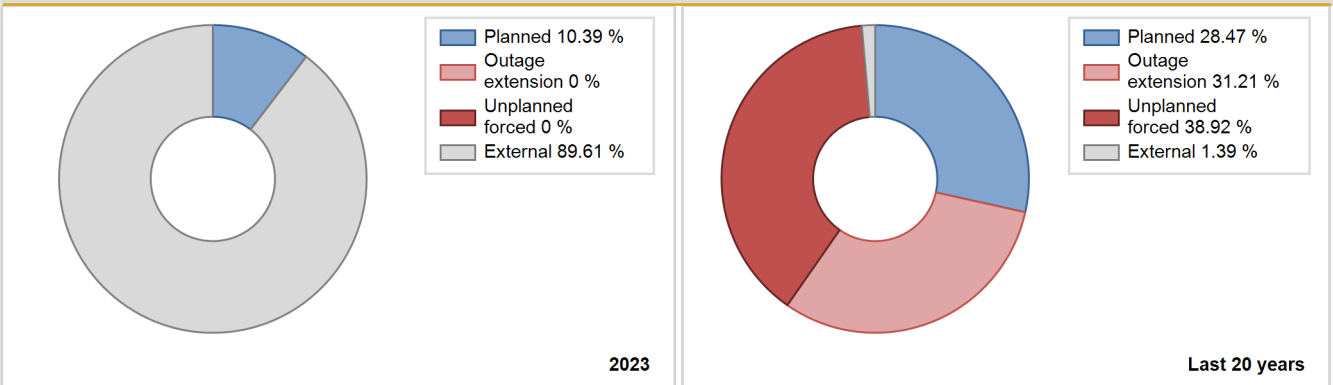
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 5507.00 | 6373 | 901 | 86.91 | 86.91 | 86.90 | 89.78 | 6.11 | 5.65 | 7.44 | 0.00 |
| 1984 | 6856.00 | 7693 | 901 | 86.39 | 86.39 | 86.63 | 87.58 | 4.58 | 4.15 | 9.46 | 0.00 |
| 1985 | 6636.00 | 7890 | 900 | 87.77 | 89.42 | 84.17 | 90.07 | 2.48 | 2.27 | 8.31 | 1.65 |
| 1986 | 6189.00 | 7509 | 900 | 83.08 | 84.95 | 78.50 | 85.72 | 3.80 | 3.35 | 11.69 | 1.87 |
| 1987 | 6584.00 | 7477 | 900 | 83.41 | 84.30 | 83.51 | 85.35 | 5.97 | 5.35 | 10.35 | 0.89 |
| 1988 | 6966.00 | 7992 | 900 | 87.93 | 89.88 | 88.11 | 90.98 | 1.01 | 0.91 | 9.21 | 1.95 |
| 1989 | 6663.00 | 7728 | 901 | 84.74 | 86.02 | 84.42 | 88.22 | 2.34 | 2.06 | 11.92 | 1.28 |
| 1990 | 6919.00 | 7827 | 901 | 88.04 | 88.48 | 87.66 | 89.35 | 3.01 | 2.75 | 8.77 | 0.44 |
| 1991 | 6850.00 | 7790 | 901 | 87.75 | 88.41 | 86.79 | 88.93 | 2.26 | 2.04 | 9.55 | 0.66 |
| 1992 | 6746.00 | 7912 | 901 | 86.92 | 89.72 | 85.24 | 90.07 | 0.29 | 0.26 | 10.02 | 2.79 |
| 1993 | 6555.00 | 7507 | 901 | 83.62 | 86.44 | 83.05 | 85.70 | 1.49 | 1.31 | 12.25 | 2.83 |
| 1994 | 7585.00 | 8501 | 894 | 96.69 | 98.32 | 96.85 | 97.04 | 1.68 | 1.68 | 0.00 | 1.63 |
| 1995 | 6849.00 | 7697 | 921 | 85.01 | 90.18 | 84.88 | 87.87 | 1.08 | 0.99 | 8.84 | 5.17 |
| 1996 | 7253.00 | 7810 | 943 | 86.99 | 88.57 | 87.51 | 88.91 | 0.10 | 0.09 | 11.34 | 1.58 |
| 1997 | 6854.00 | 7241 | 960 | 81.31 | 82.29 | 81.50 | 82.66 | 8.78 | 7.92 | 9.79 | 0.99 |
| 1998 | 7664.00 | 8015 | 960 | 90.56 | 91.05 | 91.13 | 91.50 | 0.30 | 0.27 | 8.68 | 0.49 |
| 1999 | 8111.00 | 8380 | 960 | 95.46 | 95.46 | 96.45 | 95.66 | 0.14 | 0.13 | 4.41 | 0.01 |
| 2000 | 7481.00 | 7901 | 960 | 87.97 | 89.44 | 88.71 | 89.95 | 2.72 | 2.50 | 8.05 | 1.48 |
| 2001 | 6976.00 | 7137 | 960 | 80.69 | 80.77 | 82.95 | 81.47 | 1.72 | 1.42 | 17.81 | 0.08 |
| 2002 | 7833.39 | 7821 | 1008 | 87.92 | 89.03 | 88.71 | 89.28 | 0.26 | 0.23 | 10.73 | 1.12 |
| 2003 | 7600.97 | 7589 | 1008 | 85.56 | 86.34 | 86.08 | 86.63 | 1.19 | 1.40 | 12.26 | 0.79 |
| 2004 | 8517.32 | 8478 | 1008 | 96.01 | 96.43 | 96.19 | 96.52 | 3.57 | 3.57 | 0.00 | 0.42 |
| 2005 | 7890.01 | 7929 | 1008 | 89.48 | 90.09 | 89.35 | 90.51 | 0.15 | 0.14 | 9.77 | 0.61 |
| 2006 | 7219.32 | 7348 | 1008 | 82.37 | 83.01 | 81.76 | 83.88 | 2.31 | 3.86 | 13.13 | 0.64 |
| 2007 | 8751.57 | 8760 | 1008 | 99.95 | 99.97 | 99.11 | 100.00 | 0.03 | 0.03 | 0.00 | 0.02 |
| 2008 | 7129.35 | 7165 | 1008 | 80.43 | 81.12 | 80.52 | 81.57 | 0.33 | 2.75 | 16.12 | 0.69 |
| 2009 | 7732.29 | 7664 | 1008 | 86.69 | 86.76 | 87.57 | 87.49 | 1.02 | 0.95 | 12.29 | 0.07 |
| 2010 | 8823.79 | 8726 | 1008 | 99.25 | 99.47 | 99.93 | 99.61 | 0.53 | 0.53 | 0.00 | 0.23 |
| 2011 | 7322.51 | 7345 | 1008 | 82.86 | 83.26 | 82.93 | 83.85 | 1.08 | 5.33 | 11.41 | 0.40 |
| 2012 | 5506.11 | 5475 | 1008 | 61.79 | 62.11 | 62.19 | 62.33 | 0.59 | 25.24 | 12.64 | 0.33 |
| 2013 | 4939.33 | 4963 | 1008 | 55.58 | 55.75 | 55.94 | 56.66 | 0.98 | 43.74 | 0.51 | 0.17 |
| 2014 | 2056.12 | 2025 | 1008 | 22.95 | 22.95 | 23.29 | 23.12 | 74.07 | 65.55 | 11.51 | 0.00 |
| 2015 | 385.00 | 411 | 1008 | 4.29 | 4.29 | 4.36 | 4.69 | 95.71 | 95.71 | 0.00 | 0.00 |
| 2016 | 8603.65 | 8521 | 1008 | 96.20 | 96.42 | 97.17 | 97.01 | 3.56 | 3.56 | 0.02 | 0.23 |
| 2017 | 7131.59 | 7351 | 1008 | 80.14 | 80.45 | 80.76 | 83.92 | 0.34 | 7.46 | 12.09 | 0.31 |
| 2018 | 5478.07 | 5460 | 1008 | 61.46 | 61.67 | 62.04 | 62.33 | 1.85 | 17.88 | 20.46 | 0.20 |
| 2019 | 3276.69 | 3377 | 1008 | 37.06 | 37.70 | 37.11 | 38.55 | 23.60 | 61.81 | 0.49 | 0.65 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|-------|-------|------|
| 2020 | 7373.82 | 7398 | 1008 | 83.13 | 83.88 | 83.28 | 84.22 | 2.92 | 4.17 | 11.95 | 0.75 |
| 2021 | 7597.40 | 7835 | 1008 | 85.75 | 86.16 | 86.04 | 89.44 | 7.80 | 13.07 | 0.76 | 0.41 |
| 2022 | 7476.91 | 7665 | 1008 | 84.64 | 85.35 | 84.68 | 87.50 | 1.99 | 2.57 | 12.08 | 0.71 |
| 2023 | 721.74 | 743 | 1008 | 96.24 | 99.61 | 96.24 | 99.87 | 0.00 | 0.00 | 0.39 | 3.37 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 812 | |
| B. Refuelling without maintenance | | | | | 12 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 690 | 4 | |
| D. Inspection, maintenance or repair without refuelling | | | | 84 | | |
| E. Testing of plant systems or components | | | | | 2 | |
| H. Nuclear regulatory requirements | | | | | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 29 | |
| M. Governmental requirements or court decisions | | | 1 | | | 0 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 10 |
| Z. Other | | | | 9 | 1 | |
| Subtotal | | | 1 | 783 | 860 | 10 |
| Total | | 1 | | | 1653 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 491 |
| 12. Reactor I&C Systems | | 9 |
| 13. Reactor Auxiliary Systems | | 31 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 38 |
| 16. Steam generation systems | | 20 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 39 |
| 32. Feedwater and Main Steam System | | 155 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 13 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 10 |
| Total | | 812 |

Highlights (2023)

2023 02 01 : STOP FINAL

2023 Operating Experience

BE-8

TIHANGE-3

BELGIUM

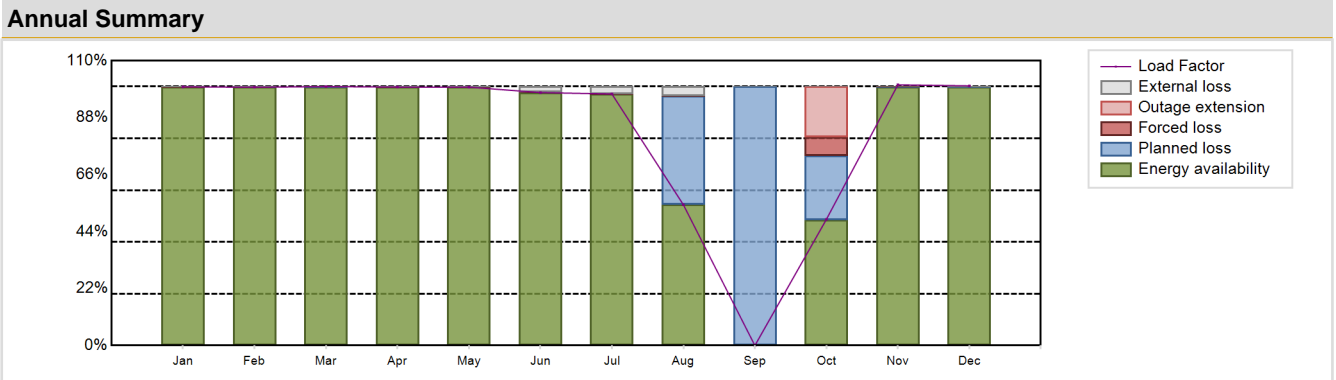
Status at end of year : **Operational**
 Operator : EBL (ENGIE ELECTRABEL)
 Owner : EBL (ENGIE ELECTRABEL)
 Reactor Supplier : ACECOWEN (ACEC-COCKERILL-WESTINGHOUSE)
 Turbine Supplier : BBC/ACEC (BBC - CEM / ACEC)



| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP | Construction Date | : 1978-11-01 |
| Thermal power | : 3000 MWth | Grid Date | : 1985-06-15 |
| Gross electrical power | : 1089 MWe | Commercial Date | : 1985-09-01 |
| Reference unit power (net) | : 1030 MWe | Age at end of year | : 38 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.52 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 330.3 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.35 |
| Average fuel enrichment [% of U235] | : 4.35 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 45000 | Number of LP cylinders per turbine | : 2 |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 7.28 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : 24 |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 16.47 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 28 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : 6 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 7544.13 GW(e).h | Forced Loss Rate (FLR) | : 0.74 % |
| Energy Availability Factor (EAF) | : 83.03 % | Unplanned Capability Loss Factor (UCL) | : 2.27 % |
| Unit Capability Factor (UCF) | : 83.82 % | Planned Unavailability Factor (PUF) | : 13.9 % |
| Load Factor (LF) | : 83.13 % | Externally cause unavailability (XUF) | : 0.79 % |
| Operating Factor (OF) | : 84.35 % | Total off-line time | : 1371 hours |

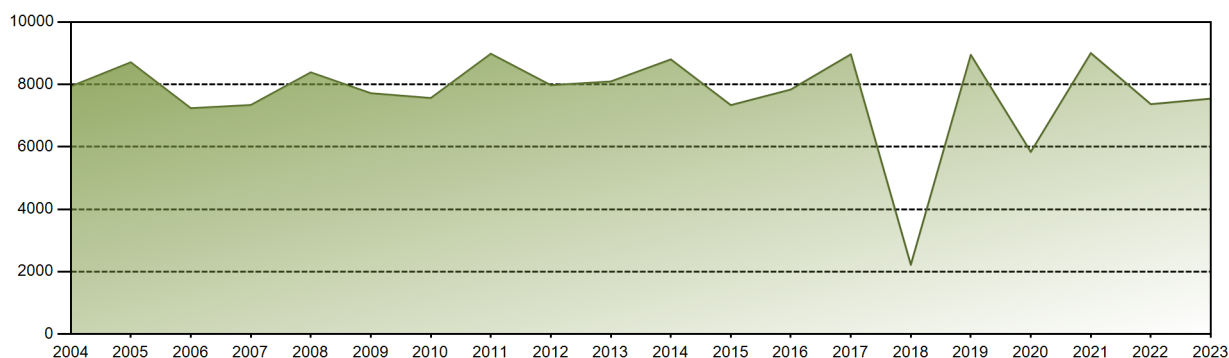


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 771.53 | 695.78 | 771.26 | 745.96 | 770.69 | 730.07 | 750.27 | 419.72 | 0.00 | 373.75 | 746.60 | 768.50 | 7544.13 |
| EAF [%] | 99.81 | 99.75 | 99.98 | 99.81 | 99.81 | 97.69 | 97.15 | 54.35 | 0.00 | 48.61 | 99.98 | 99.98 | 83.03 |
| UCF [%] | 99.99 | 100.00 | 99.98 | 99.96 | 99.95 | 99.87 | 99.93 | 58.05 | 0.00 | 48.61 | 99.98 | 99.99 | 83.82 |
| LF [%] | 99.90 | 99.75 | 100.00 | 99.81 | 99.80 | 97.69 | 97.15 | 54.35 | 0.00 | 48.71 | 100.67 | 100.28 | 83.13 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 58.60 | 0.00 | 53.96 | 100.00 | 100.00 | 84.35 |
| FLR [%] | 0.00 | 0.00 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.05 | 0.00 | 13.04 | 0.02 | 0.00 | 0.74 |
| UCL [%] | 0.00 | 0.00 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.00 | 26.78 | 0.02 | 0.00 | 2.27 |
| PUF [%] | 0.01 | 0.00 | 0.01 | 0.03 | 0.04 | 0.11 | 0.04 | 41.93 | 100.00 | 24.61 | 0.00 | 0.01 | 13.90 |
| XUF [%] | 0.18 | 0.25 | 0.00 | 0.15 | 0.13 | 2.19 | 2.78 | 3.70 | 0.00 | 0.00 | 0.00 | 0.02 | 0.79 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 297104.96 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.73 % |
| Cumulative Energy Availability Factor (EAF) | : 86.09 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.52 % |
| Cumulative Unit Capability Factor (UCF) | : 87.43 % | Cumulative Planned Unavailability Factor (PUF) | : 9.05 % |
| Cumulative Load Factor (LF) | : 85.85 % | Cumulative Externally cause unavailability (XUF) | : 1.35 % |
| Cumulative Operating Factor (OF) | : 87.93 % | | |

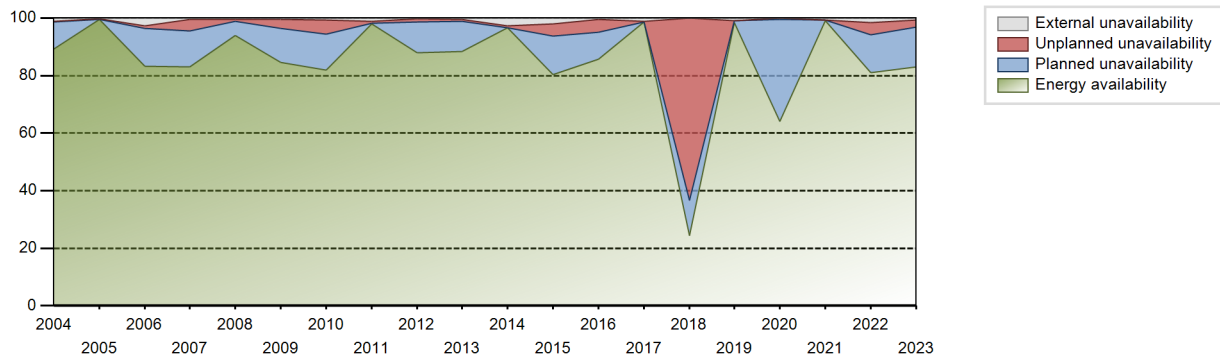
Electricity Production (net) [GWh]



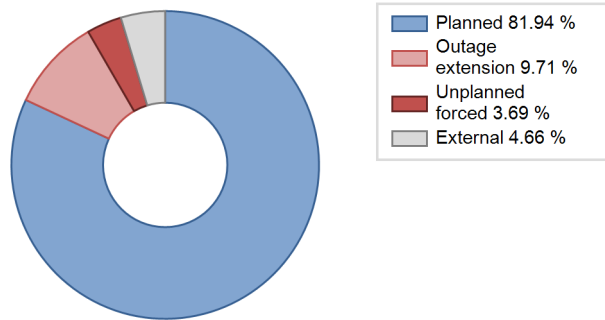
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | | | | Data not provided | | | | | | | |
| 1986 | 7558.00 | 7733 | 1020 | 85.57 | 86.51 | 84.59 | 88.28 | 4.86 | 4.42 | 9.07 | 0.94 |
| 1987 | 7829.00 | 7872 | 1020 | 87.31 | 89.01 | 87.62 | 89.86 | 0.98 | 0.88 | 10.12 | 1.70 |
| 1988 | 7623.00 | 7773 | 1020 | 85.05 | 87.38 | 85.08 | 88.49 | 3.04 | 2.74 | 9.88 | 2.33 |
| 1989 | 7749.00 | 7790 | 1020 | 86.99 | 87.45 | 86.72 | 88.93 | 0.89 | 0.79 | 11.76 | 0.46 |
| 1990 | 7794.00 | 7924 | 1020 | 87.11 | 90.01 | 87.23 | 90.46 | 0.30 | 0.27 | 9.73 | 2.90 |
| 1991 | 7649.00 | 7903 | 1020 | 86.15 | 88.35 | 85.61 | 90.22 | 2.95 | 2.69 | 8.96 | 2.20 |
| 1992 | 8335.00 | 8246 | 1020 | 93.30 | 93.36 | 93.03 | 93.88 | 0.55 | 0.51 | 6.13 | 0.06 |
| 1993 | 7748.00 | 7874 | 1020 | 88.06 | 89.50 | 86.71 | 89.89 | 0.01 | 0.01 | 10.49 | 1.43 |
| 1994 | 7480.00 | 7666 | 1015 | 84.68 | 86.84 | 84.13 | 87.51 | 3.22 | 2.89 | 10.27 | 2.16 |
| 1995 | 7559.00 | 7632 | 1015 | 84.70 | 86.70 | 85.01 | 87.12 | 1.06 | 0.93 | 12.37 | 2.00 |
| 1996 | 7189.00 | 7142 | 1015 | 81.08 | 81.08 | 80.63 | 81.31 | 11.24 | 10.26 | 8.66 | 0.00 |
| 1997 | 8357.00 | 8342 | 1015 | 94.40 | 99.15 | 93.99 | 95.23 | 0.49 | 0.49 | 0.36 | 4.76 |
| 1998 | 6738.00 | 6903 | 1015 | 75.93 | 77.89 | 75.78 | 78.80 | 0.46 | 0.36 | 21.75 | 1.96 |
| 1999 | 8799.00 | 8686 | 1015 | 98.92 | 99.13 | 98.96 | 99.16 | 0.87 | 0.87 | 0.00 | 0.21 |
| 2000 | 7597.00 | 7656 | 1015 | 84.93 | 86.40 | 85.21 | 87.16 | 5.04 | 4.59 | 9.01 | 1.47 |
| 2001 | 7729.00 | 7929 | 1015 | 86.49 | 89.90 | 86.92 | 90.50 | 2.47 | 2.28 | 7.82 | 3.41 |
| 2002 | 8340.47 | 8368 | 1015 | 93.71 | 95.68 | 93.80 | 95.53 | 1.23 | 1.19 | 3.13 | 1.97 |
| 2003 | 7661.54 | 7846 | 1015 | 86.51 | 89.43 | 86.16 | 89.56 | 0.14 | 0.13 | 10.45 | 2.91 |
| 2004 | 7936.43 | 7969 | 1015 | 89.18 | 90.40 | 89.02 | 90.72 | 0.12 | 0.11 | 9.50 | 1.22 |
| 2005 | 8707.53 | 8753 | 1015 | 99.58 | 99.77 | 97.93 | 99.92 | 0.23 | 0.23 | 0.00 | 0.18 |
| 2006 | 7237.59 | 7592 | 1015 | 83.33 | 86.09 | 81.40 | 86.67 | 1.08 | 0.94 | 12.97 | 2.76 |
| 2007 | 7339.40 | 7406 | 1015 | 82.97 | 83.40 | 82.54 | 84.54 | 4.73 | 4.14 | 12.47 | 0.43 |
| 2008 | 8385.26 | 8365 | 1015 | 93.88 | 94.26 | 94.05 | 95.23 | 0.75 | 0.71 | 5.03 | 0.38 |
| 2009 | 7717.15 | 7480 | 1054 | 84.64 | 85.23 | 84.61 | 85.39 | 0.23 | 3.02 | 11.75 | 0.59 |
| 2010 | 7563.23 | 7489 | 1046 | 81.88 | 82.49 | 82.02 | 85.49 | 3.79 | 4.91 | 12.60 | 0.61 |
| 2011 | 8981.89 | 8701 | 1046 | 98.01 | 99.11 | 98.02 | 99.33 | 0.73 | 0.73 | 0.15 | 1.10 |
| 2012 | 7974.73 | 7800 | 1046 | 87.85 | 88.17 | 86.79 | 88.80 | 0.53 | 1.10 | 10.72 | 0.33 |
| 2013 | 8094.07 | 7839 | 1046 | 88.34 | 88.89 | 88.33 | 89.49 | 0.63 | 0.56 | 10.54 | 0.55 |
| 2014 | 8800.74 | 8550 | 1046 | 96.61 | 99.30 | 96.05 | 97.60 | 0.68 | 0.68 | 0.02 | 2.69 |
| 2015 | 7336.42 | 7264 | 1038 | 80.45 | 82.40 | 80.48 | 82.92 | 4.90 | 4.25 | 13.35 | 1.95 |
| 2016 | 7835.57 | 7623 | 1038 | 85.78 | 86.19 | 85.94 | 86.78 | 0.30 | 4.46 | 9.36 | 0.40 |
| 2017 | 8963.79 | 8737 | 1038 | 98.52 | 99.59 | 98.58 | 99.74 | 0.41 | 0.41 | 0.00 | 1.07 |
| 2018 | 2221.56 | 2138 | 1038 | 24.37 | 24.37 | 24.43 | 24.41 | 0.00 | 63.44 | 12.19 | 0.00 |
| 2019 | 8945.12 | 8758 | 1038 | 98.45 | 99.43 | 98.37 | 99.98 | 0.03 | 0.05 | 0.52 | 0.98 |
| 2020 | 5838.22 | 5686 | 1038 | 63.97 | 64.08 | 64.03 | 64.73 | 0.59 | 0.38 | 35.54 | 0.11 |
| 2021 | 9001.86 | 8760 | 1038 | 99.16 | 99.96 | 99.00 | 100.00 | 0.01 | 0.01 | 0.04 | 0.80 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 7366.37 | 7297 | 1038 | 81.11 | 82.64 | 81.01 | 83.30 | 5.00 | 4.35 | 13.01 | 1.53 |
| 2023 | 7544.13 | 7389 | 1030 | 83.03 | 83.82 | 83.13 | 84.35 | 0.74 | 2.27 | 13.90 | 0.79 |

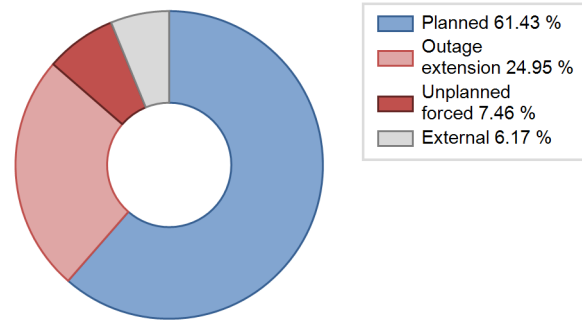
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 198 | | | 272 | |
| C. Inspection, maintenance or repair combined with refuelling | 1172 | | | 720 | 7 | |
| D. Inspection, maintenance or repair without refuelling | | | | 21 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 3 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 14 | | 15 |
| Z. Other | | | | 4 | | |
| Subtotal | 1172 | 198 | | 760 | 283 | 16 |
| Total | | 1370 | | | 1059 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 6 |
| 15. Reactor Cooling Systems | 145 | 29 |
| 16. Steam generation systems | | 30 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | 53 | 28 |
| 32. Feedwater and Main Steam System | | 169 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | | 1 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | 198 | 276 |

2023 Operating Experience

BR-1

ANGRA-1

BRAZIL

Status at end of year : **Operational**
 Operator : ELETRONUCLEAR S (ELETRONUCLEAR S.A.)
 Owner : ELETRONUCLEAR S (ELETRONUCLEAR S.A.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 2LP
 Thermal power : 1882 MWth
 Gross electrical power : 640 MWe
 Reference unit power (net) : 609 MWe

Key Dates

Construction Date : 1971-05-01
 Grid Date : 1982-04-01
 Commercial Date : 1985-01-01
 Age at end of year : 41 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.0
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 35.1
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 2.47
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 17.6
 Number of control rod assemblies : 21
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.71
 Reactor outlet temperature [°C] : 323
 Number of SG : 2
 Containment type : Double
 Containment design pressure [MPa] : 0.32

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.05
 Output voltage [kV] : 19
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 4

Non-electrical applications

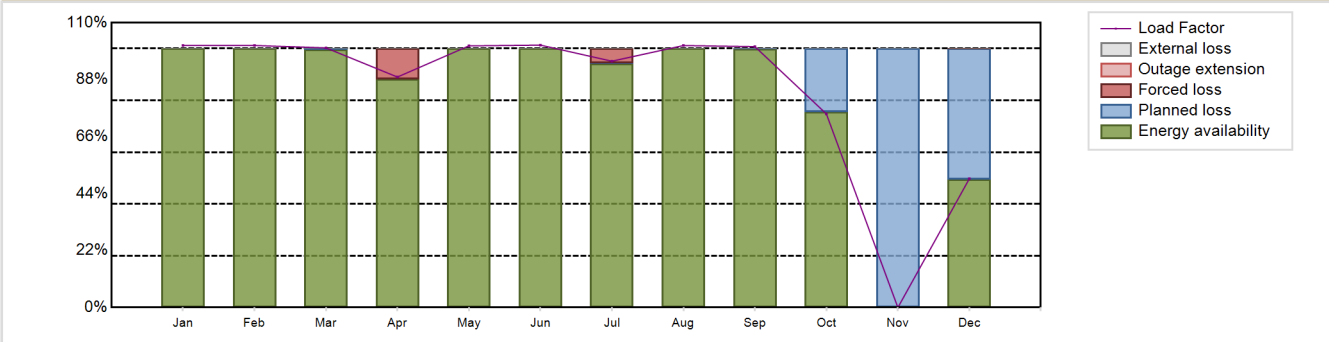
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 4515.48 GW(e).h
 Energy Availability Factor (EAF) : 83.91 %
 Unit Capability Factor (UCF) : 83.91 %
 Load Factor (LF) : 84.63 %
 Operating Factor (OF) : 85.7 %

Forced Loss Rate (FLR) : 1.69 %
 Unplanned Capability Loss Factor (UCL) : 1.44 %
 Planned Unavailability Factor (PUF) : 14.65 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1253 hours

Annual Summary

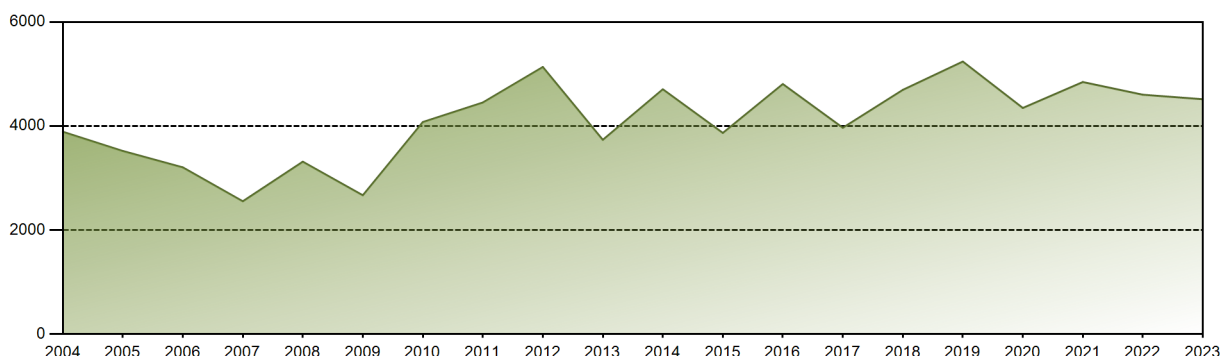


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 458.40 | 414.17 | 454.32 | 390.32 | 457.88 | 444.39 | 431.06 | 458.43 | 441.85 | 338.84 | 0.00 | 225.84 | 4515.48 |
| EAF [%] | 100.00 | 100.00 | 99.73 | 88.17 | 100.00 | 100.00 | 94.12 | 100.00 | 99.99 | 75.59 | 0.00 | 49.45 | 83.91 |
| UCF [%] | 100.00 | 100.00 | 99.73 | 88.17 | 100.00 | 100.00 | 94.12 | 100.00 | 99.99 | 75.59 | 0.00 | 49.45 | 83.91 |
| LF [%] | 101.17 | 101.20 | 100.27 | 89.02 | 101.05 | 101.35 | 95.14 | 101.18 | 100.77 | 74.78 | 0.00 | 49.78 | 84.63 |
| OF [%] | 100.00 | 100.00 | 100.00 | 90.42 | 100.00 | 100.00 | 97.04 | 100.00 | 100.00 | 87.10 | 0.00 | 53.56 | 85.70 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 11.83 | 0.00 | 0.00 | 5.51 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 1.69 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 11.83 | 0.00 | 0.00 | 5.49 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.44 |
| PUF [%] | 0.00 | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.39 | 0.00 | 0.01 | 24.41 | 100.00 | 50.54 | 14.65 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 123793.53 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 14.84 % |
| Cumulative Energy Availability Factor (EAF) | : 64.68 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 12.46 % |
| Cumulative Unit Capability Factor (UCF) | : 69.26 % | Cumulative Planned Unavailability Factor (PUF) | : 18.29 % |
| Cumulative Load Factor (LF) | : 58.2 % | Cumulative Externally cause unavailability (XUF) | : 4.57 % |
| Cumulative Operating Factor (OF) | : 71.22 % | | |

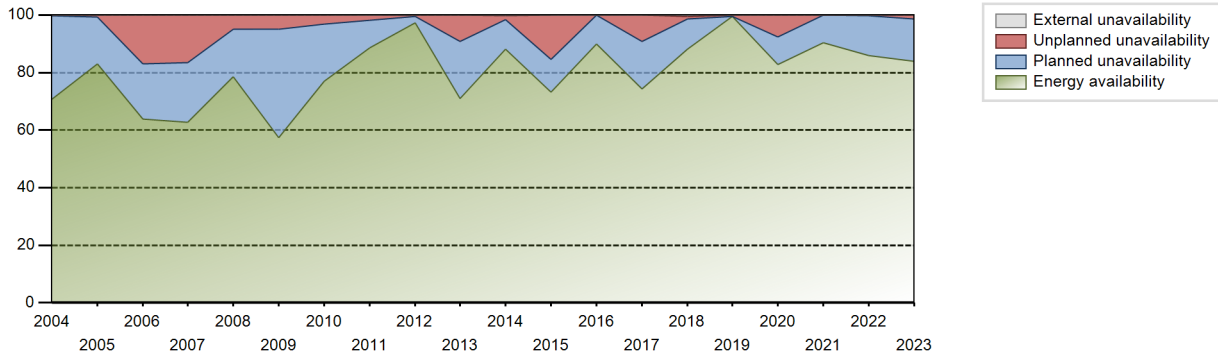
Electricity Production (net) [GWh]



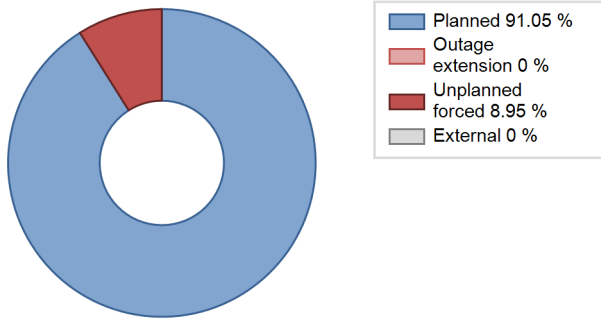
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 3169.38 | 6847 | 626 | 57.80 | 57.80 | 57.80 | 78.16 | 37.49 | 34.66 | 7.55 | 0.00 |
| 1986 | 132.36 | 512 | 626 | 3.70 | 3.70 | 2.41 | 5.84 | 89.62 | 31.97 | 64.33 | 0.00 |
| 1987 | 910.56 | 1958 | 626 | 19.72 | 19.72 | 16.60 | 22.35 | 80.28 | 80.28 | 0.00 | 0.00 |
| 1988 | 566.64 | 1488 | 626 | 18.52 | 18.52 | 10.30 | 16.94 | 81.48 | 81.48 | 0.00 | 0.00 |
| 1989 | 1695.10 | 5362 | 626 | 61.30 | 61.78 | 30.91 | 61.21 | 6.96 | 4.62 | 33.60 | 0.47 |
| 1990 | 2055.34 | 7400 | 626 | 82.54 | 86.08 | 37.48 | 84.47 | 10.13 | 9.71 | 4.21 | 3.54 |
| 1991 | 1306.35 | 5046 | 626 | 57.18 | 57.18 | 23.82 | 57.60 | 1.56 | 0.91 | 41.92 | 0.00 |
| 1992 | 1506.37 | 4275 | 626 | 47.93 | 47.93 | 27.39 | 48.67 | 16.27 | 9.31 | 42.76 | 0.00 |
| 1993 | 402.70 | 1524 | 626 | 17.17 | 17.17 | 7.34 | 17.40 | 82.83 | 82.83 | 0.00 | 0.00 |
| 1994 | 41.45 | 305 | 626 | 3.48 | 83.84 | 0.76 | 3.48 | 16.16 | 16.16 | 0.00 | 80.35 |
| 1995 | 2333.64 | 8127 | 626 | 42.56 | 92.77 | 42.56 | 92.77 | 3.09 | 2.96 | 4.27 | 50.22 |
| 1996 | 2288.84 | 5063 | 626 | 55.23 | 66.99 | 41.62 | 57.64 | 0.00 | 0.00 | 33.01 | 11.76 |
| 1997 | 2989.97 | 6219 | 626 | 53.17 | 60.65 | 54.52 | 70.99 | 0.75 | 0.46 | 38.89 | 7.49 |
| 1998 | 3093.82 | 6976 | 626 | 56.42 | 56.42 | 56.42 | 79.63 | 6.39 | 3.85 | 39.73 | 0.00 |
| 1999 | 3631.68 | 8429 | 626 | 64.79 | 65.19 | 66.23 | 96.22 | 4.69 | 3.21 | 31.60 | 0.40 |
| 2000 | 3164.93 | 6514 | 626 | 58.73 | 58.73 | 57.56 | 74.16 | 15.27 | 10.59 | 30.69 | 0.00 |
| 2001 | 3614.43 | 7295 | 626 | 82.88 | 82.88 | 65.91 | 83.28 | 4.94 | 4.31 | 12.82 | 0.00 |
| 2002 | 3775.19 | 7595 | 626 | 85.93 | 87.66 | 68.84 | 86.70 | 0.64 | 0.56 | 11.78 | 1.73 |
| 2003 | 3137.06 | 6551 | 626 | 57.20 | 74.53 | 57.21 | 74.78 | 9.74 | 8.04 | 17.43 | 17.33 |
| 2004 | 3890.16 | 7968 | 626 | 70.75 | 70.75 | 70.75 | 90.71 | 0.35 | 0.25 | 29.00 | 0.00 |
| 2005 | 3520.38 | 7275 | 626 | 83.05 | 83.05 | 64.20 | 83.05 | 0.85 | 0.71 | 16.24 | 0.00 |
| 2006 | 3205.23 | 6743 | 626 | 63.96 | 63.96 | 58.45 | 76.97 | 20.91 | 16.91 | 19.12 | 0.00 |
| 2007 | 2553.47 | 5481 | 520 | 62.79 | 62.79 | 56.06 | 62.57 | 8.97 | 16.59 | 20.61 | 0.00 |
| 2008 | 3314.53 | 6967 | 491 | 78.60 | 78.60 | 76.85 | 79.31 | 5.95 | 4.98 | 16.43 | 0.00 |
| 2009 | 2668.92 | 5256 | 609 | 57.41 | 57.41 | 50.87 | 60.00 | 7.83 | 4.88 | 37.71 | 0.00 |
| 2010 | 4076.72 | 7055 | 609 | 77.02 | 77.02 | 76.42 | 80.54 | 3.94 | 3.16 | 19.81 | 0.00 |
| 2011 | 4452.48 | 7789 | 609 | 88.65 | 88.76 | 83.46 | 88.92 | 1.93 | 1.75 | 9.49 | 0.11 |
| 2012 | 5134.91 | 8734 | 609 | 97.39 | 97.39 | 95.99 | 99.43 | 0.58 | 0.57 | 2.04 | 0.00 |
| 2013 | 3734.79 | 6765 | 609 | 70.91 | 70.91 | 70.01 | 77.23 | 11.56 | 9.27 | 19.82 | 0.00 |
| 2014 | 4706.85 | 7857 | 609 | 88.17 | 88.54 | 88.23 | 89.69 | 1.43 | 1.28 | 10.18 | 0.37 |
| 2015 | 3867.66 | 6619 | 609 | 73.21 | 73.29 | 72.50 | 75.56 | 11.77 | 15.33 | 11.38 | 0.08 |
| 2016 | 4807.12 | 7951 | 609 | 89.98 | 90.08 | 89.86 | 90.52 | 0.04 | 0.03 | 9.89 | 0.10 |
| 2017 | 3966.79 | 6633 | 609 | 74.22 | 74.34 | 74.36 | 75.72 | 10.96 | 9.15 | 16.51 | 0.12 |
| 2018 | 4695.30 | 7793 | 609 | 88.12 | 88.61 | 88.01 | 88.96 | 0.06 | 0.87 | 10.52 | 0.49 |
| 2019 | 5239.68 | 8668 | 609 | 99.46 | 99.54 | 98.21 | 98.94 | 0.36 | 0.36 | 0.10 | 0.08 |
| 2020 | 4347.14 | 7299 | 609 | 82.69 | 82.69 | 81.26 | 83.09 | 8.37 | 7.56 | 9.75 | 0.00 |
| 2021 | 4845.93 | 8014 | 609 | 90.41 | 90.43 | 90.84 | 91.48 | 0.05 | 0.04 | 9.53 | 0.02 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 4602.31 | 7603 | 609 | 85.82 | 85.82 | 86.27 | 86.79 | 0.23 | 0.20 | 13.98 | 0.00 |
| 2023 | 4515.48 | 7508 | 609 | 83.91 | 83.91 | 84.63 | 85.70 | 1.69 | 1.44 | 14.65 | 0.00 |

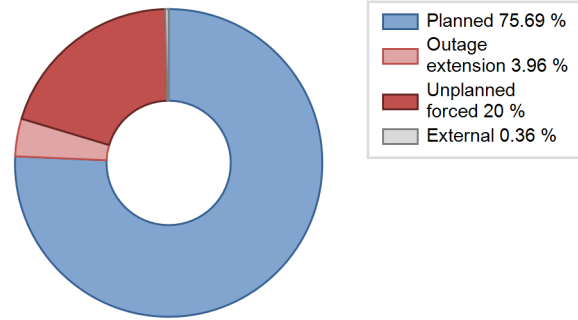
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 71 | | | 1139 | |
| B. Refuelling without maintenance | | | | 26 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1168 | | | 1027 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 231 | | |
| E. Testing of plant systems or components | | 17 | | 48 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 81 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 12 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 6 |
| L. Human factor related | | | | | 17 | |
| M. Governmental requirements or court decisions | | | | | | 212 |
| P. Fire | | | | | 0 | |
| Z. Other | | | | | 17 | 2 |
| Subtotal | 1168 | 88 | | 1413 | 1175 | 232 |
| Total | | 1256 | | | 2820 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 255 |
| 12. Reactor I&C Systems | 17 | 44 |
| 13. Reactor Auxiliary Systems | | 75 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 11 |
| 16. Steam generation systems | | 28 |
| 31. Turbine and auxiliaries | 71 | 109 |
| 32. Feedwater and Main Steam System | | 41 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | | 0 |
| 41. Main Generator Systems | | 348 |
| 42. Electrical Power Supply Systems | | 172 |
| Total | 88 | 1090 |

2023 Operating Experience

BR-2

ANGRA-2

BRAZIL

Status at end of year : **Operational**
 Operator : ELETRONUCLEAR S (ELETRONUCLEAR S.A.)
 Owner : ELETRONUCLEAR S (ELETRONUCLEAR S.A.)
 Reactor Supplier : KWU (KRAFTWERK UNION, AG)
 Turbine Supplier : KWU (KRAFTWERK UNION, AG)



Reactor Unit Details

Reactor type and model : PWR / PRE KONVOI
 Thermal power : 3764 MWth
 Gross electrical power : 1350 MWe
 Reference unit power (net) : 1275 MWe

Key Dates

Construction Date : 1976-01-01
 Grid Date : 2000-07-21
 Commercial Date : 2001-02-01
 Age at end of year : 23 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.5
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 35000
 Active core diameter [m] : 3.61
 Active core height/length [m] : 3.9
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 20.79
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.9
 Reactor outlet temperature [°C] : 326
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 0.53

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.295
 Output voltage [kV] : 25
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 8

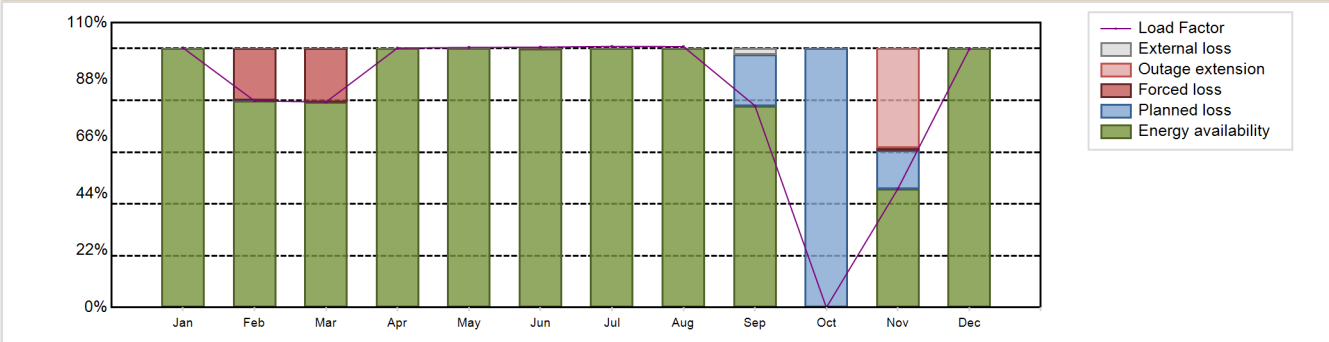
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9179.95 GW(e).h
 Energy Availability Factor (EAF) : 81.91 %
 Unit Capability Factor (UCF) : 82.09 %
 Load Factor (LF) : 82.19 %
 Operating Factor (OF) : 82.51 %
 Forced Loss Rate (FLR) : 3.95 %
 Unplanned Capability Loss Factor (UCL) : 6.52 %
 Planned Unavailability Factor (PUF) : 11.38 %
 Externally cause unavailability (XUF) : 0.19 %
 Total off-line time : 1532 hours

Annual Summary

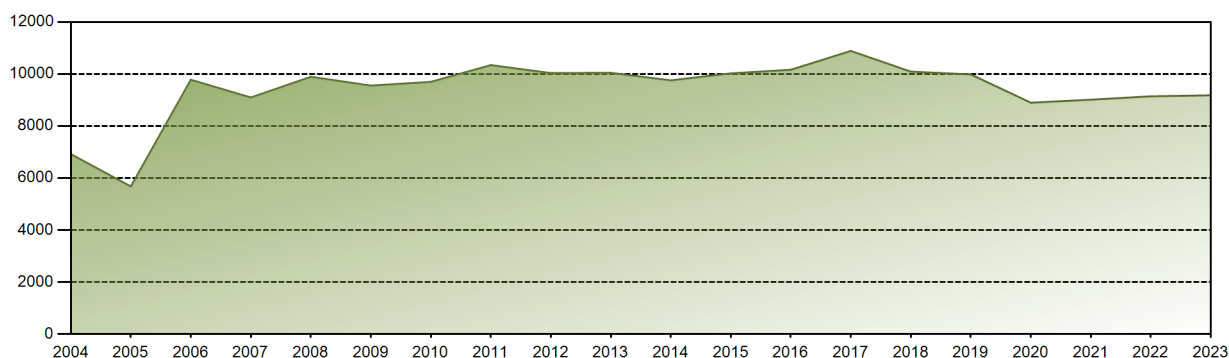


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 951.36 | 683.89 | 752.79 | 919.93 | 952.62 | 923.02 | 956.67 | 955.98 | 715.65 | 0.00 | 420.79 | 947.25 | 9179.95 |
| EAF [%] | 100.00 | 79.82 | 79.36 | 100.00 | 100.00 | 99.80 | 100.00 | 100.00 | 77.75 | 0.00 | 45.84 | 100.00 | 81.91 |
| UCF [%] | 100.00 | 79.82 | 79.36 | 100.00 | 100.00 | 99.80 | 100.00 | 100.00 | 80.00 | 0.00 | 45.84 | 100.00 | 82.09 |
| LF [%] | 100.29 | 79.82 | 79.36 | 100.21 | 100.42 | 100.55 | 100.85 | 100.78 | 77.96 | 0.00 | 45.84 | 99.86 | 82.19 |
| OF [%] | 100.00 | 80.80 | 81.18 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 80.00 | 0.00 | 47.92 | 100.00 | 82.51 |
| FLR [%] | 0.00 | 20.04 | 20.64 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 2.13 | 0.00 | 3.95 |
| UCL [%] | 0.00 | 20.00 | 20.64 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 39.29 | 0.00 | 6.52 |
| PUF [%] | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 20.00 | 100.00 | 14.87 | 0.00 | 11.38 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.25 | 0.00 | 0.00 | 0.00 | 0.19 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 219163.81 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.69 % |
| Cumulative Energy Availability Factor (EAF) | : 86.23 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.73 % |
| Cumulative Unit Capability Factor (UCF) | : 87.31 % | Cumulative Planned Unavailability Factor (PUF) | : 8.96 % |
| Cumulative Load Factor (LF) | : 84.19 % | Cumulative Externally cause unavailability (XUF) | : 1.08 % |
| Cumulative Operating Factor (OF) | : 88.34 % | | |

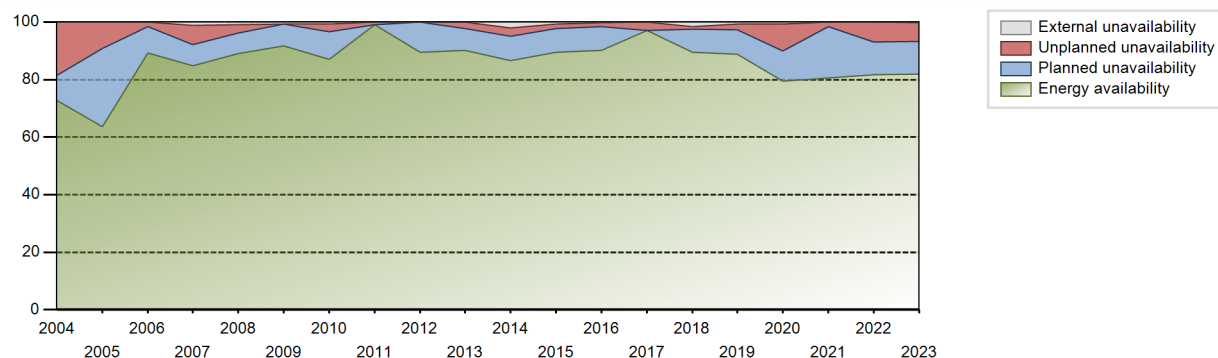
Electricity Production (net) [GWh]



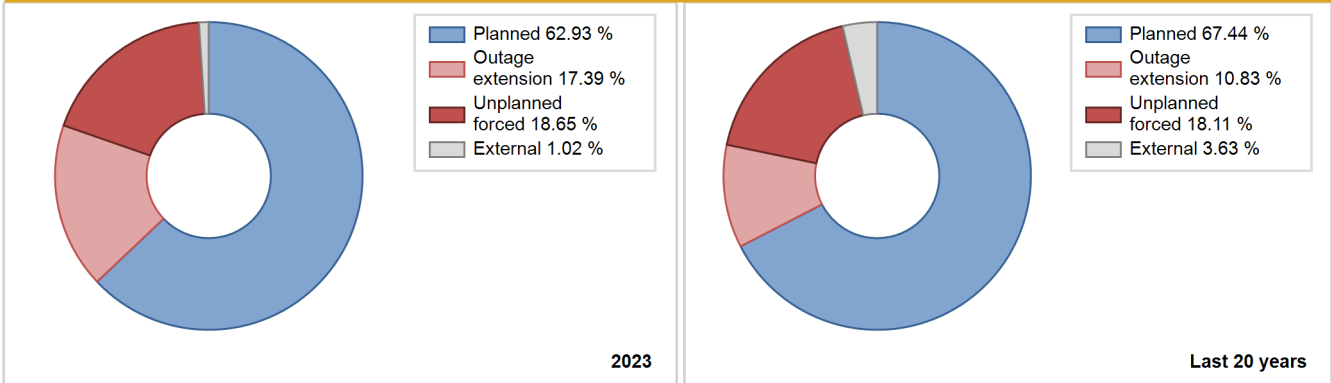
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2001 | 9904.99 | 8315 | 1350 | 94.21 | 94.34 | 85.69 | 97.27 | 3.11 | 3.02 | 2.64 | 0.13 |
| 2002 | 9238.24 | 8060 | 1275 | 83.33 | 91.26 | 82.71 | 92.01 | 0.43 | 0.39 | 8.35 | 7.93 |
| 2003 | 9418.97 | 8019 | 1275 | 84.29 | 90.97 | 84.33 | 91.54 | 1.91 | 1.77 | 7.26 | 6.68 |
| 2004 | 6919.82 | 6497 | 1275 | 72.76 | 72.76 | 61.79 | 73.96 | 20.26 | 18.49 | 8.74 | 0.00 |
| 2005 | 5676.66 | 5581 | 1275 | 63.71 | 63.71 | 50.83 | 63.71 | 4.70 | 9.17 | 27.12 | 0.00 |
| 2006 | 9778.32 | 8014 | 1275 | 89.34 | 89.34 | 87.55 | 91.48 | 1.64 | 1.49 | 9.17 | 0.00 |
| 2007 | 9096.95 | 7606 | 1275 | 84.70 | 85.92 | 81.45 | 86.83 | 4.68 | 6.68 | 7.39 | 1.22 |
| 2008 | 9894.03 | 7924 | 1275 | 89.12 | 90.06 | 88.34 | 90.21 | 0.41 | 2.83 | 7.10 | 0.94 |
| 2009 | 9554.65 | 8068 | 1275 | 91.66 | 92.40 | 85.55 | 92.10 | 0.00 | 0.00 | 7.60 | 0.73 |
| 2010 | 9697.44 | 7727 | 1275 | 87.10 | 87.92 | 86.82 | 88.21 | 2.89 | 2.62 | 9.47 | 0.82 |
| 2011 | 10342.26 | 8682 | 1275 | 99.04 | 99.11 | 92.60 | 99.11 | 0.89 | 0.89 | 0.00 | 0.07 |
| 2012 | 10035.50 | 8064 | 1275 | 89.50 | 89.50 | 89.61 | 91.80 | 0.00 | 0.00 | 10.50 | 0.00 |
| 2013 | 10045.27 | 7961 | 1275 | 90.06 | 90.06 | 89.94 | 90.88 | 1.74 | 2.19 | 7.75 | 0.00 |
| 2014 | 9756.54 | 7754 | 1275 | 86.57 | 88.61 | 87.35 | 88.52 | 0.77 | 2.82 | 8.57 | 2.04 |
| 2015 | 10023.96 | 7990 | 1275 | 89.41 | 90.22 | 89.75 | 91.21 | 1.18 | 1.56 | 8.22 | 0.81 |
| 2016 | 10163.34 | 7939 | 1275 | 90.05 | 90.20 | 90.75 | 90.38 | 0.03 | 1.45 | 8.35 | 0.16 |
| 2017 | 10887.54 | 8521 | 1275 | 96.97 | 97.02 | 97.48 | 97.27 | 2.95 | 2.95 | 0.03 | 0.05 |
| 2018 | 10091.65 | 8011 | 1275 | 89.53 | 91.22 | 90.35 | 91.45 | 0.19 | 0.81 | 7.97 | 1.69 |
| 2019 | 9984.43 | 7895 | 1275 | 88.83 | 89.57 | 89.38 | 90.12 | 1.76 | 1.93 | 8.50 | 0.74 |
| 2020 | 8897.22 | 7423 | 1275 | 79.38 | 79.99 | 79.44 | 84.51 | 0.03 | 9.50 | 10.51 | 0.61 |
| 2021 | 9012.51 | 7497 | 1275 | 80.52 | 80.52 | 80.69 | 85.58 | 2.04 | 1.67 | 17.81 | 0.00 |
| 2022 | 9142.51 | 7171 | 1275 | 81.58 | 81.59 | 81.86 | 81.86 | 6.81 | 6.90 | 11.51 | 0.02 |
| 2023 | 9179.95 | 7228 | 1275 | 81.91 | 82.09 | 82.19 | 82.51 | 3.95 | 6.52 | 11.38 | 0.19 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2001 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 551 | | | 262 | |
| C. Inspection, maintenance or repair combined with refuelling | 982 | | | 626 | 23 | |
| D. Inspection, maintenance or repair without refuelling | | | | 143 | | |
| E. Testing of plant systems or components | | | | 2 | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 8 | |
| Subtotal | 982 | 551 | | 771 | 294 | 4 |
| Total | | 1533 | | | 1069 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2001 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 49 |
| 13. Reactor Auxiliary Systems | | 27 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 21 |
| 16. Steam generation systems | | 0 |
| 31. Turbine and auxiliaries | | 8 |
| 32. Feedwater and Main Steam System | | 9 |
| 33. Circulating Water System | | 2 |
| 41. Main Generator Systems | 275 | 89 |
| 42. Electrical Power Supply Systems | | 74 |
| Total | 551 | 280 |

Highlights (2023)

Angra 2 remained connected to the National Electrical Grid for 301,14 days in 2023 and performed its refueling outage (19th) in 52,75 days, for refueling, maintenance and routine testing.

Angra 2 operated cycle 19 and cycle 20, until the end of December, without fuel failure.

During core unloading, in the course of the 19th refueling outage, although in smaller quantities, the appearance of white particles falling from the Fuel Elements (ECs) during Unloading was observed, indicating the presence of the corrosion phenomenon in some ECs of the Cycle 19 core. As planned, during the visual inspection of all ECs that would return to the cycle 20 core, it was observed that they presented an oxidation level within the expected range for the relative burning of each EC. During the 2P19 refueling outage in this measurement activity, good corrosion performance was observed, without any indication of advanced corrosion and with maximum oxide thicknesses with values within those expected for the burning of each EC measured, allowing the safe and reliable return of the Plant to operation and demonstrating that the measures taken by Eletronuclear to resolve the issue of surface oxidation of the coating on the EC rods presented the expected result.

On February 18th 2023, Angra 2 Turbine automatically shutdown due to the activation of the Generator Rotor Ground Fault Protection. On the same day, the Reactor was manually shutdown. After evaluations, performing "Feed and Bleed" of the Generator Cooling System (MKF), Megger measurement and mainly the emergency chemical cleaning of the Rotor, the plant was reconnected to the grid on February 24th 2023.

On March 8, the power was reduced to 80% Nominal Power (PN), due to the reduction in the insulation resistance of the electric generator rotor.

The plant remained at 80% PN until March 10th, when the power reduction of the Plant began, to manually shut down the Generator. On the same day, Angra 2 was disconnected from grid, with the unit's turbogenerator being manually turned off (TUSA) and the reactor turned off on the same date. After evaluations, performing "Feed and Bleed" of the Generator Cooling System (MKF), Megger measurement and mainly the chemical cleaning of the Rotor, the reactor was criticalized on March 16th. And on the same day, the unit was reconnected to grid.

On September 7th, the stretch out operation to extend an operating cycle.

On September 24th, power reduction began to shut down the plant for the beginning of the 19th Refueling Outage.

On September 25th, at 00:00, the unit was turned off, starting its 19th refueling outage (2P19).

On September 16th, the 19th Recharging Stop (2P19) was closed, with the plant synchronizing with to grid on the same date, and to start Angra 2 20th Cycle 20.

2023 Operating Experience

BG-5 **KOZLODUY-5** **BULGARIA**

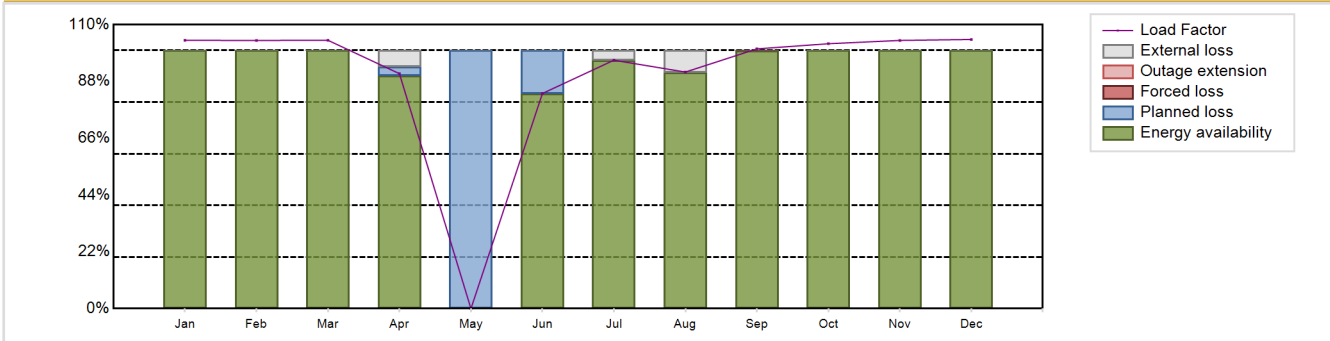
Status at end of year : **Operational**
 Operator : KNPP (Kozloduy Npp ,lc)
 Owner : BEH (Bulgarian Energy Holding)
 Reactor Supplier : AEE (ATOMENERGOEXPORT)
 Turbine Supplier : AEE (ATOMENERGOEXPORT)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 1980-07-09 |
| Thermal power | : 3120 MWth | Grid Date | : 1987-11-29 |
| Gross electrical power | : 1040 MWe | Commercial Date | : 1988-12-23 |
| Reference unit power (net) | : 1003 MWe | Age at end of year | : 36 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 16 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 320 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.5 |
| Average fuel enrichment [% of U235] | : 4.23 | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 30 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 48870 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Active core height/length [m] | : 3.55 | Output voltage [kV] | : 24 |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.3 | Number of main condensate pumps | : 6 |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : DH |

| Annual Production Results (2023) | | | |
|--|-------------------|--|-------------|
| Net Energy Production | : 7932.76 GW(e).h | Forced Loss Rate (FLR) | : 0.01 % |
| Energy Availability Factor (EAF) | : 88.29 % | Unplanned Capability Loss Factor (UCL) | : 0.01 % |
| Unit Capability Factor (UCF) | : 89.86 % | Planned Unavailability Factor (PUF) | : 10.14 % |
| Load Factor (LF) | : 90.29 % | Externally cause unavailability (XUF) | : 1.57 % |
| Operating Factor (OF) | : 90.05 % | Total off-line time | : 872 hours |
| Equivalent non-electrical energy generated (NEG) | : 38.5 GW(e).h | | |

Annual Summary

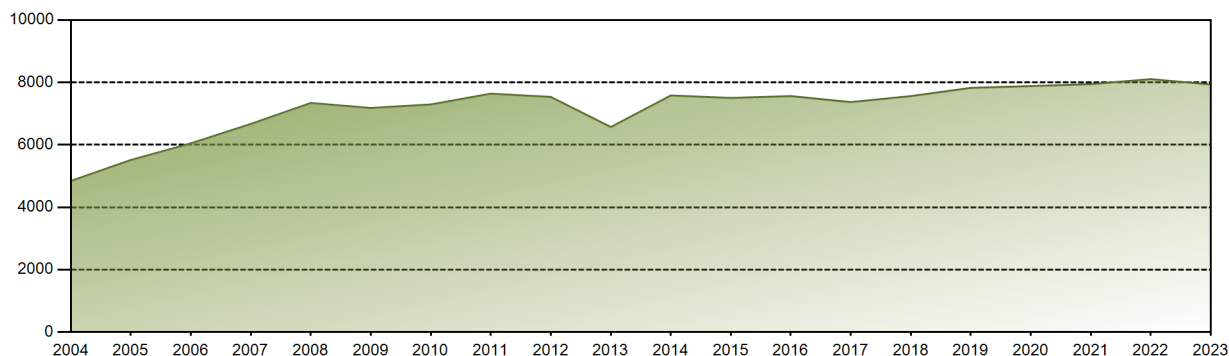


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 775.47 | 700.24 | 775.60 | 657.15 | 0.00 | 601.82 | 718.10 | 683.84 | 726.62 | 765.69 | 750.21 | 778.03 | 7932.76 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 90.26 | 0.00 | 83.33 | 96.23 | 91.53 | 99.92 | 100.00 | 100.00 | 100.00 | 88.29 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 96.68 | 0.00 | 83.33 | 100.00 | 100.00 | 99.92 | 100.00 | 100.00 | 100.00 | 89.86 |
| LF [%] | 103.92 | 103.89 | 103.94 | 91.00 | 0.00 | 83.34 | 96.23 | 91.64 | 100.62 | 102.61 | 103.88 | 104.26 | 90.29 |
| OF [%] | 100.00 | 100.00 | 100.00 | 96.94 | 0.00 | 85.28 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.05 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.01 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.01 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 3.32 | 100.00 | 16.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.14 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 6.42 | 0.00 | 0.00 | 3.77 | 8.47 | 0.00 | 0.00 | 0.00 | 0.00 | 1.57 |

Historical Summary

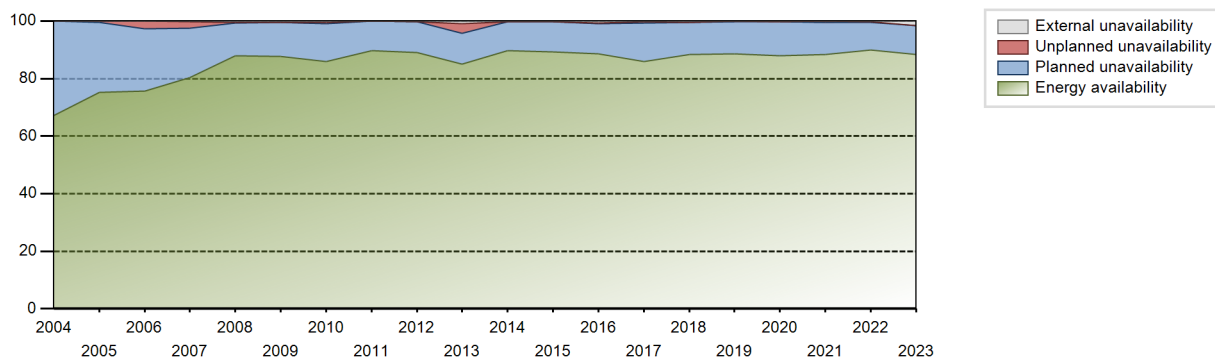
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 203967.01 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.17 % |
| Cumulative Energy Availability Factor (EAF) | : 74.25 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.69 % |
| Cumulative Unit Capability Factor (UCF) | : 76.21 % | Cumulative Planned Unavailability Factor (PUF) | : 22.1 % |
| Cumulative Load Factor (LF) | : 68.91 % | Cumulative Externally cause unavailability (XUF) | : 1.96 % |
| Cumulative Operating Factor (OF) | : 76.51 % | | |

Electricity Production (net) [GWh]

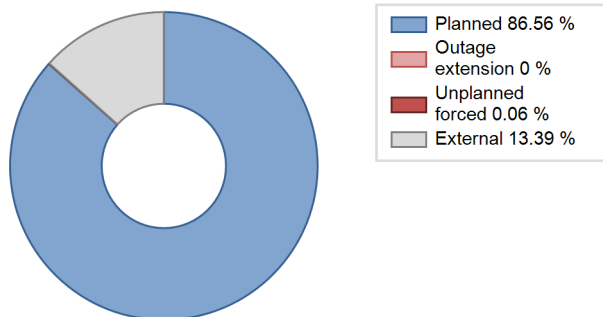


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF | |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | |
| 1988 | 3933.16 | 7027 | 887 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1989 | 3355.08 | 4663 | 953 | 51.52 | 51.52 | 40.19 | 53.23 | 5.32 | 2.90 | 45.58 | 0.00 | 0.00 |
| 1990 | 3380.91 | 5592 | 953 | 41.77 | 58.12 | 40.50 | 63.84 | 36.14 | 32.89 | 9.00 | 16.35 | 16.35 |
| 1991 | 1950.37 | 2777 | 953 | 31.73 | 31.73 | 23.36 | 31.70 | 1.27 | 0.41 | 67.86 | 0.00 | 0.00 |
| 1992 | 3540.69 | 4982 | 953 | 47.04 | 56.65 | 42.30 | 56.72 | 9.57 | 5.99 | 37.35 | 9.61 | 9.61 |
| 1993 | 3278.01 | 4675 | 953 | 47.53 | 50.50 | 39.27 | 53.37 | 0.74 | 0.38 | 49.12 | 2.97 | 2.97 |
| 1994 | 2880.40 | 4350 | 953 | 48.05 | 52.58 | 34.50 | 49.66 | 1.91 | 1.03 | 46.39 | 4.53 | 4.53 |
| 1995 | 4699.34 | 5988 | 953 | 59.36 | 68.12 | 56.29 | 68.36 | 2.13 | 1.48 | 30.40 | 8.76 | 8.76 |
| 1996 | 4720.27 | 6468 | 953 | 73.84 | 73.84 | 56.39 | 73.63 | 0.00 | 0.00 | 26.16 | 0.00 | 0.00 |
| 1997 | 4410.25 | 6034 | 953 | 68.67 | 68.67 | 52.83 | 68.88 | 0.31 | 0.21 | 31.12 | 0.00 | 0.00 |
| 1998 | 3741.00 | 6467 | 953 | 73.34 | 73.34 | 44.81 | 73.82 | 0.31 | 0.23 | 26.43 | 0.00 | 0.00 |
| 1999 | 3423.21 | 4838 | 953 | 50.36 | 54.80 | 41.00 | 55.23 | 1.82 | 1.01 | 44.19 | 4.43 | 4.43 |
| 2000 | 4340.81 | 5406 | 1000 | 54.42 | 63.52 | 49.42 | 61.54 | 2.23 | 1.45 | 35.03 | 9.10 | 9.10 |
| 2001 | 5049.55 | 5940 | 953 | 61.48 | 66.56 | 60.49 | 67.81 | 0.98 | 0.66 | 32.78 | 5.08 | 5.08 |
| 2002 | 5095.85 | 7003 | 953 | 79.39 | 79.77 | 61.04 | 79.94 | 0.18 | 0.14 | 20.08 | 0.38 | 0.38 |
| 2003 | 5596.69 | 8579 | 953 | 98.60 | 98.60 | 67.04 | 97.93 | 0.00 | 0.00 | 1.40 | 0.00 | 0.00 |
| 2004 | 4842.04 | 5906 | 953 | 67.18 | 67.19 | 57.84 | 67.24 | 0.10 | 0.07 | 32.75 | 0.00 | 0.00 |
| 2005 | 5513.48 | 6641 | 953 | 75.23 | 75.23 | 66.04 | 75.81 | 0.51 | 0.38 | 24.38 | 0.01 | 0.01 |
| 2006 | 6047.02 | 6691 | 953 | 75.73 | 75.82 | 72.43 | 76.38 | 3.28 | 2.57 | 21.61 | 0.09 | 0.09 |
| 2007 | 6669.92 | 7090 | 953 | 80.25 | 80.42 | 79.90 | 80.94 | 2.83 | 2.35 | 17.23 | 0.18 | 0.18 |
| 2008 | 7341.29 | 7796 | 953 | 87.85 | 88.44 | 87.70 | 88.75 | 0.00 | 0.12 | 11.44 | 0.59 | 0.59 |
| 2009 | 7181.55 | 7759 | 953 | 87.72 | 88.30 | 86.02 | 88.57 | 0.01 | 0.01 | 11.70 | 0.58 | 0.58 |
| 2010 | 7293.30 | 7620 | 953 | 85.87 | 86.41 | 87.37 | 87.00 | 0.48 | 0.42 | 13.17 | 0.54 | 0.54 |
| 2011 | 7639.25 | 7878 | 953 | 89.71 | 89.75 | 91.51 | 89.93 | 0.00 | 0.00 | 10.25 | 0.04 | 0.04 |
| 2012 | 7534.46 | 7876 | 953 | 89.12 | 89.38 | 90.01 | 89.66 | 0.00 | 0.00 | 10.62 | 0.26 | 0.26 |
| 2013 | 6569.82 | 7551 | 953 | 85.11 | 85.97 | 78.70 | 86.20 | 3.77 | 3.37 | 10.66 | 0.86 | 0.86 |
| 2014 | 7580.91 | 7912 | 963 | 89.66 | 89.93 | 89.87 | 90.32 | 0.05 | 0.04 | 10.02 | 0.27 | 0.27 |
| 2015 | 7502.66 | 7856 | 963 | 89.34 | 89.52 | 88.94 | 89.68 | 0.13 | 0.11 | 10.37 | 0.18 | 0.18 |
| 2016 | 7562.34 | 7875 | 963 | 88.62 | 89.39 | 89.40 | 89.65 | 0.27 | 0.24 | 10.37 | 0.77 | 0.77 |
| 2017 | 7369.19 | 7580 | 963 | 85.90 | 86.27 | 87.36 | 86.53 | 0.33 | 0.29 | 13.44 | 0.37 | 0.37 |
| 2018 | 7561.29 | 7788 | 963 | 88.28 | 88.77 | 89.63 | 88.90 | 0.00 | 0.00 | 11.23 | 0.49 | 0.49 |
| 2019 | 7825.41 | 7808 | 1003 | 88.51 | 88.57 | 92.12 | 89.13 | 0.30 | 0.27 | 11.16 | 0.06 | 0.06 |
| 2020 | 7881.46 | 7768 | 1003 | 87.85 | 88.20 | 89.46 | 88.43 | 0.00 | 0.00 | 11.80 | 0.34 | 0.34 |
| 2021 | 7946.42 | 7771 | 1003 | 88.27 | 88.38 | 90.44 | 88.71 | 0.49 | 0.43 | 11.19 | 0.11 | 0.11 |
| 2022 | 8104.37 | 7923 | 1003 | 89.98 | 90.20 | 92.24 | 90.45 | 0.28 | 0.25 | 9.55 | 0.22 | 0.22 |
| 2023 | 7932.76 | 7888 | 1003 | 88.29 | 89.86 | 90.29 | 90.05 | 0.01 | 0.01 | 10.14 | 1.57 | 1.57 |

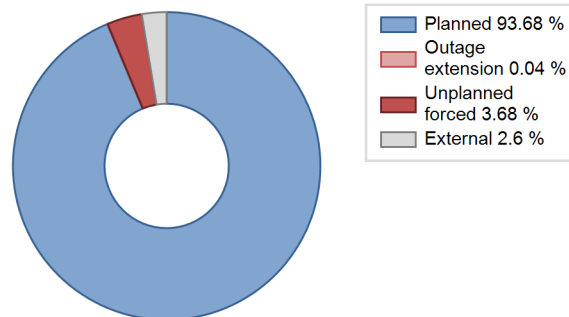
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 115 | |
| C. Inspection, maintenance or repair combined with refuelling | 872 | | | 1416 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 146 | | |
| E. Testing of plant systems or components | | | | 0 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 70 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| Subtotal | 872 | | | 1632 | 121 | 1 |
| Total | | 872 | | | 1754 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 6 |
| 13. Reactor Auxiliary Systems | | 1 |
| 15. Reactor Cooling Systems | | 5 |
| 16. Steam generation systems | | 7 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 10 |
| 32. Feedwater and Main Steam System | | 10 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 68 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 112 |

Highlights (2023)

Unit 5 was operated on base load mode at the optimal mode incl. fuel coast down mode in April.

The planned outage for annual maintenance, refueling and modernization was moved due to a maintenance at Unit 6 for one week, and was performed in the period 30th April – 5th June (total outage duration – 36.3 days). During the planned outage were carried out a number of modernizations related to the Unit life time prolongation.

2023 Operating Experience

BG-6

KOZLODUY-6

BULGARIA

Status at end of year : **Operational**
 Operator : KNPP (Kozloduy Npp ,lc)
 Owner : B EH (Bulgarian Energy Holding)
 Reactor Supplier : AEE (ATOMENERGOEXPORT)
 Turbine Supplier : AEE (ATOMENERGOEXPORT)

Reactor Unit Details

Reactor type and model : PWR / VVER V-320
 Thermal power : 3120 MWth
 Gross electrical power : 1040 MWe
 Reference unit power (net) : 1003 MWe

Key Dates

Construction Date : 1982-04-01
 Grid Date : 1991-08-02
 Commercial Date : 1993-12-30
 Age at end of year : 32 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.25
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 30
 Average discharge burnup [MWd/t] : 49450
 Active core diameter [m] : 3.16
 Active core height/length [m] : 3.55
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : 17.3
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 16
 Reactor outlet temperature [°C] : 320
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 0.5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : 24
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 6
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

Non-electrical applications

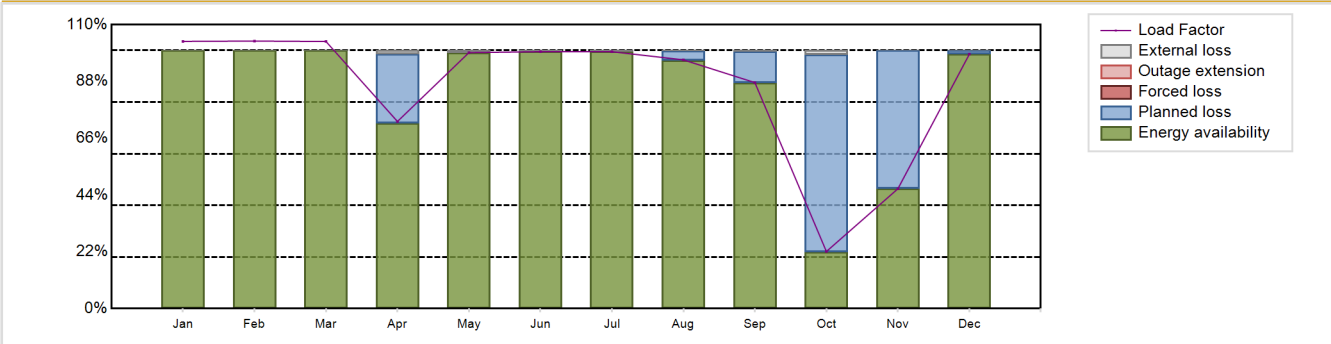
Non-electrical applications : DH

Annual Production Results (2023)

Net Energy Production : 7555.28 GW(e).h
 Energy Availability Factor (EAF) : 85.03 %
 Unit Capability Factor (UCF) : 85.46 %
 Load Factor (LF) : 85.99 %
 Operating Factor (OF) : 87.51 %
 Equivalent non-electrical energy generated (NEG) : 4.5 GW(e).h

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 14.54 %
 Externally cause unavailability (XUF) : 0.43 %
 Total off-line time : 1094 hours

Annual Summary

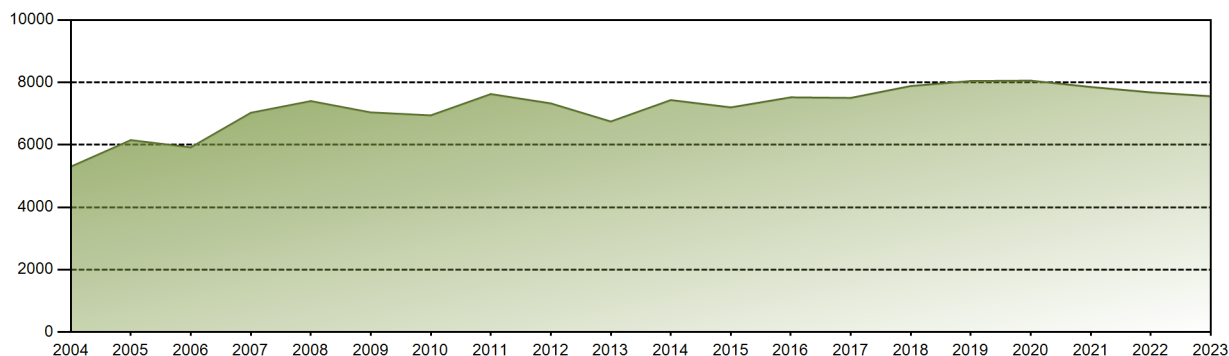


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 772.47 | 698.52 | 772.13 | 523.53 | 739.97 | 718.79 | 742.62 | 719.06 | 632.29 | 165.17 | 335.23 | 735.50 | 7555.28 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 71.76 | 99.16 | 99.53 | 99.52 | 96.18 | 87.56 | 22.00 | 46.42 | 98.56 | 85.03 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 73.05 | 100.00 | 100.00 | 100.00 | 96.30 | 87.89 | 23.65 | 46.42 | 98.56 | 85.46 |
| LF [%] | 103.52 | 103.64 | 103.47 | 72.50 | 99.16 | 99.53 | 99.52 | 96.36 | 87.56 | 22.13 | 46.42 | 98.56 | 85.99 |
| OF [%] | 100.00 | 100.00 | 100.00 | 75.56 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 26.21 | 48.75 | 100.00 | 87.51 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 26.95 | 0.00 | 0.00 | 0.00 | 3.70 | 12.11 | 76.35 | 53.58 | 1.44 | 14.54 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 1.29 | 0.84 | 0.47 | 0.48 | 0.12 | 0.33 | 1.65 | 0.00 | 0.00 | 0.43 |

Historical Summary

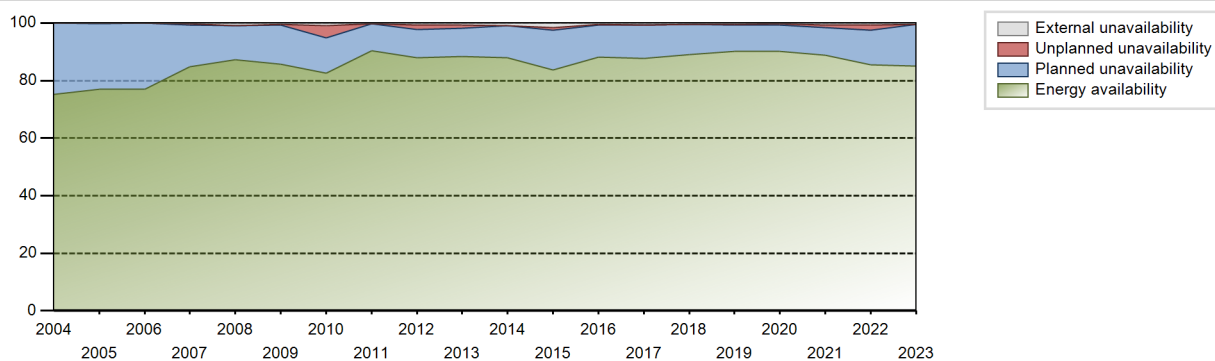
| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 190684.6 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.7 % |
| Cumulative Energy Availability Factor (EAF) | : 79.47 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.69 % |
| Cumulative Unit Capability Factor (UCF) | : 81.15 % | Cumulative Planned Unavailability Factor (PUF) | : 18.17 % |
| Cumulative Load Factor (LF) | : 75.07 % | Cumulative Externally cause unavailability (XUF) | : 1.68 % |
| Cumulative Operating Factor (OF) | : 81.66 % | | |

Electricity Production (net) [GWh]

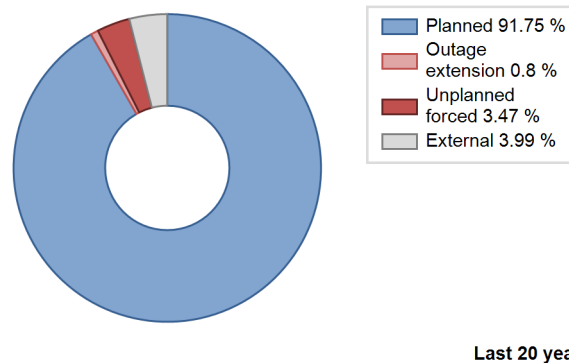
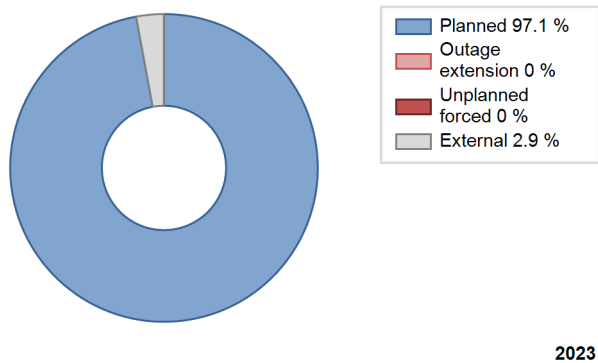


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1993 | 2799.64 | 4032 | 953 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1994 | 4862.58 | 7817 | 953 | 87.61 | 88.72 | 58.25 | 89.24 | 0.50 | 0.45 | 10.83 | 1.12 |
| 1995 | 3831.85 | 5568 | 953 | 63.56 | 63.56 | 45.90 | 63.56 | 0.09 | 0.06 | 36.38 | 0.00 |
| 1996 | 5495.89 | 6698 | 953 | 76.25 | 76.25 | 65.65 | 76.25 | 0.67 | 0.52 | 23.24 | 0.00 |
| 1997 | 4825.42 | 6380 | 953 | 72.83 | 72.83 | 57.80 | 72.83 | 0.00 | 0.00 | 27.17 | 0.00 |
| 1998 | 3970.04 | 6079 | 953 | 63.70 | 63.70 | 47.56 | 69.39 | 7.10 | 4.87 | 31.44 | 0.00 |
| 1999 | 4407.84 | 6194 | 953 | 60.71 | 69.56 | 52.80 | 70.71 | 1.16 | 0.82 | 29.62 | 8.86 |
| 2000 | 4064.35 | 5772 | 1000 | 51.23 | 66.78 | 46.27 | 65.71 | 0.60 | 0.41 | 32.82 | 15.55 |
| 2001 | 4189.45 | 5441 | 953 | 50.42 | 63.42 | 50.18 | 62.11 | 0.01 | 0.00 | 36.58 | 13.00 |
| 2002 | 5324.95 | 6256 | 953 | 71.52 | 71.52 | 63.78 | 71.42 | 0.03 | 1.10 | 27.38 | 0.00 |
| 2003 | 5480.56 | 6474 | 953 | 72.89 | 72.89 | 65.65 | 73.90 | 0.16 | 0.11 | 27.00 | 0.00 |
| 2004 | 5298.10 | 6614 | 953 | 75.25 | 75.25 | 63.29 | 75.30 | 0.00 | 0.00 | 24.75 | 0.00 |
| 2005 | 6149.97 | 6772 | 953 | 76.94 | 76.96 | 73.67 | 77.31 | 0.17 | 0.13 | 22.91 | 0.01 |
| 2006 | 5917.29 | 6821 | 953 | 76.96 | 77.05 | 70.88 | 77.87 | 0.06 | 0.04 | 22.90 | 0.10 |
| 2007 | 7024.83 | 7493 | 953 | 84.72 | 85.02 | 84.15 | 85.54 | 0.54 | 0.46 | 14.52 | 0.31 |
| 2008 | 7400.25 | 7753 | 953 | 87.23 | 88.14 | 88.40 | 88.26 | 0.00 | 0.00 | 11.86 | 0.91 |
| 2009 | 7037.38 | 7562 | 953 | 85.61 | 86.19 | 84.30 | 86.32 | 0.08 | 0.07 | 13.75 | 0.58 |
| 2010 | 6943.07 | 7387 | 953 | 82.68 | 83.70 | 83.17 | 84.33 | 2.98 | 4.11 | 12.19 | 1.02 |
| 2011 | 7624.89 | 7962 | 953 | 90.28 | 90.43 | 91.32 | 90.88 | 0.17 | 0.15 | 9.42 | 0.15 |
| 2012 | 7326.44 | 7842 | 953 | 87.90 | 88.54 | 87.52 | 89.28 | 1.74 | 1.57 | 9.89 | 0.64 |
| 2013 | 6746.29 | 7848 | 953 | 88.32 | 89.10 | 80.81 | 89.59 | 1.10 | 0.99 | 9.91 | 0.77 |
| 2014 | 7433.08 | 7863 | 963 | 88.02 | 88.95 | 88.11 | 89.76 | 0.00 | 0.00 | 11.05 | 0.93 |
| 2015 | 7198.32 | 7489 | 963 | 83.65 | 85.24 | 85.33 | 85.49 | 0.20 | 0.96 | 13.80 | 1.58 |
| 2016 | 7521.11 | 7807 | 963 | 88.06 | 88.64 | 88.91 | 88.88 | 0.21 | 0.18 | 11.18 | 0.58 |
| 2017 | 7503.07 | 7784 | 963 | 87.62 | 88.35 | 88.94 | 88.86 | 0.07 | 0.07 | 11.58 | 0.73 |
| 2018 | 7883.42 | 7864 | 1003 | 88.93 | 89.51 | 90.31 | 89.77 | 0.00 | 0.00 | 10.49 | 0.58 |
| 2019 | 8043.47 | 7973 | 1003 | 90.19 | 90.57 | 91.55 | 91.02 | 0.39 | 0.36 | 9.07 | 0.38 |
| 2020 | 8056.13 | 8007 | 1003 | 90.20 | 90.54 | 91.44 | 91.15 | 0.42 | 0.39 | 9.08 | 0.33 |
| 2021 | 7852.47 | 7970 | 1003 | 88.80 | 89.54 | 89.37 | 90.98 | 1.00 | 0.91 | 9.55 | 0.75 |
| 2022 | 7679.72 | 7576 | 1003 | 85.47 | 86.15 | 87.41 | 86.48 | 2.15 | 1.89 | 11.95 | 0.68 |
| 2023 | 7555.28 | 7666 | 1003 | 85.03 | 85.46 | 85.99 | 87.51 | 0.00 | 0.00 | 14.54 | 0.43 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1993 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 137 | |
| C. Inspection, maintenance or repair combined with refuelling | 918 | | | 1350 | | |
| D. Inspection, maintenance or repair without refuelling | 176 | | | 87 | | |
| E. Testing of plant systems or components | | | | 6 | 0 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 72 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 0 | |
| Subtotal | 1094 | | | 1515 | 137 | 3 |
| Total | | 1094 | | | 1655 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1993 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 8 |
| 14. Safety Systems | | 16 |
| 31. Turbine and auxiliaries | | 9 |
| 32. Feedwater and Main Steam System | | 1 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 14 |
| 42. Electrical Power Supply Systems | | 79 |
| Total | | 127 |

Highlights (2023)

Unit 6 was operated on base load mode with optimal power. As a preventive measure the Unit #6 was shut down in April for one week for repairing Steam Generator #3 (no operational limit has been reached). The planned outage for annual maintenance, refueling and modernization was displaced due to the outage in April. Before the planned outage for annual maintenance, refueling and modernization power is reduced for scheduled measurements. Annual maintenance with refueling was performed in the period 9th October – 16th November (total outage duration – 38 days). During the planned outage were carried out a number of modernizations related to the Unit life time prolongation.

2023 Operating Experience

CA-8

BRUCE-1

CANADA

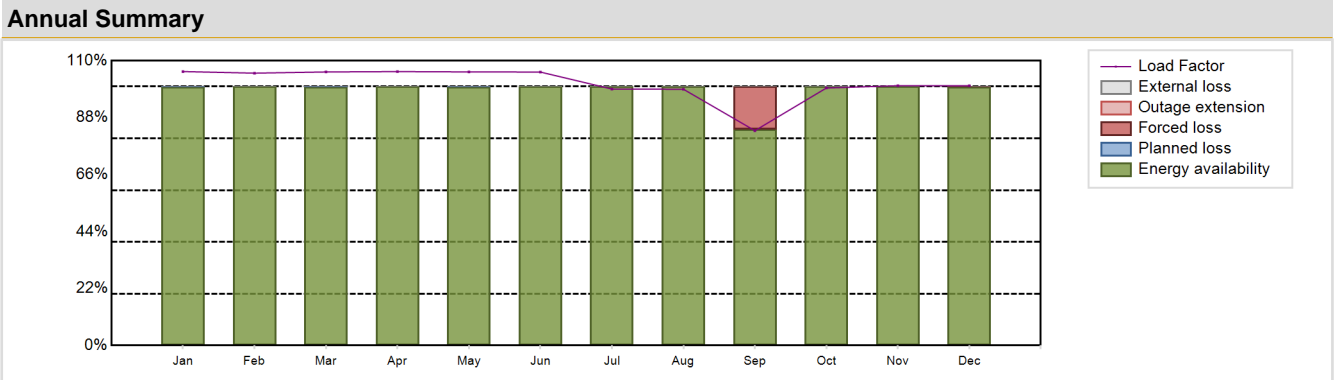
Status at end of year : **Operational**
 Operator : BRUCEPOW (Bruce Power)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 791 | Construction Date | : 1971-06-01 |
| Thermal power | : 2620 MWth | Grid Date | : 1977-01-14 |
| Gross electrical power | : 868 MWe | Commercial Date | : 1977-09-01 |
| Reference unit power (net) | : 811 MWe | Age at end of year | : 46 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 9.36 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 300 |
| Fuel material | : UO2 | Number of SG | : 8 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 1.74 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 8750 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 5.67 | HP cylinder inlet steam pressure [MPa] | : 4.37 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 6240 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 24.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 4 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 1 | Number of on-site safety related diesel generators | : NA |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 7022.43 GW(e).h | Forced Loss Rate (FLR) | : 1.38 % |
| Energy Availability Factor (EAF) | : 98.59 % | Unplanned Capability Loss Factor (UCL) | : 1.38 % |
| Unit Capability Factor (UCF) | : 98.59 % | Planned Unavailability Factor (PUF) | : 0.03 % |
| Load Factor (LF) | : 101.13 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 98.73 % | Total off-line time | : 111 hours |

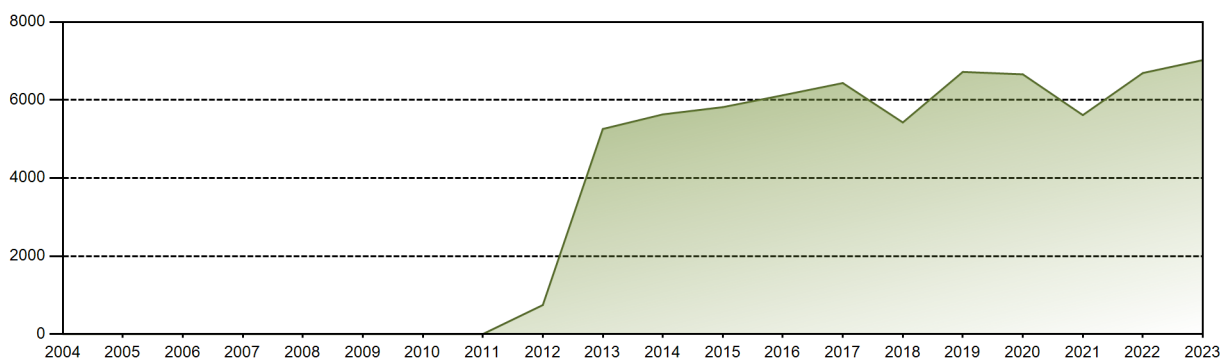


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 609.35 | 547.12 | 608.44 | 589.55 | 608.55 | 588.59 | 597.66 | 597.28 | 484.57 | 600.07 | 585.93 | 605.33 | 7022.43 |
| EAF [%] | 99.92 | 100.00 | 99.88 | 100.00 | 99.88 | 100.00 | 100.00 | 100.00 | 83.60 | 100.00 | 100.00 | 99.95 | 98.59 |
| UCF [%] | 99.92 | 100.00 | 99.88 | 100.00 | 99.88 | 100.00 | 100.00 | 100.00 | 83.60 | 100.00 | 100.00 | 99.95 | 98.59 |
| LF [%] | 105.82 | 105.19 | 105.66 | 105.79 | 105.68 | 105.62 | 99.05 | 98.99 | 82.99 | 99.45 | 100.34 | 100.32 | 101.13 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 84.58 | 100.00 | 100.00 | 100.00 | 98.73 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.40 | 0.00 | 0.00 | 0.05 | 1.38 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.40 | 0.00 | 0.00 | 0.05 | 1.38 |
| PUF [%] | 0.08 | 0.00 | 0.12 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 159703.03 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 17.51 % |
| Cumulative Energy Availability Factor (EAF) | : 73.79 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 15.89 % |
| Cumulative Unit Capability Factor (UCF) | : 74.22 % | Cumulative Planned Unavailability Factor (PUF) | : 9.89 % |
| Cumulative Load Factor (LF) | : 73.54 % | Cumulative Externally cause unavailability (XUF) | : 0.43 % |
| Cumulative Operating Factor (OF) | : 81.62 % | | |

Electricity Production (net) [GWh]

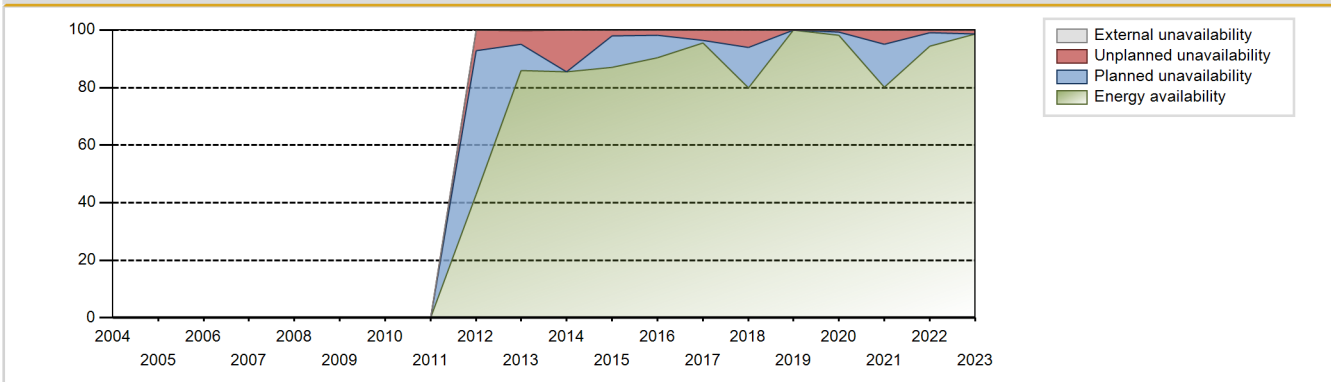


Performance for Years of Commercial Operation

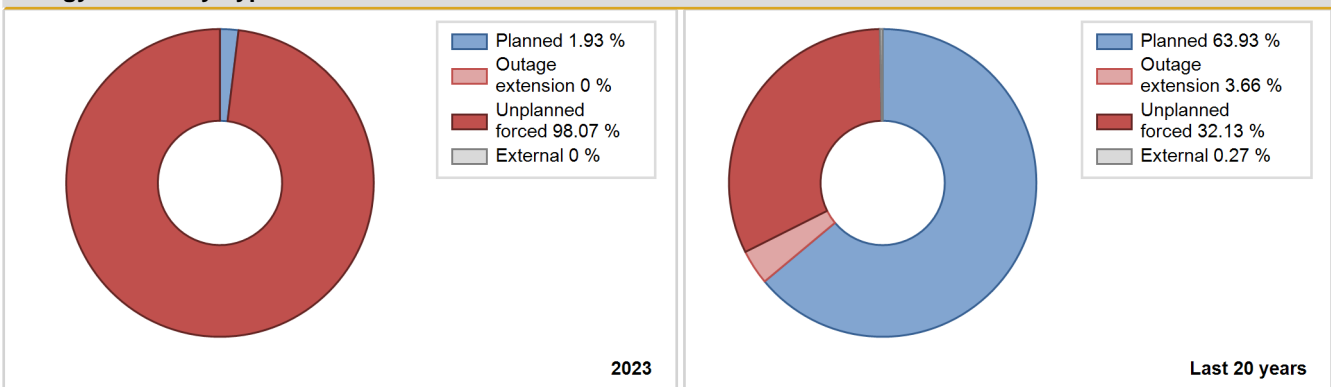
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|--|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1977 | 1860.70 | 2698 | 740 | 88.40 | 88.40 | 88.04 | 94.47 | 11.60 | 11.60 | 0.00 | 0.00 |
| 1978 | 4152.60 | 6649 | 740 | 72.65 | 72.65 | 64.24 | 76.11 | 15.38 | 13.20 | 14.15 | 0.00 |
| 1979 | 5018.80 | 7334 | 740 | 81.48 | 81.48 | 76.58 | 82.81 | 18.52 | 18.52 | 0.00 | 0.00 |
| 1980 | 5597.50 | 7902 | 740 | 86.18 | 86.18 | 86.11 | 89.96 | 7.87 | 7.36 | 6.46 | 0.00 |
| 1981 | 6253.30 | 8486 | 740 | 96.66 | 96.66 | 96.47 | 96.87 | 3.34 | 3.34 | 0.00 | 0.00 |
| 1982 | 5914.90 | 7884 | 740 | 88.80 | 88.80 | 91.25 | 90.00 | 11.20 | 11.20 | 0.00 | 0.00 |
| 1983 | 5802.80 | 7590 | 740 | 84.81 | 84.81 | 89.52 | 86.64 | 15.04 | 15.01 | 0.18 | 0.00 |
| 1984 | 6457.62 | 8546 | 740 | 94.76 | 94.76 | 99.35 | 97.29 | 5.10 | 5.09 | 0.15 | 0.00 |
| 1985 | 6417.45 | 8349 | 772 | 94.89 | 99.99 | 94.78 | 95.31 | 0.01 | 0.01 | 0.00 | 5.10 |
| 1986 | 4398.02 | 5783 | 770 | 65.33 | 65.97 | 65.20 | 66.02 | 0.07 | 0.05 | 33.98 | 0.64 |
| 1987 | 4087.07 | 5462 | 848 | 60.73 | 63.26 | 55.02 | 62.35 | 19.62 | 15.44 | 21.29 | 2.54 |
| 1988 | 4642.66 | 6066 | 848 | 65.95 | 66.85 | 62.33 | 69.06 | 15.12 | 11.91 | 21.24 | 0.89 |
| 1989 | 5094.78 | 7543 | 848 | 68.74 | 69.91 | 68.58 | 86.11 | 25.23 | 23.59 | 6.50 | 1.16 |
| 1990 | 2451.13 | 4629 | 848 | 32.98 | 33.58 | 33.00 | 52.84 | 39.00 | 21.46 | 44.96 | 0.60 |
| 1991 | 2394.45 | 3467 | 848 | 32.22 | 34.08 | 32.23 | 39.58 | 65.87 | 65.78 | 0.14 | 1.87 |
| 1992 | 4546.54 | 7484 | 848 | 61.04 | 61.04 | 61.04 | 85.20 | 38.96 | 38.96 | 0.00 | 0.00 |
| 1993 | 3389.20 | 6869 | 848 | 45.67 | 45.67 | 45.62 | 78.41 | 45.60 | 38.28 | 16.06 | 0.00 |
| 1994 | 3849.03 | 7094 | 848 | 51.81 | 51.81 | 51.81 | 80.98 | 48.19 | 48.19 | 0.00 | 0.00 |
| 1995 | 3531.45 | 5827 | 848 | 47.54 | 47.54 | 47.54 | 66.52 | 34.50 | 25.04 | 27.42 | 0.00 |
| 1996 | 4326.40 | 7306 | 848 | 58.09 | 58.09 | 58.08 | 83.17 | 39.23 | 37.49 | 4.42 | 0.00 |
| 1997 | 1383.58 | 2254 | 848 | 23.52 | 23.52 | 23.52 | 32.50 | 63.04 | 40.12 | 36.35 | 0.00 |
| 1998 | Data not available - Suspended Operation | | | | | | | | | | |
| 1999 | | | | | | | | | | | |
| 2000 | | | | | | | | | | | |
| 2001 | | | | | | | | | | | |
| 2002 | | | | | | | | | | | |
| 2003 | | | | | | | | | | | |
| 2004 | | | | | | | | | | | |
| 2005 | | | | | | | | | | | |
| 2006 | | | | | | | | | | | |
| 2007 | | | | | | | | | | | |
| 2008 | | | | | | | | | | | |
| 2009 | | | | | | | | | | | |
| 2010 | | | | | | | | | | | |
| 2011 | | | | | | | | | | | |
| 2012 | 743.65 | 1365 | 772 | 42.86 | 42.86 | 42.87 | 57.11 | 14.46 | 7.25 | 49.90 | 0.00 |
| 2013 | 5257.07 | 7883 | 772 | 85.98 | 86.14 | 77.74 | 89.99 | 5.31 | 4.83 | 9.03 | 0.16 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|--------|--------|-------|-------|-------|------|
| 2014 | 5630.95 | 7540 | 772 | 85.52 | 85.52 | 83.26 | 86.07 | 14.48 | 14.48 | 0.00 | 0.00 |
| 2015 | 5816.97 | 7711 | 760 | 86.96 | 86.96 | 87.37 | 88.03 | 2.37 | 2.11 | 10.94 | 0.00 |
| 2016 | 6122.17 | 8004 | 760 | 90.36 | 90.42 | 91.71 | 91.12 | 1.55 | 1.69 | 7.89 | 0.06 |
| 2017 | 6434.23 | 8412 | 760 | 95.42 | 95.42 | 96.64 | 96.03 | 3.40 | 3.59 | 0.99 | 0.01 |
| 2018 | 5424.38 | 7046 | 760 | 79.92 | 79.93 | 81.48 | 80.43 | 7.03 | 6.04 | 14.03 | 0.01 |
| 2019 | 6720.15 | 8760 | 760 | 99.95 | 99.95 | 100.94 | 100.00 | 0.00 | 0.00 | 0.05 | 0.00 |
| 2020 | 6658.49 | 8630 | 774 | 98.13 | 98.15 | 97.94 | 98.25 | 0.76 | 0.75 | 1.10 | 0.02 |
| 2021 | 5613.00 | 7075 | 774 | 80.11 | 80.17 | 82.78 | 80.76 | 1.24 | 4.84 | 14.99 | 0.06 |
| 2022 | 6691.27 | 8298 | 774 | 94.38 | 94.38 | 98.69 | 94.73 | 1.07 | 1.02 | 4.60 | 0.00 |
| 2023 | 7022.43 | 8649 | 811 | 98.59 | 98.59 | 101.13 | 98.73 | 1.38 | 1.38 | 0.03 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1977 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 112 | | | 752 | |
| D. Inspection, maintenance or repair without refuelling | | | | 733 | | |
| E. Testing of plant systems or components | | | | 72 | 2 | |
| H. Nuclear regulatory requirements | | | | | 16 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 5 |
| L. Human factor related | | | | | 6 | |
| P. Fire | | | | | 4 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 13 |
| Z. Other | | | | 11 | 2 | |
| Subtotal | | 112 | | 816 | 782 | 18 |
| Total | | 112 | | | 1616 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1977 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 47 |
| 12. Reactor I&C Systems | | 70 |
| 13. Reactor Auxiliary Systems | | 78 |
| 14. Safety Systems | | 55 |
| 15. Reactor Cooling Systems | | 80 |
| 16. Steam generation systems | | 206 |
| 21. Fuel Handling and Storage Facilities | | 26 |
| 31. Turbine and auxiliaries | 112 | 39 |
| 32. Feedwater and Main Steam System | | 23 |
| 34. Miscellaneous Systems | | 19 |
| 41. Main Generator Systems | | 65 |
| 42. Electrical Power Supply Systems | | 41 |
| Total | 112 | 749 |

2023 Operating Experience

CA-9

BRUCE-2

CANADA

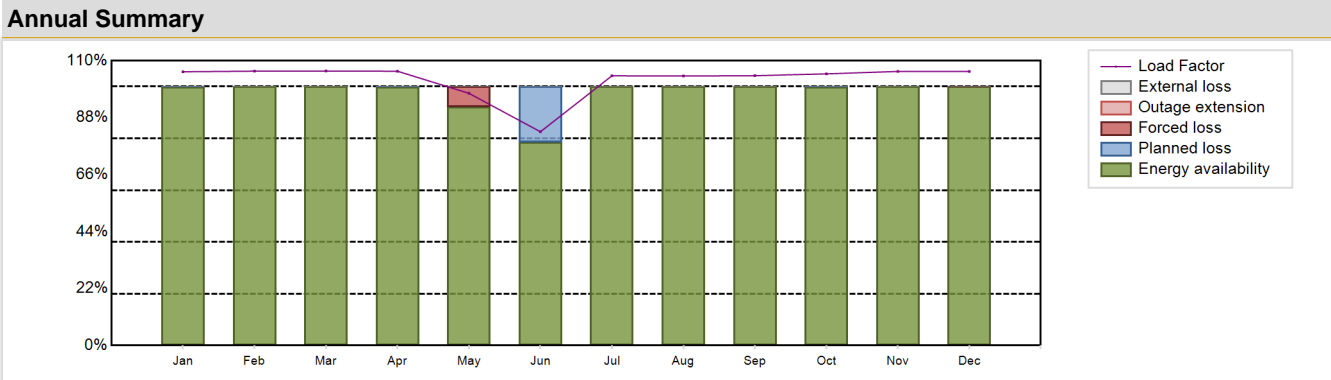
Status at end of year : **Operational**
 Operator : BRUCEPOW (Bruce Power)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 791 | Construction Date | : 1970-12-01 |
| Thermal power | : 2620 MWth | Grid Date | : 1976-09-04 |
| Gross electrical power | : 836 MWe | Commercial Date | : 1977-09-01 |
| Reference unit power (net) | : 777 MWe | Age at end of year | : 47 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 9.36 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 300 |
| Fuel material | : UO2 | Number of SG | : 8 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 1.74 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 8750 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 5.67 | HP cylinder inlet steam pressure [MPa] | : 4.37 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 6240 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 24.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 4 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 1 | Number of on-site safety related diesel generators | : NA |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|------------------|--|-------------|
| Net Energy Production | : 6992.4 GW(e).h | Forced Loss Rate (FLR) | : 0.68 % |
| Energy Availability Factor (EAF) | : 97.54 % | Unplanned Capability Loss Factor (UCL) | : 0.67 % |
| Unit Capability Factor (UCF) | : 97.54 % | Planned Unavailability Factor (PUF) | : 1.79 % |
| Load Factor (LF) | : 102.73 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 97.76 % | Total off-line time | : 196 hours |

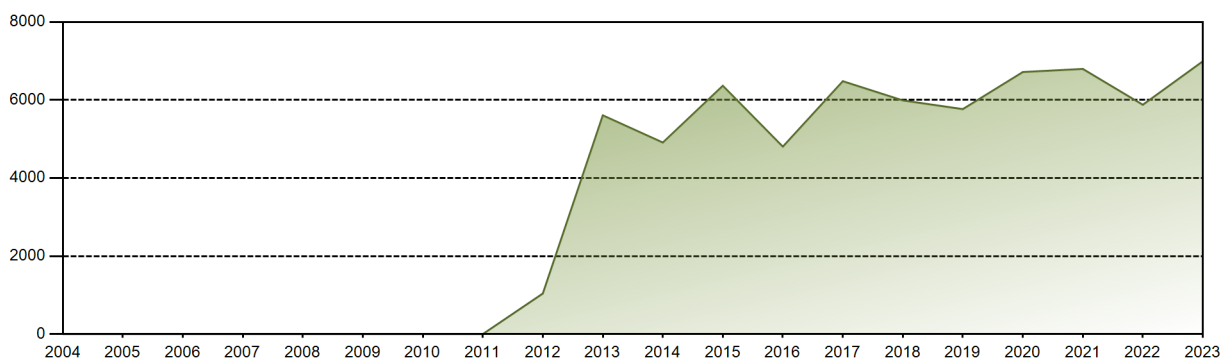


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 611.20 | 553.31 | 612.82 | 592.66 | 563.10 | 461.87 | 602.18 | 601.70 | 583.01 | 606.52 | 592.22 | 611.82 | 6992.40 |
| EAF [%] | 99.90 | 100.00 | 100.00 | 99.92 | 92.11 | 78.52 | 100.00 | 100.00 | 100.00 | 99.92 | 100.00 | 99.99 | 97.54 |
| UCF [%] | 99.90 | 100.00 | 100.00 | 99.92 | 92.11 | 78.52 | 100.00 | 100.00 | 100.00 | 99.92 | 100.00 | 99.99 | 97.54 |
| LF [%] | 105.73 | 105.97 | 106.01 | 105.94 | 97.41 | 82.56 | 104.17 | 104.09 | 104.21 | 104.92 | 105.86 | 105.84 | 102.73 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 93.55 | 79.44 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.76 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 7.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.68 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 7.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.67 |
| PUF [%] | 0.10 | 0.00 | 0.00 | 0.08 | 0.00 | 21.48 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 1.79 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 143112.62 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 18.98 % |
| Cumulative Energy Availability Factor (EAF) | : 71.35 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 16.98 % |
| Cumulative Unit Capability Factor (UCF) | : 71.78 % | Cumulative Planned Unavailability Factor (PUF) | : 11.24 % |
| Cumulative Load Factor (LF) | : 71.09 % | Cumulative Externally cause unavailability (XUF) | : 0.43 % |
| Cumulative Operating Factor (OF) | : 77.46 % | | |

Electricity Production (net) [GWh]

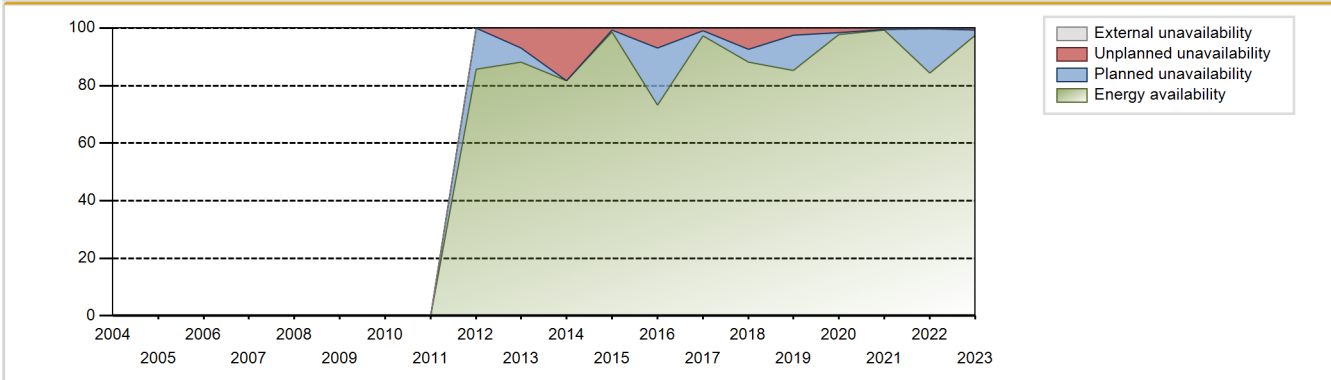


Performance for Years of Commercial Operation

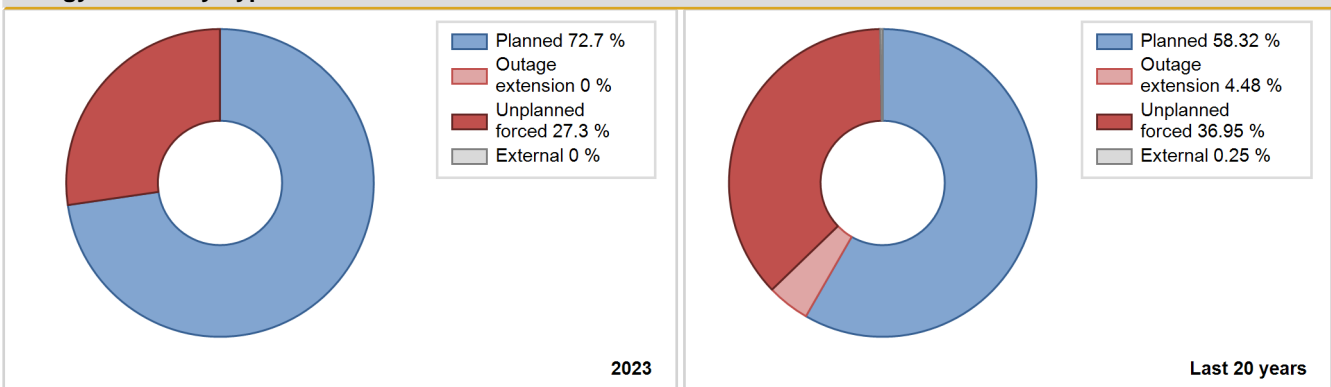
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--|-------|-------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1977 | 1696.80 | 2481 | 740 | 87.01 | 87.01 | 80.29 | 86.87 | 12.99 | 12.99 | 0.00 | 0.00 |
| 1978 | 3603.80 | 5946 | 740 | 65.23 | 65.45 | 55.75 | 68.06 | 22.17 | 18.65 | 15.91 | 0.22 |
| 1979 | 4408.80 | 6534 | 740 | 73.76 | 73.76 | 67.27 | 73.78 | 19.40 | 17.75 | 8.49 | 0.00 |
| 1980 | 6074.90 | 8463 | 740 | 93.52 | 93.52 | 93.46 | 96.35 | 6.48 | 6.48 | 0.00 | 0.00 |
| 1981 | 5795.10 | 7904 | 740 | 89.57 | 89.57 | 89.40 | 90.23 | 4.02 | 3.75 | 6.67 | 0.00 |
| 1982 | 4432.40 | 6163 | 740 | 68.00 | 68.00 | 68.38 | 70.35 | 32.00 | 32.00 | 0.00 | 0.00 |
| 1983 | 6112.80 | 7941 | 740 | 89.51 | 89.51 | 94.30 | 90.65 | 10.35 | 10.34 | 0.15 | 0.00 |
| 1984 | 6223.90 | 8649 | 740 | 91.03 | 91.03 | 95.75 | 98.46 | 8.84 | 8.83 | 0.15 | 0.00 |
| 1985 | 4979.30 | 6525 | 781 | 73.54 | 77.95 | 72.76 | 74.49 | 11.25 | 9.88 | 12.17 | 4.41 |
| 1986 | 4257.63 | 5308 | 848 | 56.97 | 59.21 | 57.31 | 60.59 | 40.79 | 40.79 | 0.00 | 2.24 |
| 1987 | 3781.40 | 4636 | 848 | 50.56 | 52.18 | 50.90 | 52.92 | 6.98 | 3.91 | 43.91 | 1.62 |
| 1988 | 4971.25 | 7741 | 848 | 71.70 | 71.70 | 66.74 | 88.13 | 25.15 | 24.08 | 4.22 | 0.00 |
| 1989 | 1316.31 | 2149 | 848 | 17.72 | 17.82 | 17.72 | 24.53 | 26.85 | 6.54 | 75.64 | 0.10 |
| 1990 | 2578.32 | 3460 | 848 | 35.22 | 35.48 | 34.71 | 39.50 | 41.05 | 24.71 | 39.81 | 0.26 |
| 1991 | 4483.48 | 5915 | 848 | 60.25 | 63.20 | 60.36 | 67.52 | 36.71 | 36.66 | 0.15 | 2.95 |
| 1992 | 353.88 | 625 | 848 | 4.73 | 4.73 | 4.75 | 7.12 | 95.27 | 95.27 | 0.00 | 0.00 |
| 1993 | 3016.81 | 6041 | 848 | 40.75 | 40.75 | 40.61 | 68.96 | 45.16 | 33.56 | 25.69 | 0.00 |
| 1994 | 3882.47 | 7046 | 848 | 52.26 | 52.26 | 52.26 | 80.43 | 40.39 | 35.41 | 12.32 | 0.00 |
| 1995 | 3791.00 | 6225 | 848 | 66.34 | 66.34 | 66.34 | 92.22 | 27.76 | 25.50 | 8.16 | 0.00 |
| 1996 | | | | Data not available - Suspended Operation | | | | | | | |
| 1997 | | | | | | | | | | | |
| 1998 | | | | | | | | | | | |
| 1999 | | | | | | | | | | | |
| 2000 | | | | | | | | | | | |
| 2001 | | | | | | | | | | | |
| 2002 | | | | | | | | | | | |
| 2003 | | | | | | | | | | | |
| 2004 | | | | | | | | | | | |
| 2005 | | | | | | | | | | | |
| 2006 | | | | | | | | | | | |
| 2007 | | | | | | | | | | | |
| 2008 | | | | | | | | | | | |
| 2009 | | | | | | | | | | | |
| 2010 | | | | | | | | | | | |
| 2011 | | | | | | | | | | | |
| 2012 | 1039.20 | 1826 | 734 | 85.69 | 85.71 | 85.41 | 100.00 | 0.00 | 0.00 | 14.29 | 0.02 |
| 2013 | 5607.65 | 8190 | 734 | 88.10 | 88.23 | 87.21 | 93.49 | 7.18 | 6.82 | 4.94 | 0.13 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|--------|--------|-------|-------|-------|------|
| 2014 | 4910.32 | 6984 | 734 | 81.74 | 81.74 | 76.37 | 79.73 | 18.26 | 18.26 | 0.00 | 0.00 |
| 2015 | 6365.71 | 8660 | 730 | 98.65 | 98.65 | 99.55 | 98.86 | 0.68 | 0.68 | 0.68 | 0.00 |
| 2016 | 4804.60 | 6408 | 760 | 73.21 | 73.23 | 73.17 | 72.95 | 2.57 | 6.93 | 19.84 | 0.02 |
| 2017 | 6482.56 | 8560 | 760 | 97.35 | 97.35 | 97.37 | 97.72 | 0.88 | 0.87 | 1.78 | 0.00 |
| 2018 | 5989.70 | 7828 | 760 | 88.11 | 88.12 | 89.97 | 89.36 | 7.67 | 7.32 | 4.55 | 0.01 |
| 2019 | 5766.96 | 7526 | 760 | 85.27 | 85.27 | 86.62 | 85.91 | 2.92 | 2.57 | 12.16 | 0.00 |
| 2020 | 6717.44 | 8584 | 777 | 97.69 | 97.69 | 98.42 | 97.72 | 1.69 | 1.68 | 0.63 | 0.00 |
| 2021 | 6797.00 | 8760 | 777 | 99.29 | 99.40 | 99.86 | 100.00 | 0.47 | 0.47 | 0.13 | 0.11 |
| 2022 | 5878.11 | 7481 | 777 | 84.33 | 84.33 | 86.36 | 85.40 | 0.28 | 0.23 | 15.44 | 0.00 |
| 2023 | 6992.40 | 8564 | 777 | 97.54 | 97.54 | 102.73 | 97.76 | 0.68 | 0.67 | 1.79 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1977 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 943 | |
| D. Inspection, maintenance or repair without refuelling | 147 | | | 901 | | |
| E. Testing of plant systems or components | | 48 | | | 3 | |
| H. Nuclear regulatory requirements | | | | | 9 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 24 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 2 |
| L. Human factor related | | | | | 36 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant , spare part delivery problems etc.) | | | | | | 14 |
| Z. Other | | | | | 30 | |
| Subtotal | 147 | 48 | | 901 | 1021 | 40 |
| Total | | 195 | | | 1962 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1977 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 119 |
| 12. Reactor I&C Systems | | 46 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | 48 | 13 |
| 15. Reactor Cooling Systems | | 128 |
| 16. Steam generation systems | | 426 |
| 21. Fuel Handling and Storage Facilities | | 26 |
| 31. Turbine and auxiliaries | | 20 |
| 32. Feedwater and Main Steam System | | 12 |
| 34. Miscellaneous Systems | | 13 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 125 |
| 42. Electrical Power Supply Systems | | 27 |
| Total | 48 | 963 |

2023 Operating Experience

CA-10

BRUCE-3

CANADA

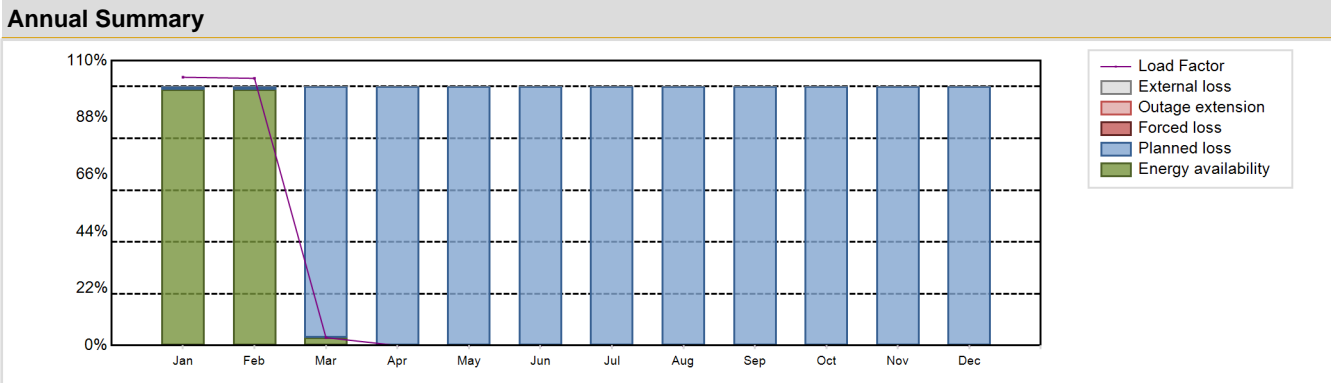
Status at end of year : **Operational**
 Operator : BRUCEPOW (Bruce Power)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)



| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 750A | Construction Date | : 1972-07-01 |
| Thermal power | : 2550 MWth | Grid Date | : 1977-12-12 |
| Gross electrical power | : 865 MWe | Commercial Date | : 1978-02-01 |
| Reference unit power (net) | : 770 MWe | Age at end of year | : 46 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 9.36 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 300 |
| Fuel material | : UO2 | Number of SG | : 8 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 1.74 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 8750 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 5.67 | HP cylinder inlet steam pressure [MPa] | : 4.37 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 6240 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 24.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 4 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 1 | Number of on-site safety related diesel generators | : NA |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 1145.06 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 16.24 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 16.24 % | Planned Unavailability Factor (PUF) | : 83.76 % |
| Load Factor (LF) | : 16.98 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 16.42 % | Total off-line time | : 7322 hours |

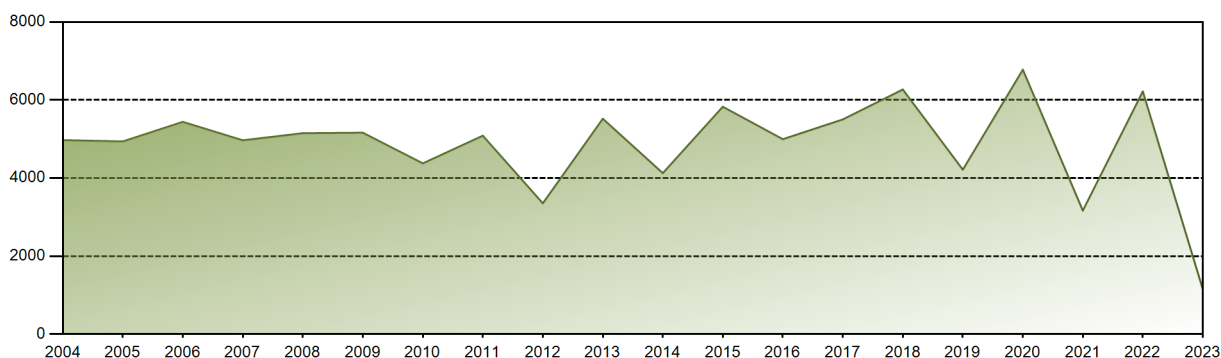


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 593.56 | 533.97 | 17.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1145.06 |
| EAF [%] | 98.91 | 98.84 | 3.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.24 |
| UCF [%] | 98.91 | 98.84 | 3.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.24 |
| LF [%] | 103.61 | 103.19 | 3.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.98 |
| OF [%] | 100.00 | 100.00 | 2.96 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.42 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 1.09 | 1.16 | 96.94 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 83.76 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 187117.98 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 13.66 % |
| Cumulative Energy Availability Factor (EAF) | : 72.79 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 12.86 % |
| Cumulative Unit Capability Factor (UCF) | : 73.33 % | Cumulative Planned Unavailability Factor (PUF) | : 13.81 % |
| Cumulative Load Factor (LF) | : 72.91 % | Cumulative Externally cause unavailability (XUF) | : 0.54 % |
| Cumulative Operating Factor (OF) | : 78.02 % | | |

Electricity Production (net) [GWh]

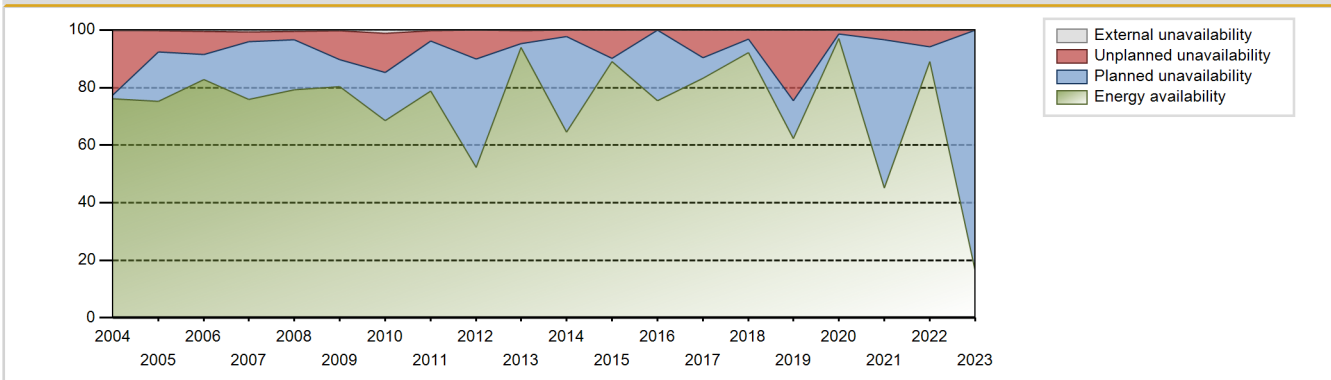


Performance for Years of Commercial Operation

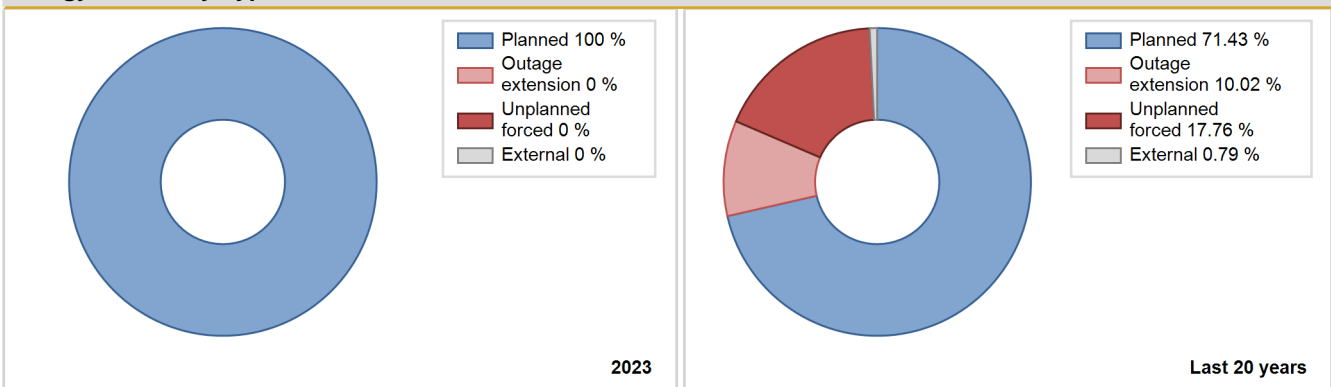
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|--|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1978 | 4793.00 | 7361 | 740 | 87.56 | 87.56 | 82.03 | 93.22 | 12.44 | 12.44 | 0.00 | 0.00 |
| 1979 | 4797.90 | 6885 | 740 | 77.78 | 77.78 | 73.21 | 77.74 | 11.80 | 10.41 | 11.82 | 0.00 |
| 1980 | 5939.80 | 8276 | 740 | 91.44 | 91.44 | 91.38 | 94.22 | 8.56 | 8.56 | 0.00 | 0.00 |
| 1981 | 5795.00 | 7873 | 740 | 89.48 | 89.48 | 89.40 | 89.87 | 4.74 | 4.45 | 6.07 | 0.00 |
| 1982 | 6381.90 | 8497 | 740 | 96.72 | 96.72 | 98.45 | 97.00 | 3.28 | 3.28 | 0.00 | 0.00 |
| 1983 | 6091.10 | 7905 | 740 | 89.23 | 89.23 | 93.96 | 90.24 | 10.64 | 10.62 | 0.15 | 0.00 |
| 1984 | 6148.73 | 8077 | 740 | 91.19 | 91.19 | 94.59 | 91.95 | 8.56 | 8.54 | 0.27 | 0.00 |
| 1985 | 6015.13 | 8118 | 775 | 88.59 | 93.91 | 88.60 | 92.67 | 6.09 | 6.09 | 0.00 | 5.32 |
| 1986 | 5891.24 | 7600 | 796 | 84.18 | 86.94 | 84.48 | 86.76 | 13.01 | 13.00 | 0.06 | 2.76 |
| 1987 | 6073.27 | 7724 | 848 | 81.91 | 85.78 | 81.76 | 88.17 | 7.86 | 7.32 | 6.90 | 3.87 |
| 1988 | 3310.57 | 4044 | 848 | 45.61 | 45.61 | 44.44 | 46.04 | 4.02 | 1.91 | 52.48 | 0.00 |
| 1989 | 4031.74 | 5364 | 848 | 54.79 | 57.43 | 54.27 | 61.23 | 31.42 | 26.31 | 16.26 | 2.64 |
| 1990 | 5652.68 | 7472 | 848 | 76.30 | 76.77 | 76.09 | 85.30 | 23.03 | 22.97 | 0.26 | 0.48 |
| 1991 | 6126.29 | 7950 | 848 | 82.38 | 84.29 | 82.47 | 90.75 | 15.71 | 15.71 | 0.00 | 1.90 |
| 1992 | 5800.97 | 7438 | 848 | 77.89 | 77.89 | 77.88 | 84.68 | 18.25 | 17.39 | 4.72 | 0.00 |
| 1993 | 3158.23 | 6557 | 848 | 42.99 | 42.99 | 42.52 | 74.85 | 54.42 | 51.32 | 5.69 | 0.00 |
| 1994 | 2737.62 | 5006 | 848 | 36.85 | 36.85 | 36.85 | 57.15 | 37.07 | 21.71 | 41.44 | 0.00 |
| 1995 | 4225.82 | 7000 | 848 | 56.89 | 56.89 | 56.89 | 79.91 | 43.11 | 43.11 | 0.00 | 0.00 |
| 1996 | 3321.48 | 5684 | 848 | 44.59 | 44.59 | 44.59 | 64.71 | 32.38 | 21.35 | 34.06 | 0.00 |
| 1997 | 4214.82 | 6325 | 848 | 56.76 | 56.76 | 56.74 | 72.20 | 43.24 | 43.24 | 0.00 | 0.00 |
| 1998 | 1642.52 | 2328 | 848 | 81.45 | 81.45 | 81.45 | 97.87 | 18.55 | 18.55 | 0.00 | 0.00 |
| 1999 | Data not available - Suspended Operation | | | | | | | | | | |
| 2000 | " | | | | | | | | | | |
| 2001 | " | | | | | | | | | | |
| 2002 | " | | | | | | | | | | |
| 2003 | " | | | | | | | | | | |
| 2004 | 4971.58 | 7154 | 750 | 76.09 | 76.45 | 75.30 | 81.44 | 22.51 | 22.21 | 1.34 | 0.36 |
| 2005 | 4938.11 | 6782 | 750 | 75.24 | 75.52 | 75.16 | 77.42 | 8.92 | 7.40 | 17.08 | 0.28 |
| 2006 | 5440.25 | 7435 | 750 | 82.86 | 83.27 | 82.80 | 84.87 | 8.75 | 8.05 | 8.68 | 0.41 |
| 2007 | 4966.67 | 6911 | 750 | 75.95 | 76.68 | 75.60 | 78.89 | 3.18 | 3.34 | 19.97 | 0.73 |
| 2008 | 5148.88 | 7125 | 734 | 79.32 | 79.77 | 79.86 | 81.11 | 3.51 | 2.90 | 17.33 | 0.45 |
| 2009 | 5162.09 | 7148 | 730 | 80.39 | 80.59 | 80.72 | 81.60 | 2.07 | 10.14 | 9.27 | 0.20 |
| 2010 | 4375.77 | 6198 | 730 | 68.44 | 69.58 | 68.43 | 70.75 | 16.32 | 13.57 | 16.85 | 1.15 |
| 2011 | 5084.86 | 6959 | 730 | 78.89 | 79.13 | 79.52 | 79.44 | 4.24 | 3.50 | 17.37 | 0.25 |
| 2012 | 3352.06 | 4617 | 730 | 52.21 | 52.26 | 52.28 | 52.56 | 5.80 | 9.96 | 37.78 | 0.06 |
| 2013 | 5518.71 | 7914 | 730 | 94.01 | 94.16 | 86.30 | 90.34 | 4.71 | 4.66 | 1.18 | 0.14 |
| 2014 | 4125.00 | 5718 | 730 | 64.55 | 64.55 | 64.51 | 65.27 | 3.30 | 2.20 | 33.25 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|--------|-------|-------|-------|-------|------|
| 2015 | 5827.57 | 7831 | 750 | 89.01 | 89.01 | 88.90 | 89.39 | 10.00 | 9.89 | 1.09 | 0.00 |
| 2016 | 4995.72 | 6579 | 750 | 75.54 | 75.60 | 75.83 | 74.90 | 0.00 | 0.00 | 24.40 | 0.06 |
| 2017 | 5502.68 | 7344 | 750 | 83.22 | 83.22 | 83.75 | 83.84 | 0.08 | 9.65 | 7.13 | 0.00 |
| 2018 | 6268.88 | 8079 | 750 | 92.18 | 92.21 | 95.42 | 92.23 | 3.26 | 3.11 | 4.68 | 0.03 |
| 2019 | 4213.89 | 5592 | 750 | 62.40 | 62.40 | 64.14 | 63.84 | 1.68 | 24.63 | 12.98 | 0.00 |
| 2020 | 6776.48 | 8574 | 770 | 97.08 | 97.12 | 100.19 | 97.61 | 1.35 | 1.33 | 1.54 | 0.04 |
| 2021 | 3164.00 | 4022 | 770 | 45.09 | 45.09 | 46.91 | 45.91 | 0.00 | 3.40 | 51.51 | 0.00 |
| 2022 | 6220.67 | 7953 | 770 | 89.12 | 89.15 | 92.22 | 90.79 | 6.16 | 5.85 | 5.00 | 0.03 |
| 2023 | 1145.06 | 1438 | 770 | 16.24 | 16.24 | 16.98 | 16.42 | 0.00 | 0.00 | 83.76 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1978 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 683 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 37 | 0 | |
| D. Inspection, maintenance or repair without refuelling | | | | 884 | | |
| E. Testing of plant systems or components | | | | 13 | 1 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | 7320 | | | 254 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 16 |
| L. Human factor related | | | | | 10 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 12 |
| Z. Other | | | | | 8 | |
| Subtotal | 7320 | | | 1188 | 702 | 32 |
| Total | | 7320 | | | 1922 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1978 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 128 |
| 12. Reactor I&C Systems | | 42 |
| 13. Reactor Auxiliary Systems | | 22 |
| 14. Safety Systems | | 61 |
| 15. Reactor Cooling Systems | | 83 |
| 16. Steam generation systems | | 96 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 21. Fuel Handling and Storage Facilities | | 28 |
| 31. Turbine and auxiliaries | | 95 |
| 32. Feedwater and Main Steam System | | 33 |
| 33. Circulating Water System | | 5 |
| 34. Miscellaneous Systems | | 7 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 75 |
| 42. Electrical Power Supply Systems | | 18 |
| Total | | 701 |

Highlights (2023)

Unit taken off-line 01MAR @ 22:03 to begin Major Component Replacement (MCR) & Refurbishment.

2023 Operating Experience

CA-11

BRUCE-4

CANADA

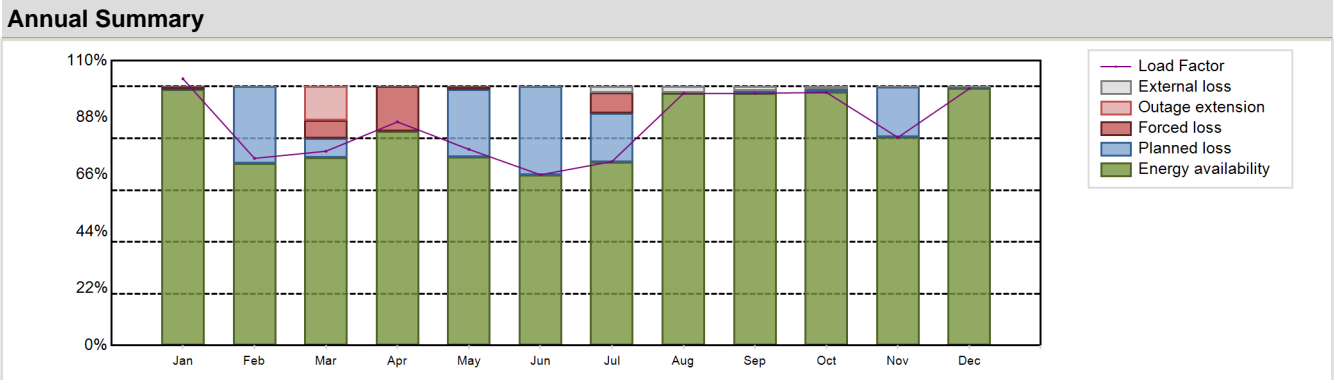
Status at end of year : **Operational**
 Operator : BRUCEPOW (Bruce Power)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)



| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 750A | Construction Date | : 1972-09-01 |
| Thermal power | : 2550 MWth | Grid Date | : 1978-12-21 |
| Gross electrical power | : 868 MWe | Commercial Date | : 1979-01-18 |
| Reference unit power (net) | : 807 MWe | Age at end of year | : 45 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 9.36 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 300 |
| Fuel material | : UO2 | Number of SG | : 8 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 1.74 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 8750 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 5.67 | HP cylinder inlet steam pressure [MPa] | : 4.37 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 6240 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 24.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 4 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 1 | Number of on-site safety related diesel generators | : NA |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 5895.12 GW(e).h | Forced Loss Rate (FLR) | : 3.23 % |
| Energy Availability Factor (EAF) | : 84.15 % | Unplanned Capability Loss Factor (UCL) | : 3.91 % |
| Unit Capability Factor (UCF) | : 84.77 % | Planned Unavailability Factor (PUF) | : 11.32 % |
| Load Factor (LF) | : 85.38 % | Externally cause unavailability (XUF) | : 0.62 % |
| Operating Factor (OF) | : 88.76 % | Total off-line time | : 985 hours |

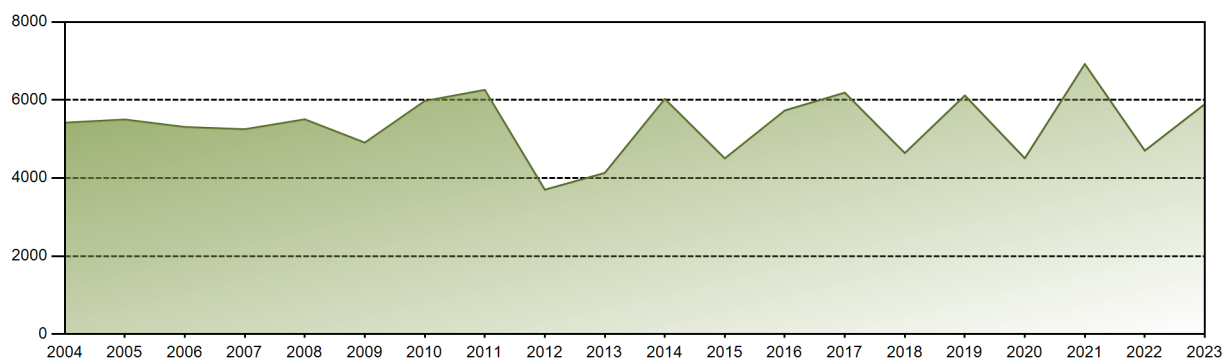


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 589.22 | 373.55 | 429.32 | 478.12 | 433.46 | 365.09 | 426.51 | 584.42 | 565.93 | 586.88 | 466.93 | 595.71 | 5895.12 |
| EAF [%] | 98.77 | 70.43 | 72.54 | 82.68 | 72.73 | 65.94 | 70.93 | 97.39 | 97.38 | 97.78 | 80.41 | 99.28 | 84.15 |
| UCF [%] | 98.77 | 70.43 | 72.54 | 82.68 | 72.73 | 65.94 | 73.35 | 99.67 | 98.93 | 98.62 | 80.50 | 99.32 | 84.77 |
| LF [%] | 102.99 | 72.29 | 75.04 | 86.35 | 75.76 | 65.94 | 71.04 | 97.34 | 97.40 | 97.75 | 80.36 | 99.22 | 85.38 |
| OF [%] | 100.00 | 71.13 | 75.81 | 83.06 | 73.79 | 83.61 | 93.01 | 100.00 | 100.00 | 100.00 | 82.78 | 100.00 | 88.76 |
| FLR [%] | 1.04 | 0.00 | 8.85 | 17.32 | 1.44 | 0.00 | 9.66 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 3.23 |
| UCL [%] | 1.04 | 0.00 | 20.08 | 17.32 | 1.06 | 0.00 | 7.85 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 3.91 |
| PUF [%] | 0.19 | 29.57 | 7.38 | 0.00 | 26.21 | 34.06 | 18.81 | 0.31 | 1.07 | 1.38 | 19.50 | 0.68 | 11.32 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.42 | 2.29 | 1.55 | 0.84 | 0.09 | 0.04 | 0.62 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 190125.39 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 13.8 % |
| Cumulative Energy Availability Factor (EAF) | : 74.69 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 13.04 % |
| Cumulative Unit Capability Factor (UCF) | : 75.33 % | Cumulative Planned Unavailability Factor (PUF) | : 11.63 % |
| Cumulative Load Factor (LF) | : 74.55 % | Cumulative Externally cause unavailability (XUF) | : 0.64 % |
| Cumulative Operating Factor (OF) | : 79.44 % | | |

Electricity Production (net) [GWh]

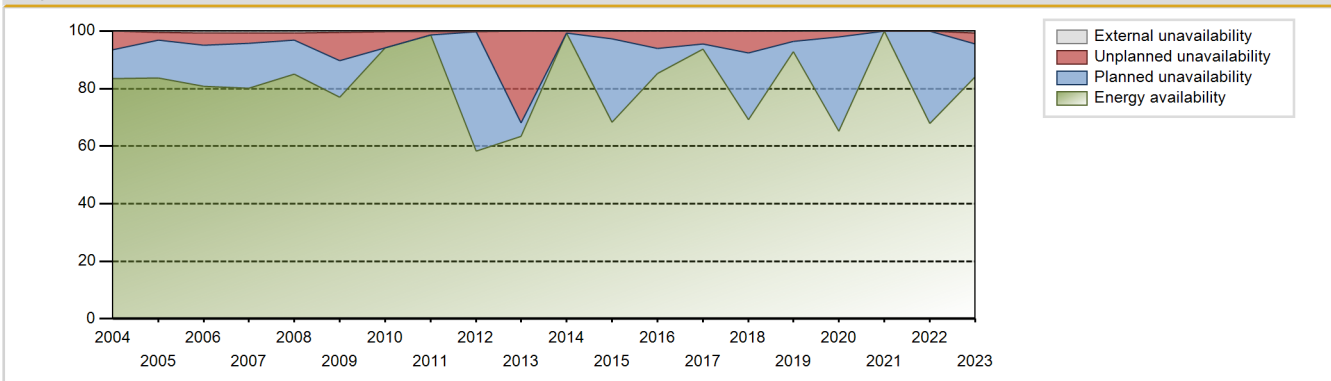


Performance for Years of Commercial Operation

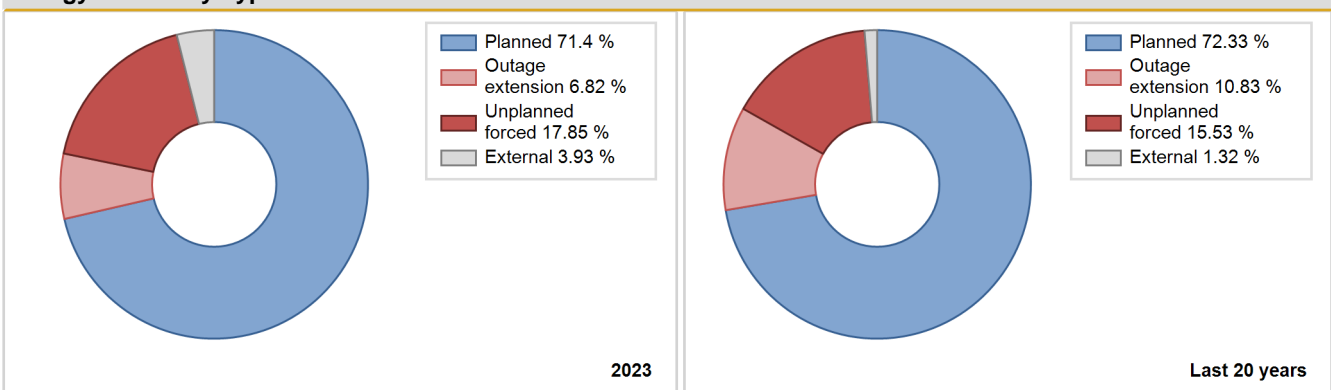
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|--|---------------------------|---------------------------------|---|--------|--------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1979 | 4966.40 | 7084 | 740 | 84.17 | 84.17 | 79.65 | 84.18 | 15.83 | 15.83 | 0.00 | 0.00 |
| 1980 | 4945.10 | 6962 | 740 | 76.12 | 76.12 | 76.08 | 79.26 | 14.06 | 12.46 | 11.42 | 0.00 |
| 1981 | 5753.50 | 7874 | 740 | 89.10 | 89.10 | 88.76 | 89.89 | 10.90 | 10.90 | 0.00 | 0.00 |
| 1982 | 6050.20 | 8150 | 740 | 92.18 | 92.18 | 93.33 | 93.04 | 2.13 | 2.01 | 5.81 | 0.00 |
| 1983 | 6407.40 | 8345 | 740 | 94.25 | 94.25 | 98.84 | 95.26 | 5.68 | 5.67 | 0.07 | 0.00 |
| 1984 | 6664.64 | 8625 | 740 | 97.85 | 97.85 | 102.53 | 98.19 | 2.08 | 2.07 | 0.08 | 0.00 |
| 1985 | 4995.16 | 6518 | 788 | 73.24 | 78.99 | 72.29 | 74.41 | 7.88 | 6.76 | 14.26 | 5.75 |
| 1986 | 6891.57 | 8644 | 848 | 92.85 | 95.51 | 92.77 | 98.68 | 4.49 | 4.49 | 0.00 | 2.67 |
| 1987 | 5044.99 | 6366 | 848 | 67.90 | 71.54 | 67.91 | 72.67 | 5.78 | 4.39 | 24.07 | 3.64 |
| 1988 | 4663.68 | 5997 | 848 | 65.71 | 66.92 | 62.61 | 68.27 | 18.05 | 14.74 | 18.34 | 1.21 |
| 1989 | 5584.21 | 7290 | 848 | 75.29 | 77.00 | 75.17 | 83.22 | 17.87 | 16.75 | 6.25 | 1.71 |
| 1990 | 3533.03 | 4611 | 848 | 47.54 | 48.29 | 47.56 | 52.64 | 51.71 | 51.71 | 0.00 | 0.75 |
| 1991 | 5940.70 | 7955 | 848 | 79.91 | 81.65 | 79.97 | 90.81 | 17.92 | 17.83 | 0.52 | 1.74 |
| 1992 | 5843.37 | 8070 | 848 | 78.37 | 80.08 | 78.45 | 91.87 | 19.92 | 19.92 | 0.00 | 1.71 |
| 1993 | 350.09 | 527 | 848 | 4.71 | 4.71 | 4.71 | 6.02 | 79.26 | 18.01 | 77.27 | 0.00 |
| 1994 | 3655.98 | 7206 | 848 | 49.30 | 49.30 | 49.22 | 82.26 | 50.38 | 50.06 | 0.64 | 0.00 |
| 1995 | 3034.92 | 5024 | 848 | 40.87 | 40.87 | 40.86 | 57.35 | 42.28 | 29.94 | 29.19 | 0.00 |
| 1996 | 5296.28 | 8686 | 848 | 71.17 | 71.17 | 71.10 | 98.88 | 28.83 | 28.83 | 0.00 | 0.00 |
| 1997 | 2923.05 | 4968 | 848 | 39.36 | 39.36 | 39.35 | 56.71 | 60.64 | 60.64 | 0.00 | 0.00 |
| 1998 | 12.34 | 45 | 848 | 0.81 | 0.81 | 0.81 | 2.50 | 99.19 | 99.19 | 0.00 | 0.00 |
| 1999 | Data not available - Suspended Operation | | | | | | | | | | |
| 2000 | " | | | | | | | | | | |
| 2001 | " | | | | | | | | | | |
| 2002 | " | | | | | | | | | | |
| 2003 | 934.47 | 802 | 769 | 100.00 | 100.00 | 55.01 | 36.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 5418.78 | 7469 | 769 | 83.42 | 83.42 | 82.08 | 85.03 | 6.58 | 6.45 | 10.13 | 0.00 |
| 2005 | 5499.12 | 7469 | 750 | 83.67 | 84.10 | 83.70 | 85.26 | 3.21 | 2.79 | 13.11 | 0.43 |
| 2006 | 5308.22 | 7261 | 750 | 80.78 | 81.59 | 80.79 | 82.89 | 2.28 | 4.12 | 14.29 | 0.81 |
| 2007 | 5250.98 | 7298 | 750 | 80.15 | 80.78 | 79.92 | 83.31 | 4.27 | 3.60 | 15.62 | 0.63 |
| 2008 | 5504.43 | 7603 | 734 | 84.92 | 85.62 | 85.37 | 86.56 | 2.17 | 2.35 | 12.03 | 0.70 |
| 2009 | 4907.55 | 7014 | 730 | 76.92 | 77.37 | 76.74 | 80.07 | 5.42 | 9.91 | 12.72 | 0.44 |
| 2010 | 5976.18 | 8360 | 730 | 94.11 | 94.49 | 93.45 | 95.43 | 5.50 | 5.50 | 0.02 | 0.37 |
| 2011 | 6259.24 | 8670 | 730 | 98.71 | 98.97 | 97.88 | 98.97 | 1.03 | 1.03 | 0.00 | 0.26 |
| 2012 | 3700.41 | 5137 | 730 | 58.31 | 58.46 | 57.71 | 58.48 | 0.00 | 0.00 | 41.54 | 0.15 |
| 2013 | 4131.32 | 5778 | 730 | 63.44 | 63.55 | 64.60 | 65.96 | 10.79 | 31.78 | 4.67 | 0.11 |
| 2014 | 6027.76 | 8243 | 730 | 99.39 | 99.39 | 94.26 | 94.10 | 0.61 | 0.61 | 0.00 | 0.00 |
| 2015 | 4503.60 | 6069 | 750 | 68.26 | 68.26 | 68.55 | 69.28 | 0.00 | 2.74 | 29.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|--------|--------|--------|------|------|-------|------|
| 2016 | 5731.38 | 7511 | 750 | 85.23 | 85.25 | 87.00 | 85.51 | 6.54 | 5.96 | 8.78 | 0.02 |
| 2017 | 6188.10 | 8262 | 750 | 93.76 | 93.77 | 94.19 | 94.32 | 4.65 | 4.58 | 1.65 | 0.02 |
| 2018 | 4638.81 | 6146 | 750 | 69.12 | 69.13 | 70.61 | 70.16 | 4.78 | 7.58 | 23.30 | 0.00 |
| 2019 | 6115.21 | 8168 | 750 | 92.93 | 92.93 | 93.08 | 93.24 | 3.71 | 3.58 | 3.49 | 0.00 |
| 2020 | 4506.10 | 5775 | 769 | 65.21 | 65.35 | 66.71 | 65.74 | 2.84 | 1.91 | 32.74 | 0.14 |
| 2021 | 6922.00 | 8760 | 769 | 99.98 | 100.00 | 102.75 | 100.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| 2022 | 4701.86 | 6006 | 769 | 67.91 | 68.04 | 69.80 | 68.56 | 0.00 | 0.00 | 31.96 | 0.13 |
| 2023 | 5895.12 | 7775 | 807 | 84.15 | 84.77 | 85.38 | 88.76 | 3.23 | 3.91 | 11.32 | 0.62 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1979 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 320 | | | 730 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 58 | | |
| D. Inspection, maintenance or repair without refuelling | 668 | | | 886 | | |
| E. Testing of plant systems or components | | | | 39 | | |
| H. Nuclear regulatory requirements | | | | | 5 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 15 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 2 |
| L. Human factor related | | | | | 7 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 13 |
| Z. Other | | | | | 11 | 2 |
| Subtotal | 668 | 320 | | 983 | 753 | 34 |
| Total | | 988 | | | 1770 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1979 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 98 |
| 12. Reactor I&C Systems | 47 | 41 |
| 14. Safety Systems | | 41 |
| 15. Reactor Cooling Systems | | 65 |
| 16. Steam generation systems | 123 | 162 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 17 |
| 31. Turbine and auxiliaries | 97 | 62 |
| 32. Feedwater and Main Steam System | | 32 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | | 31 |
| 35. All other I&C Systems | | 88 |
| 41. Main Generator Systems | | 73 |
| 42. Electrical Power Supply Systems | 52 | 33 |
| Total | 319 | 750 |

2023 Operating Experience

CA-18

BRUCE-5

CANADA

Status at end of year : **Operational**
 Operator : BRUCEPOW (Bruce Power)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : CGE (CANADIAN GENERAL ELECTRIC)



Reactor Unit Details

Reactor type and model : PHWR / CANDU 750B
 Thermal power : 2832 MWth
 Gross electrical power : 872 MWe
 Reference unit power (net) : 817 MWe

Key Dates

Construction Date : 1978-05-31
 Grid Date : 1984-12-01
 Commercial Date : 1985-02-28
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : NA
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 7710
 Active core diameter [m] : 5.67
 Active core height/length [m] : 5.94
 Number of fissile fuel assemblies/bundles : 6240
 Fuel linear heat generation rate [kW/m] : 24.5
 Number of control rod assemblies : 24
 Number of external reactor coolant loops : 1
 Coolant type : D2O

Operating coolant pressure [MPa] : 9.49
 Reactor outlet temperature [°C] : 305
 Number of SG : 8
 Containment type : Single
 Containment design pressure [MPa] : 1.88

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 4.78
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : NA

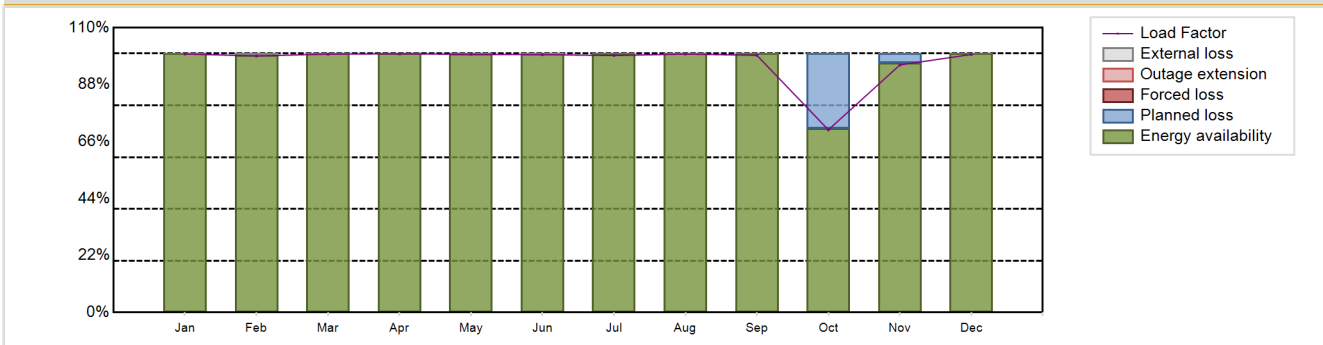
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6928.72 GW(e).h
 Energy Availability Factor (EAF) : 97.18 %
 Unit Capability Factor (UCF) : 97.25 %
 Load Factor (LF) : 96.81 %
 Operating Factor (OF) : 97.34 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 2.75 %
 Externally cause unavailability (XUF) : 0.07 %
 Total off-line time : 233 hours

Annual Summary

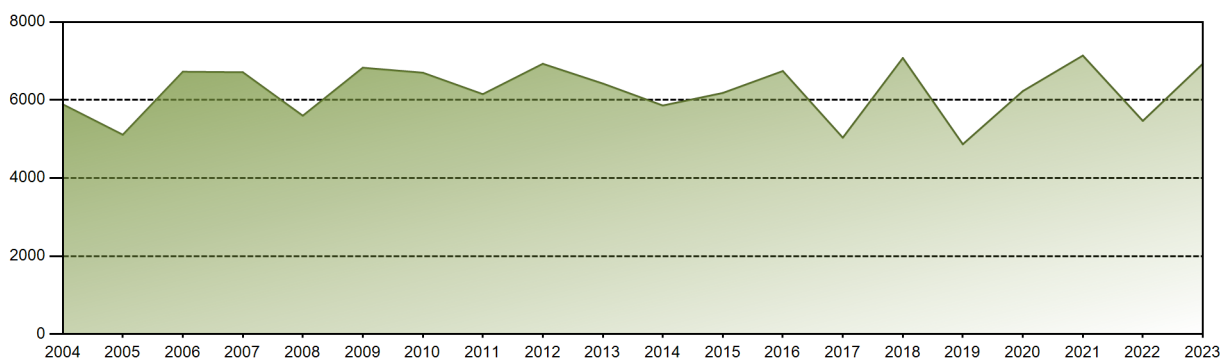


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 606.91 | 544.08 | 606.54 | 587.72 | 606.15 | 585.82 | 603.28 | 606.77 | 584.32 | 428.91 | 562.43 | 605.80 | 6928.72 |
| EAF [%] | 100.00 | 99.30 | 100.00 | 100.00 | 99.91 | 99.92 | 100.00 | 100.00 | 100.00 | 70.97 | 96.49 | 100.00 | 97.18 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 70.97 | 96.49 | 100.00 | 97.25 |
| LF [%] | 99.85 | 99.10 | 99.79 | 99.91 | 99.72 | 99.59 | 99.25 | 99.82 | 99.33 | 70.56 | 95.61 | 99.66 | 96.81 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 70.97 | 97.64 | 100.00 | 97.34 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 29.03 | 3.51 | 0.00 | 2.75 |
| XUF [%] | 0.00 | 0.70 | 0.00 | 0.00 | 0.09 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 237713.67 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.56 % |
| Cumulative Energy Availability Factor (EAF) | : 85.74 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.47 % |
| Cumulative Unit Capability Factor (UCF) | : 86.2 % | Cumulative Planned Unavailability Factor (PUF) | : 9.33 % |
| Cumulative Load Factor (LF) | : 85.06 % | Cumulative Externally cause unavailability (XUF) | : 0.46 % |
| Cumulative Operating Factor (OF) | : 88.1 % | | |

Electricity Production (net) [GWh]

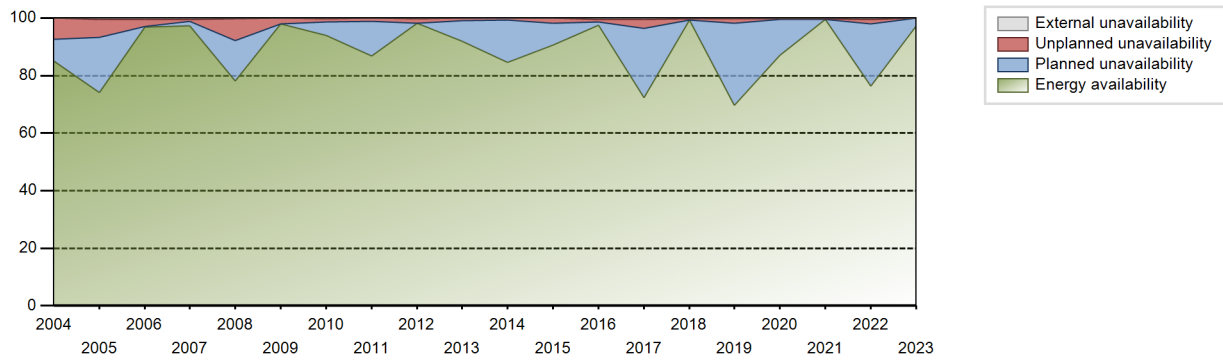


Performance for Years of Commercial Operation

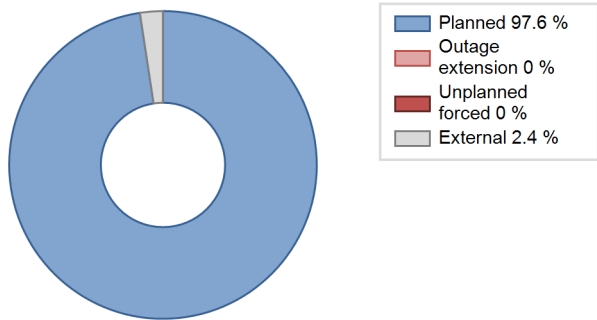
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 5464.16 | 7163 | 805 | 85.86 | 91.57 | 84.23 | 86.11 | 8.43 | 8.43 | 0.00 | 5.71 |
| 1986 | 7078.03 | 8675 | 835 | 96.67 | 98.43 | 96.77 | 99.03 | 1.57 | 1.57 | 0.00 | 1.76 |
| 1987 | 5730.15 | 7197 | 835 | 78.18 | 80.17 | 78.34 | 82.16 | 8.82 | 7.76 | 12.08 | 1.99 |
| 1988 | 6673.56 | 7824 | 860 | 88.49 | 88.52 | 88.34 | 89.07 | 6.14 | 5.79 | 5.69 | 0.02 |
| 1989 | 7130.76 | 8589 | 860 | 94.14 | 97.10 | 94.65 | 98.05 | 2.28 | 2.26 | 0.64 | 2.96 |
| 1990 | 5534.66 | 6656 | 860 | 73.53 | 74.60 | 73.47 | 75.98 | 10.83 | 9.06 | 16.34 | 1.06 |
| 1991 | 6769.63 | 8130 | 860 | 90.30 | 90.74 | 89.86 | 92.81 | 2.14 | 1.98 | 7.27 | 0.44 |
| 1992 | 6452.05 | 7636 | 860 | 85.79 | 85.79 | 85.41 | 86.93 | 4.20 | 3.76 | 10.45 | 0.00 |
| 1993 | 5118.34 | 7457 | 860 | 68.08 | 68.08 | 67.94 | 85.13 | 21.44 | 18.58 | 13.34 | 0.00 |
| 1994 | 5629.34 | 7671 | 860 | 75.02 | 75.02 | 74.72 | 87.57 | 15.74 | 14.02 | 10.97 | 0.00 |
| 1995 | 6125.27 | 7859 | 860 | 81.41 | 81.41 | 81.31 | 89.71 | 18.59 | 18.59 | 0.00 | 0.00 |
| 1996 | 5767.61 | 7153 | 860 | 76.40 | 76.40 | 76.35 | 81.43 | 8.58 | 7.17 | 16.42 | 0.00 |
| 1997 | 6388.27 | 8148 | 860 | 84.80 | 84.80 | 84.80 | 93.01 | 13.20 | 12.89 | 2.31 | 0.00 |
| 1998 | 5623.11 | 7305 | 785 | 81.68 | 81.69 | 81.77 | 83.39 | 10.74 | 9.83 | 8.48 | 0.01 |
| 1999 | 5281.90 | 6719 | 785 | 76.57 | 76.58 | 76.81 | 76.70 | 4.27 | 3.42 | 20.01 | 0.01 |
| 2000 | 6908.74 | 8719 | 785 | 99.08 | 99.08 | 100.19 | 99.26 | 0.92 | 0.92 | 0.00 | 0.00 |
| 2001 | 4902.08 | 6220 | 790 | 70.91 | 70.91 | 70.84 | 71.00 | 2.07 | 1.50 | 27.59 | 0.00 |
| 2002 | 5993.14 | 7630 | 790 | 86.28 | 86.28 | 86.60 | 87.10 | 3.85 | 3.86 | 9.86 | 0.00 |
| 2003 | 5302.51 | 6783 | 790 | 77.26 | 77.26 | 76.62 | 77.43 | 0.00 | 0.00 | 22.74 | 0.00 |
| 2004 | 5889.11 | 7543 | 790 | 85.13 | 85.13 | 84.87 | 85.87 | 2.05 | 7.33 | 7.54 | 0.00 |
| 2005 | 5109.63 | 6678 | 790 | 74.14 | 74.64 | 73.83 | 76.23 | 4.77 | 6.14 | 19.22 | 0.50 |
| 2006 | 6723.49 | 8694 | 806 | 96.79 | 97.18 | 95.89 | 99.25 | 2.60 | 2.60 | 0.22 | 0.38 |
| 2007 | 6710.89 | 8760 | 795 | 97.23 | 97.69 | 96.36 | 100.00 | 0.74 | 0.73 | 1.58 | 0.46 |
| 2008 | 5596.97 | 6943 | 817 | 78.05 | 78.30 | 77.99 | 79.04 | 6.40 | 7.64 | 14.05 | 0.25 |
| 2009 | 6826.70 | 8597 | 817 | 97.91 | 98.00 | 95.39 | 98.14 | 1.98 | 1.98 | 0.01 | 0.10 |
| 2010 | 6699.69 | 8368 | 817 | 93.97 | 94.15 | 93.61 | 95.53 | 1.20 | 1.14 | 4.71 | 0.18 |
| 2011 | 6149.76 | 7666 | 817 | 86.78 | 86.86 | 85.93 | 87.51 | 1.23 | 1.08 | 12.06 | 0.08 |
| 2012 | 6927.64 | 8690 | 817 | 98.24 | 98.38 | 96.53 | 98.93 | 1.58 | 1.58 | 0.03 | 0.14 |
| 2013 | 6421.79 | 8141 | 817 | 92.04 | 92.11 | 89.73 | 92.93 | 0.62 | 0.85 | 7.04 | 0.07 |
| 2014 | 5859.11 | 7487 | 817 | 84.64 | 84.76 | 81.87 | 85.47 | 0.00 | 0.51 | 14.73 | 0.11 |
| 2015 | 6180.84 | 7978 | 817 | 90.60 | 90.70 | 86.36 | 91.07 | 1.65 | 1.63 | 7.66 | 0.10 |
| 2016 | 6742.40 | 8613 | 817 | 97.45 | 97.86 | 93.95 | 98.05 | 0.87 | 0.86 | 1.28 | 0.41 |
| 2017 | 5034.08 | 6394 | 817 | 72.35 | 72.75 | 70.34 | 72.99 | 0.52 | 3.12 | 24.13 | 0.40 |
| 2018 | 7076.65 | 8760 | 817 | 99.38 | 99.64 | 98.88 | 100.00 | 0.36 | 0.36 | 0.00 | 0.26 |
| 2019 | 4865.80 | 6173 | 817 | 69.74 | 69.96 | 67.99 | 70.47 | 2.10 | 1.50 | 28.54 | 0.22 |
| 2020 | 6227.87 | 7682 | 817 | 87.06 | 87.37 | 86.78 | 87.45 | 0.08 | 0.07 | 12.56 | 0.31 |
| 2021 | 7138.88 | 8760 | 817 | 99.56 | 99.78 | 99.75 | 100.00 | 0.20 | 0.20 | 0.03 | 0.22 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 5465.11 | 6776 | 817 | 76.36 | 76.78 | 76.36 | 77.35 | 2.08 | 1.63 | 21.58 | 0.43 |
| 2023 | 6928.72 | 8527 | 817 | 97.18 | 97.25 | 96.81 | 97.34 | 0.00 | 0.00 | 2.75 | 0.07 |

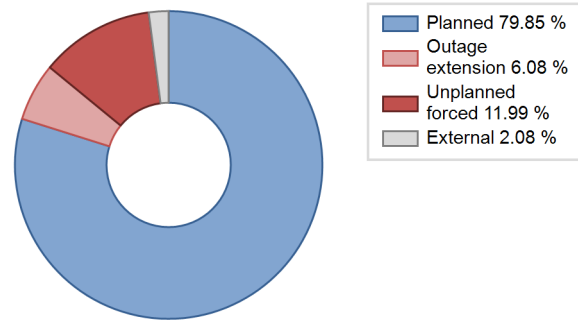
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 212 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 17 | | |
| D. Inspection, maintenance or repair without refuelling | 233 | | | 776 | 6 | |
| E. Testing of plant systems or components | | | | 5 | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 2 |
| L. Human factor related | | | | | 4 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 12 |
| Z. Other | | | | | 1 | |
| Subtotal | 233 | | | 798 | 223 | 15 |
| Total | | 233 | | | 1036 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 23 |
| 13. Reactor Auxiliary Systems | | 8 |
| 14. Safety Systems | | 16 |
| 15. Reactor Cooling Systems | | 70 |
| 16. Steam generation systems | | 19 |
| 21. Fuel Handling and Storage Facilities | | 22 |
| 31. Turbine and auxiliaries | | 16 |
| 32. Feedwater and Main Steam System | | 18 |
| 33. Circulating Water System | | 3 |
| 34. Miscellaneous Systems | | 2 |
| 41. Main Generator Systems | | 13 |
| 42. Electrical Power Supply Systems | | 10 |
| Total | | 222 |

2023 Operating Experience

CA-19

BRUCE-6

CANADA

Status at end of year : **Operational**
 Operator : BRUCEPOW (Bruce Power)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : CGE (CANADIAN GENERAL ELECTRIC)



Reactor Unit Details

Reactor type and model : PHWR / CANDU 750B
 Thermal power : 2690 MWth
 Gross electrical power : 891 MWe
 Reference unit power (net) : 817 MWe

Key Dates

Construction Date : 1978-01-01
 Grid Date : 1984-06-26
 Commercial Date : 1984-09-14
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : NA
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 7710
 Active core diameter [m] : 5.67
 Active core height/length [m] : 5.94
 Number of fissile fuel assemblies/bundles : 6240
 Fuel linear heat generation rate [kW/m] : 24.5
 Number of control rod assemblies : 24
 Number of external reactor coolant loops : 1
 Coolant type : D2O

Operating coolant pressure [MPa] : 9.49
 Reactor outlet temperature [°C] : 305
 Number of SG : 8
 Containment type : Single
 Containment design pressure [MPa] : 1.88

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 4.78
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : NA

Non-electrical applications

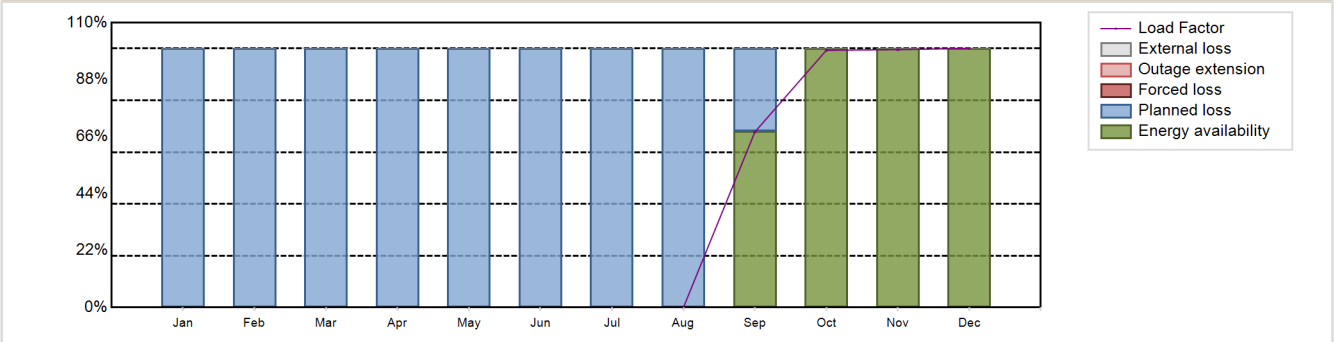
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 2197.13 GW(e).h
 Energy Availability Factor (EAF) : 30.8 %
 Unit Capability Factor (UCF) : 30.8 %
 Load Factor (LF) : 30.7 %
 Operating Factor (OF) : 31.5 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 69.2 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 6001 hours

Annual Summary

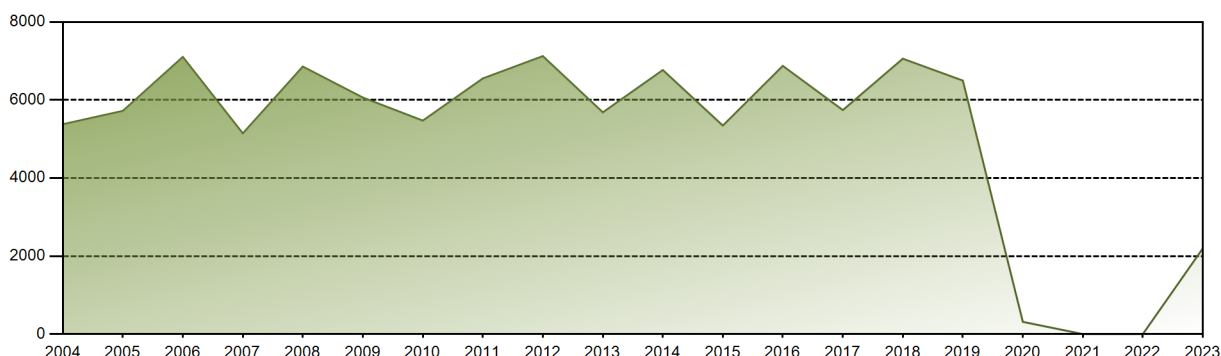


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 398.96 | 603.89 | 585.87 | 608.40 | 2197.13 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 68.08 | 100.00 | 100.00 | 100.00 | 30.80 |
| UCF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 68.08 | 100.00 | 100.00 | 100.00 | 30.80 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 67.82 | 99.35 | 99.60 | 100.09 | 30.70 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 76.53 | 100.00 | 100.00 | 100.00 | 31.50 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 31.92 | 0.00 | 0.00 | 0.00 | 69.20 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 206774.61 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.97 % |
| Cumulative Energy Availability Factor (EAF) | : 75.83 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.34 % |
| Cumulative Unit Capability Factor (UCF) | : 76.38 % | Cumulative Planned Unavailability Factor (PUF) | : 17.29 % |
| Cumulative Load Factor (LF) | : 75.19 % | Cumulative Externally cause unavailability (XUF) | : 0.54 % |
| Cumulative Operating Factor (OF) | : 78.17 % | | |

Electricity Production (net) [GWh]

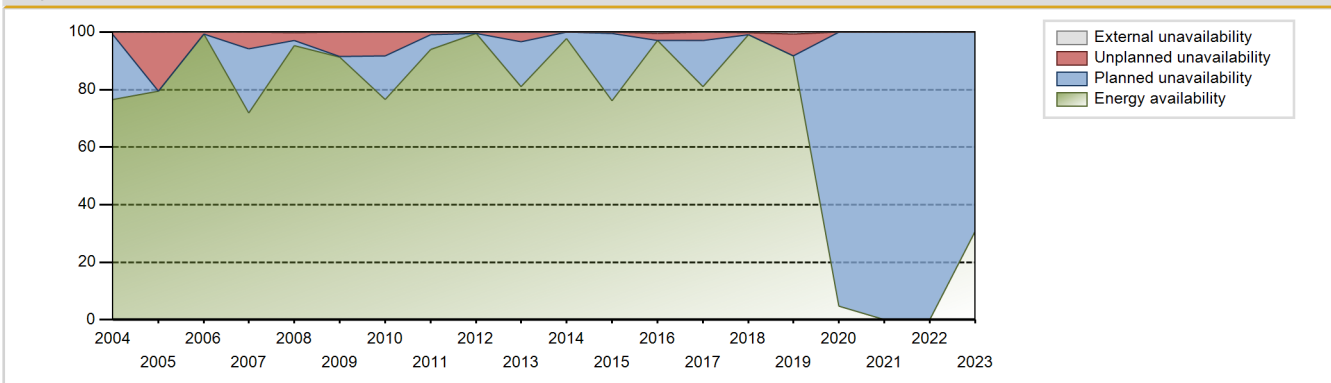


Performance for Years of Commercial Operation

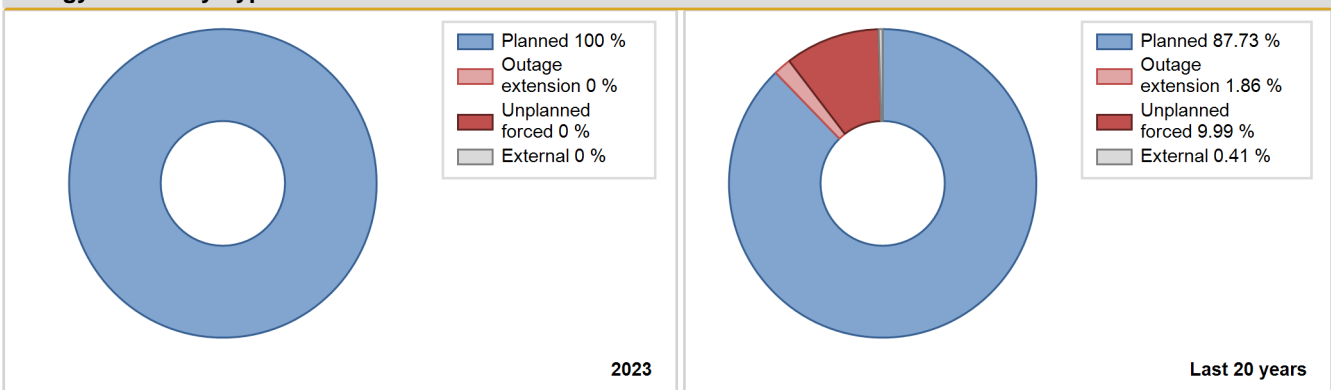
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 3068.32 | 4230 | 822 | 98.80 | 99.38 | 98.85 | 99.93 | 0.46 | 0.46 | 0.17 | 0.58 |
| 1985 | 5900.13 | 7369 | 805 | 84.04 | 88.69 | 83.66 | 84.12 | 10.23 | 10.10 | 1.20 | 4.65 |
| 1986 | 5716.03 | 7213 | 835 | 77.78 | 81.71 | 78.13 | 82.34 | 6.94 | 6.09 | 12.20 | 3.93 |
| 1987 | 7017.10 | 8610 | 837 | 95.33 | 97.85 | 95.70 | 98.29 | 1.92 | 1.92 | 0.23 | 2.52 |
| 1988 | 6139.49 | 7880 | 837 | 89.10 | 89.22 | 83.51 | 89.71 | 4.88 | 4.58 | 6.20 | 0.12 |
| 1989 | 5386.17 | 7069 | 837 | 73.43 | 78.94 | 73.46 | 80.70 | 8.94 | 7.75 | 13.32 | 5.50 |
| 1990 | 6213.64 | 7429 | 852 | 82.31 | 83.85 | 83.21 | 84.81 | 5.69 | 5.06 | 11.09 | 1.54 |
| 1991 | 7013.36 | 8194 | 860 | 93.03 | 93.31 | 93.09 | 93.54 | 0.94 | 0.89 | 5.81 | 0.27 |
| 1992 | 5328.20 | 6393 | 860 | 70.51 | 70.55 | 70.53 | 72.78 | 7.40 | 5.64 | 23.82 | 0.04 |
| 1993 | 4351.00 | 6950 | 860 | 58.03 | 58.03 | 57.75 | 79.34 | 38.84 | 36.85 | 5.12 | 0.00 |
| 1994 | 6451.71 | 8760 | 860 | 85.75 | 85.75 | 85.64 | 100.00 | 14.25 | 14.25 | 0.00 | 0.00 |
| 1995 | 4671.57 | 6049 | 860 | 62.10 | 62.10 | 62.01 | 69.05 | 11.48 | 8.05 | 29.85 | 0.00 |
| 1996 | 6822.75 | 8682 | 860 | 90.38 | 90.39 | 90.32 | 98.84 | 9.61 | 9.61 | 0.00 | 0.01 |
| 1997 | 4796.41 | 6201 | 860 | 63.70 | 63.70 | 63.67 | 70.79 | 26.88 | 23.42 | 12.88 | 0.00 |
| 1998 | 4678.62 | 6137 | 785 | 68.04 | 68.11 | 68.04 | 70.06 | 21.80 | 18.98 | 12.91 | 0.07 |
| 1999 | 6860.15 | 8760 | 785 | 99.32 | 99.44 | 99.76 | 100.00 | 0.56 | 0.56 | 0.00 | 0.12 |
| 2000 | 4668.21 | 5912 | 785 | 66.81 | 66.81 | 67.70 | 67.30 | 11.72 | 8.87 | 24.32 | 0.00 |
| 2001 | 6840.06 | 8624 | 790 | 98.32 | 98.32 | 98.84 | 98.45 | 1.68 | 1.68 | 0.00 | 0.00 |
| 2002 | 3522.45 | 4539 | 790 | 50.64 | 50.64 | 50.90 | 51.82 | 0.42 | 14.91 | 34.45 | 0.00 |
| 2003 | 6750.85 | 8559 | 790 | 98.18 | 98.18 | 97.55 | 97.71 | 1.81 | 1.81 | 0.01 | 0.00 |
| 2004 | 5379.09 | 6698 | 790 | 76.65 | 76.65 | 75.43 | 76.25 | 1.06 | 0.98 | 22.37 | 0.00 |
| 2005 | 5721.10 | 7151 | 841 | 79.56 | 79.56 | 78.90 | 81.63 | 20.44 | 20.44 | 0.00 | 0.00 |
| 2006 | 7104.45 | 8760 | 822 | 99.32 | 99.45 | 98.66 | 100.00 | 0.50 | 0.50 | 0.06 | 0.12 |
| 2007 | 5145.02 | 6363 | 822 | 71.77 | 71.77 | 71.45 | 72.64 | 7.49 | 5.81 | 22.42 | 0.00 |
| 2008 | 6857.25 | 8452 | 817 | 95.35 | 95.52 | 95.55 | 96.22 | 2.77 | 2.72 | 1.77 | 0.17 |
| 2009 | 6063.07 | 7732 | 817 | 91.32 | 91.36 | 84.72 | 88.26 | 8.43 | 8.41 | 0.23 | 0.04 |
| 2010 | 5471.91 | 6815 | 817 | 76.54 | 76.67 | 76.46 | 77.80 | 4.31 | 8.21 | 15.12 | 0.13 |
| 2011 | 6552.52 | 8277 | 817 | 94.00 | 94.07 | 91.55 | 94.49 | 0.84 | 0.80 | 5.13 | 0.07 |
| 2012 | 7125.32 | 8784 | 817 | 99.58 | 99.72 | 99.29 | 100.00 | 0.28 | 0.28 | 0.00 | 0.14 |
| 2013 | 5684.00 | 7174 | 817 | 81.00 | 81.07 | 79.42 | 81.89 | 0.67 | 3.27 | 15.66 | 0.07 |
| 2014 | 6768.62 | 8488 | 817 | 97.74 | 97.85 | 94.57 | 96.89 | 0.00 | 0.00 | 2.15 | 0.11 |
| 2015 | 5344.31 | 6694 | 817 | 76.15 | 76.15 | 74.67 | 76.42 | 0.74 | 0.57 | 23.28 | 0.00 |
| 2016 | 6875.21 | 8613 | 817 | 97.09 | 97.61 | 95.80 | 98.05 | 2.39 | 2.39 | 0.00 | 0.52 |
| 2017 | 5741.56 | 7164 | 817 | 80.96 | 81.10 | 80.22 | 81.78 | 0.19 | 2.89 | 16.01 | 0.14 |
| 2018 | 7059.65 | 8718 | 817 | 99.03 | 99.18 | 98.64 | 99.52 | 0.80 | 0.80 | 0.02 | 0.15 |
| 2019 | 6498.25 | 8224 | 817 | 91.71 | 92.35 | 90.80 | 93.88 | 7.63 | 7.63 | 0.02 | 0.64 |
| 2020 | 313.80 | 408 | 817 | 4.74 | 4.74 | 4.37 | 4.64 | 0.74 | 0.04 | 95.22 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|--------|------|
| 2021 | 0.00 | 0 | 817 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2022 | 0.00 | 0 | 817 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2023 | 2197.13 | 2759 | 817 | 30.80 | 30.80 | 30.70 | 31.50 | 0.00 | 0.00 | 69.20 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 328 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 289 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 610 | 4 | |
| E. Testing of plant systems or components | | | | 0 | 16 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 454 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | 6001 | | | 153 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 14 |
| L. Human factor related | | | | | 15 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 11 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 10 | |
| Z. Other | | | | | 12 | |
| Subtotal | 6001 | | | 1506 | 385 | 27 |
| Total | | 6001 | | | 1918 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 81 |
| 12. Reactor I&C Systems | | 50 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 22 |
| 15. Reactor Cooling Systems | | 91 |
| 16. Steam generation systems | | 51 |
| 21. Fuel Handling and Storage Facilities | | 9 |
| 31. Turbine and auxiliaries | | 12 |
| 32. Feedwater and Main Steam System | | 14 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | | 2 |
| 35. All other I&C Systems | | 6 |
| 41. Main Generator Systems | | 3 |
| 42. Electrical Power Supply Systems | | 18 |
| Total | | 367 |

2023 Operating Experience

CA-20

BRUCE-7

CANADA

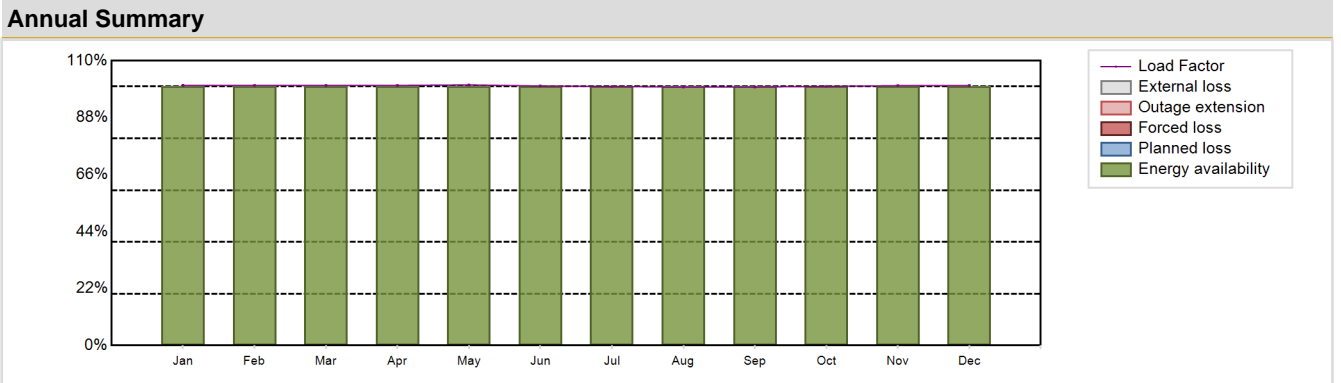
Status at end of year : **Operational**
 Operator : BRUCEPOW (Bruce Power)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : CGE (CANADIAN GENERAL ELECTRIC)



| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 750B | Construction Date | : 1979-05-01 |
| Thermal power | : 2832 MWth | Grid Date | : 1986-02-22 |
| Gross electrical power | : 872 MWe | Commercial Date | : 1986-04-10 |
| Reference unit power (net) | : 817 MWe | Age at end of year | : 37 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 9.49 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 305 |
| Fuel material | : UO2 | Number of SG | : 8 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 1.88 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 7710 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 5.67 | HP cylinder inlet steam pressure [MPa] | : 4.78 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 6240 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 24.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 24 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 1 | Number of on-site safety related diesel generators | : NA |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 7176.72 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 100 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 100 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 100.28 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

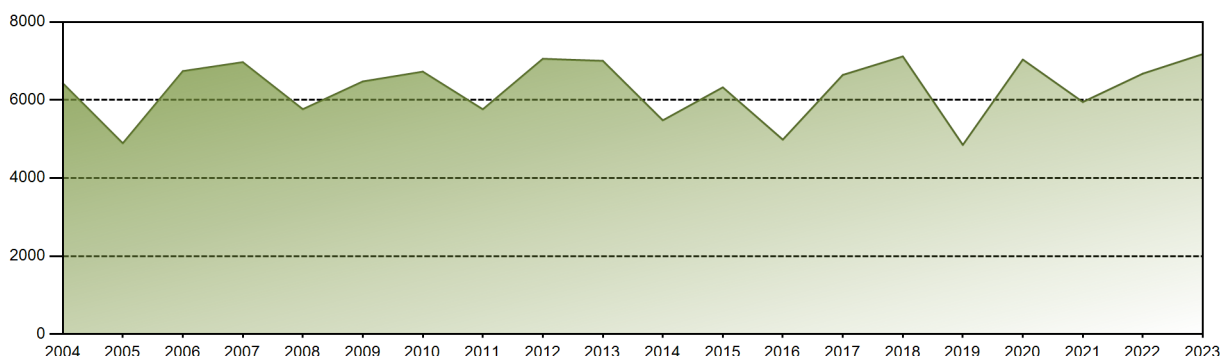


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 610.84 | 551.54 | 610.71 | 590.96 | 611.88 | 589.67 | 607.96 | 606.67 | 587.39 | 608.22 | 590.45 | 610.41 | 7176.72 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| LF [%] | 100.49 | 100.46 | 100.47 | 100.46 | 100.66 | 100.24 | 100.02 | 99.81 | 99.86 | 100.06 | 100.38 | 100.42 | 100.28 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 232224.54 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.75 % |
| Cumulative Energy Availability Factor (EAF) | : 86.28 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5 % |
| Cumulative Unit Capability Factor (UCF) | : 86.92 % | Cumulative Planned Unavailability Factor (PUF) | : 8.08 % |
| Cumulative Load Factor (LF) | : 85.41 % | Cumulative Externally cause unavailability (XUF) | : 0.64 % |
| Cumulative Operating Factor (OF) | : 89 % | | |

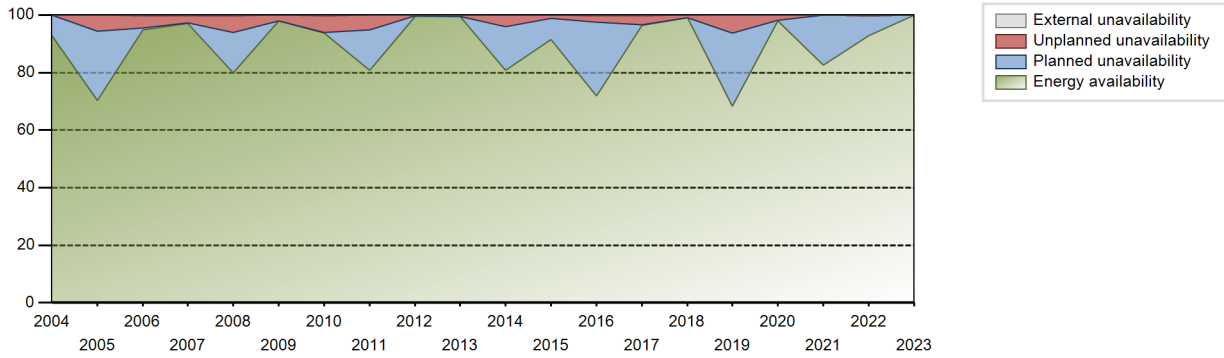
Electricity Production (net) [GWh]



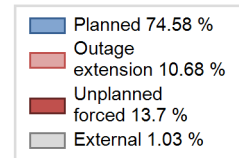
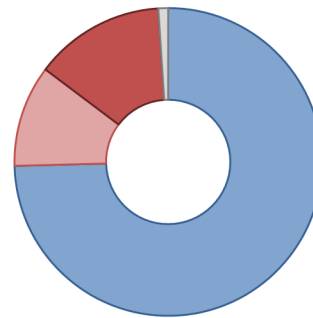
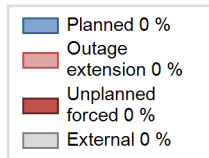
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 5256.62 | 6957 | 838 | 89.83 | 96.68 | 89.66 | 97.55 | 3.31 | 3.30 | 0.02 | 6.85 |
| 1987 | 6288.05 | 8489 | 837 | 85.91 | 96.87 | 85.76 | 96.91 | 2.80 | 2.79 | 0.34 | 10.96 |
| 1988 | 4866.19 | 6636 | 846 | 74.75 | 74.75 | 65.44 | 75.55 | 9.46 | 7.81 | 17.44 | 0.00 |
| 1989 | 7280.79 | 8632 | 860 | 96.44 | 97.83 | 96.64 | 98.54 | 1.83 | 1.82 | 0.35 | 1.39 |
| 1990 | 6659.40 | 8065 | 860 | 88.53 | 90.69 | 88.40 | 92.07 | 4.64 | 4.41 | 4.89 | 2.17 |
| 1991 | 5733.63 | 6835 | 860 | 76.27 | 76.39 | 76.11 | 78.03 | 8.22 | 6.84 | 16.77 | 0.12 |
| 1992 | 6413.41 | 7589 | 860 | 85.11 | 85.16 | 84.90 | 86.40 | 1.64 | 1.42 | 13.42 | 0.05 |
| 1993 | 5802.33 | 8760 | 860 | 78.12 | 78.12 | 77.02 | 100.00 | 21.87 | 21.87 | 0.00 | 0.00 |
| 1994 | 5496.71 | 7577 | 860 | 73.20 | 73.20 | 72.96 | 86.50 | 17.13 | 15.13 | 11.67 | 0.00 |
| 1995 | 6285.10 | 8092 | 860 | 83.47 | 83.47 | 83.43 | 92.37 | 16.53 | 16.53 | 0.00 | 0.00 |
| 1996 | 5475.68 | 7000 | 860 | 72.55 | 72.58 | 72.48 | 79.69 | 16.16 | 13.98 | 13.44 | 0.03 |
| 1997 | 6154.48 | 7874 | 860 | 81.69 | 81.69 | 81.69 | 89.89 | 18.31 | 18.31 | 0.00 | 0.00 |
| 1998 | 4990.76 | 6474 | 785 | 72.42 | 72.42 | 72.58 | 73.90 | 6.83 | 5.31 | 22.27 | 0.00 |
| 1999 | 6315.74 | 8208 | 785 | 91.84 | 92.29 | 91.84 | 93.70 | 7.71 | 7.71 | 0.00 | 0.44 |
| 2000 | 5322.68 | 6790 | 785 | 76.91 | 78.20 | 77.19 | 77.30 | 1.57 | 1.25 | 20.55 | 1.29 |
| 2001 | 7026.30 | 8760 | 790 | 100.00 | 100.00 | 101.53 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2002 | 4819.35 | 6121 | 790 | 69.49 | 69.49 | 69.64 | 69.87 | 1.46 | 3.67 | 26.84 | 0.00 |
| 2003 | 6730.24 | 8592 | 790 | 97.66 | 97.66 | 97.25 | 98.08 | 2.20 | 2.20 | 0.14 | 0.00 |
| 2004 | 6428.77 | 8188 | 790 | 92.77 | 92.77 | 92.64 | 93.21 | 0.00 | 0.03 | 7.20 | 0.00 |
| 2005 | 4890.45 | 6310 | 790 | 70.21 | 70.23 | 70.07 | 72.03 | 3.28 | 5.70 | 24.07 | 0.02 |
| 2006 | 6740.47 | 8486 | 806 | 94.79 | 95.06 | 94.37 | 96.87 | 4.30 | 4.27 | 0.67 | 0.28 |
| 2007 | 6969.91 | 8570 | 822 | 97.07 | 97.33 | 96.79 | 97.83 | 2.49 | 2.48 | 0.18 | 0.26 |
| 2008 | 5763.74 | 7101 | 817 | 79.92 | 80.08 | 80.31 | 80.84 | 3.49 | 5.99 | 13.93 | 0.16 |
| 2009 | 6475.33 | 8144 | 817 | 97.93 | 97.93 | 90.48 | 92.97 | 1.99 | 1.98 | 0.08 | 0.01 |
| 2010 | 6726.64 | 8610 | 817 | 93.68 | 93.84 | 93.99 | 98.29 | 5.98 | 5.97 | 0.19 | 0.16 |
| 2011 | 5761.53 | 7137 | 817 | 80.73 | 80.82 | 80.50 | 81.47 | 0.17 | 4.98 | 14.20 | 0.09 |
| 2012 | 7055.97 | 8731 | 817 | 99.55 | 99.68 | 98.32 | 99.40 | 0.24 | 0.24 | 0.08 | 0.14 |
| 2013 | 7003.57 | 8758 | 817 | 99.42 | 99.49 | 97.86 | 99.98 | 0.51 | 0.51 | 0.00 | 0.07 |
| 2014 | 5479.21 | 7113 | 817 | 80.72 | 80.72 | 76.56 | 81.20 | 1.04 | 4.01 | 15.27 | 0.00 |
| 2015 | 6324.10 | 8029 | 817 | 91.46 | 91.46 | 88.36 | 91.66 | 1.35 | 1.26 | 7.29 | 0.00 |
| 2016 | 4983.38 | 6332 | 817 | 71.92 | 72.20 | 69.44 | 72.09 | 0.00 | 2.23 | 25.57 | 0.27 |
| 2017 | 6643.16 | 8431 | 817 | 96.33 | 96.53 | 92.82 | 96.24 | 3.28 | 3.27 | 0.20 | 0.20 |
| 2018 | 7116.79 | 8715 | 817 | 99.01 | 99.07 | 99.44 | 99.49 | 0.91 | 0.91 | 0.02 | 0.06 |
| 2019 | 4849.09 | 6036 | 817 | 68.32 | 68.46 | 67.75 | 68.90 | 0.19 | 6.15 | 25.39 | 0.14 |
| 2020 | 7036.81 | 8664 | 817 | 97.96 | 98.04 | 98.05 | 98.63 | 1.71 | 1.71 | 0.25 | 0.08 |
| 2021 | 5948.94 | 7264 | 817 | 82.66 | 82.76 | 83.12 | 82.92 | 0.00 | 0.00 | 17.24 | 0.09 |
| 2022 | 6676.03 | 8208 | 817 | 92.94 | 93.10 | 93.28 | 93.70 | 0.07 | 0.06 | 6.84 | 0.16 |

2023 7176.72 8760 817 100.00 100.00 100.28 100.00 0.00 0.00 0.00 0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type



2023

Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 228 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 17 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 610 | 8 | |
| E. Testing of plant systems or components | | | | 8 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 60 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 18 |
| L. Human factor related | | | | | 3 | |
| Z. Other | | | | | 9 | 3 |
| Subtotal | | | | 695 | 248 | 21 |
| Total | | 0 | | | 964 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 13 |
| 12. Reactor I&C Systems | | 30 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 5 |
| 15. Reactor Cooling Systems | | 37 |
| 16. Steam generation systems | | 23 |
| 21. Fuel Handling and Storage Facilities | | 25 |
| 31. Turbine and auxiliaries | | 29 |
| 32. Feedwater and Main Steam System | | 27 |
| 33. Circulating Water System | | 4 |
| 34. Miscellaneous Systems | | 28 |
| 41. Main Generator Systems | | 9 |
| 42. Electrical Power Supply Systems | | 15 |
| Total | | 247 |

2023 Operating Experience

CA-21

BRUCE-8

CANADA

Status at end of year : **Operational**
 Operator : BRUCEPOW (Bruce Power)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : CGE (CANADIAN GENERAL ELECTRIC)



Reactor Unit Details

Reactor type and model : PHWR / CANDU 750B
 Thermal power : 2690 MWth
 Gross electrical power : 872 MWe
 Reference unit power (net) : 817 MWe

Key Dates

Construction Date : 1979-07-30
 Grid Date : 1987-03-07
 Commercial Date : 1987-05-20
 Age at end of year : 36 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : NA
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 7710
 Active core diameter [m] : 5.67
 Active core height/length [m] : 5.94
 Number of fissile fuel assemblies/bundles : 6240
 Fuel linear heat generation rate [kW/m] : 24.5
 Number of control rod assemblies : 24
 Number of external reactor coolant loops : 1
 Coolant type : D2O

Operating coolant pressure [MPa] : 9.49
 Reactor outlet temperature [°C] : 305
 Number of SG : 8
 Containment type : Single
 Containment design pressure [MPa] : 1.88

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 4.78
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : NA

Non-electrical applications

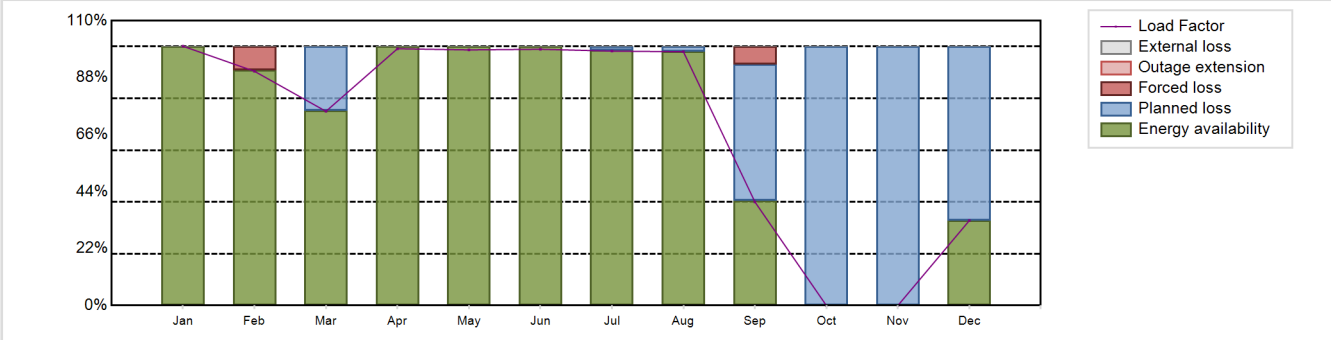
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 4955.12 GW(e).h
 Energy Availability Factor (EAF) : 69.63 %
 Unit Capability Factor (UCF) : 69.63 %
 Load Factor (LF) : 69.24 %
 Operating Factor (OF) : 71.32 %

Forced Loss Rate (FLR) : 1.77 %
 Unplanned Capability Loss Factor (UCL) : 1.26 %
 Planned Unavailability Factor (PUF) : 29.12 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 2512 hours

Annual Summary

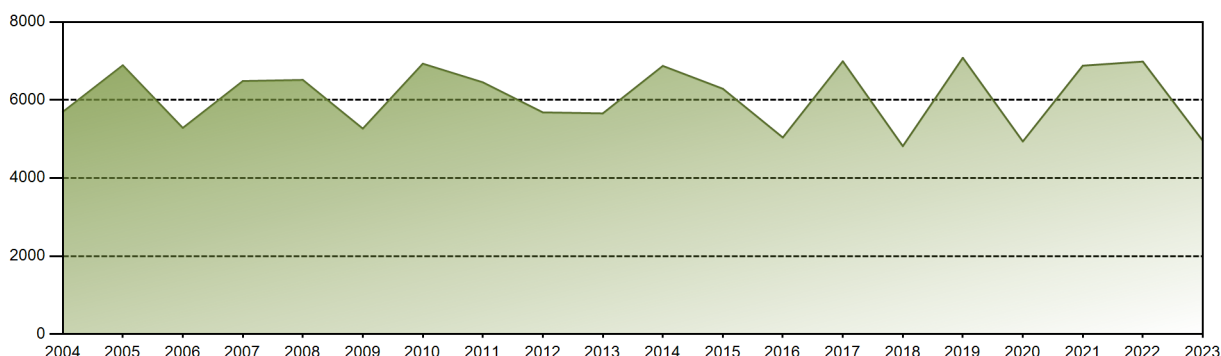


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 608.77 | 496.72 | 455.90 | 583.41 | 600.04 | 582.17 | 597.23 | 595.81 | 235.53 | 0.00 | 0.00 | 199.53 | 4955.12 |
| EAF [%] | 100.00 | 90.92 | 75.22 | 100.00 | 100.00 | 100.00 | 98.55 | 98.23 | 40.61 | 0.00 | 0.00 | 32.83 | 69.63 |
| UCF [%] | 100.00 | 90.92 | 75.22 | 100.00 | 100.00 | 100.00 | 98.55 | 98.23 | 40.61 | 0.00 | 0.00 | 32.83 | 69.63 |
| LF [%] | 100.15 | 90.47 | 75.00 | 99.18 | 98.72 | 98.97 | 98.25 | 98.02 | 40.04 | 0.00 | 0.00 | 32.83 | 69.24 |
| OF [%] | 100.00 | 90.92 | 76.88 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 42.92 | 0.00 | 0.00 | 45.70 | 71.32 |
| FLR [%] | 0.00 | 9.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.35 | 0.00 | 0.00 | 0.00 | 1.77 |
| UCL [%] | 0.00 | 9.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.81 | 0.00 | 0.00 | 0.00 | 1.26 |
| PUF [%] | 0.00 | 0.00 | 24.78 | 0.00 | 0.00 | 0.00 | 1.45 | 1.77 | 52.59 | 100.00 | 100.00 | 67.17 | 29.12 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

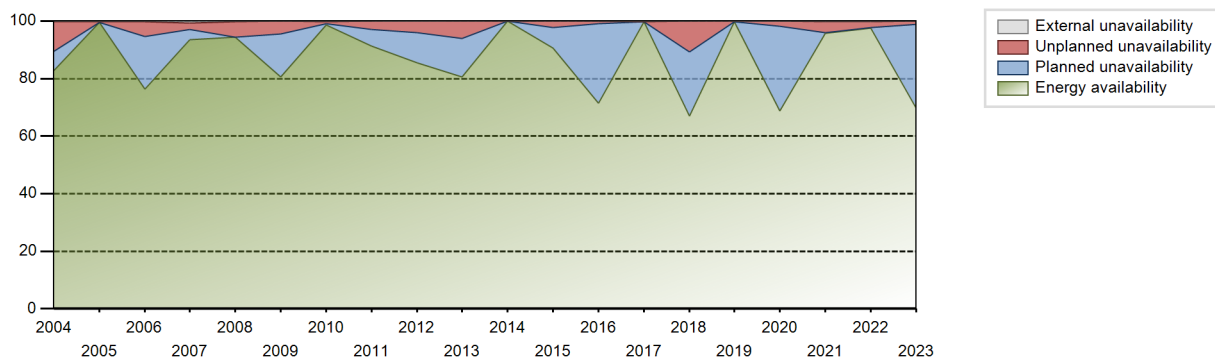
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 217835.18 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.61 % |
| Cumulative Energy Availability Factor (EAF) | : 83.98 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.79 % |
| Cumulative Unit Capability Factor (UCF) | : 84.79 % | Cumulative Planned Unavailability Factor (PUF) | : 9.42 % |
| Cumulative Load Factor (LF) | : 83.16 % | Cumulative Externally cause unavailability (XUF) | : 0.82 % |
| Cumulative Operating Factor (OF) | : 86.93 % | | |

Electricity Production (net) [GWh]

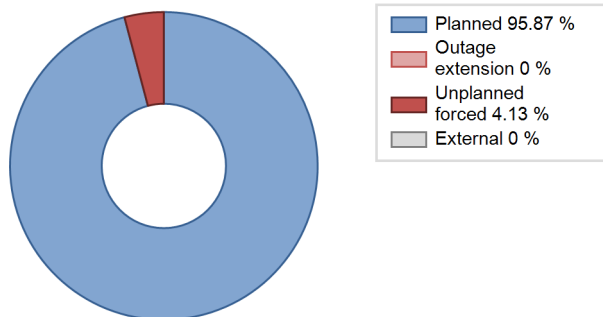


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 3673.23 | 5849 | 844 | 76.58 | 99.06 | 76.45 | 99.90 | 0.69 | 0.69 | 0.25 | 22.48 |
| 1988 | 5958.52 | 7659 | 837 | 86.53 | 86.85 | 81.04 | 87.19 | 8.74 | 8.32 | 4.83 | 0.32 |
| 1989 | 6523.47 | 8661 | 837 | 89.21 | 98.45 | 88.97 | 98.87 | 1.29 | 1.29 | 0.26 | 9.24 |
| 1990 | 5758.67 | 7186 | 842 | 78.09 | 80.67 | 78.00 | 82.03 | 7.58 | 6.62 | 12.71 | 2.58 |
| 1991 | 6932.70 | 8213 | 860 | 92.47 | 92.96 | 92.02 | 93.76 | 1.65 | 1.56 | 5.48 | 0.48 |
| 1992 | 5451.09 | 6587 | 860 | 72.41 | 72.43 | 72.16 | 74.99 | 11.73 | 9.63 | 17.94 | 0.02 |
| 1993 | 4675.90 | 7064 | 860 | 62.27 | 62.27 | 62.07 | 80.64 | 28.79 | 25.18 | 12.55 | 0.00 |
| 1994 | 6443.16 | 8760 | 860 | 86.00 | 86.00 | 85.53 | 100.00 | 13.88 | 13.86 | 0.15 | 0.00 |
| 1995 | 6113.35 | 7876 | 860 | 81.34 | 81.34 | 81.15 | 89.91 | 9.36 | 8.40 | 10.26 | 0.00 |
| 1996 | 6957.82 | 8783 | 860 | 92.14 | 92.14 | 92.10 | 99.99 | 7.86 | 7.86 | 0.00 | 0.00 |
| 1997 | 6346.54 | 8003 | 860 | 84.24 | 84.24 | 84.24 | 91.36 | 15.73 | 15.72 | 0.03 | 0.00 |
| 1998 | 4122.43 | 5368 | 785 | 59.76 | 59.86 | 59.95 | 61.28 | 18.78 | 13.84 | 26.30 | 0.10 |
| 1999 | 4114.43 | 5414 | 785 | 59.77 | 59.98 | 59.83 | 61.80 | 15.23 | 10.77 | 29.25 | 0.21 |
| 2000 | 6530.94 | 8293 | 785 | 93.67 | 93.67 | 94.71 | 94.41 | 4.25 | 4.16 | 2.17 | 0.00 |
| 2001 | 5424.77 | 6852 | 790 | 78.03 | 78.03 | 78.39 | 78.22 | 4.50 | 3.67 | 18.30 | 0.00 |
| 2002 | 6685.96 | 8543 | 790 | 97.01 | 97.01 | 96.61 | 97.52 | 2.99 | 2.99 | 0.00 | 0.00 |
| 2003 | 4959.99 | 6301 | 790 | 71.89 | 71.89 | 71.67 | 71.93 | 0.08 | 11.29 | 16.81 | 0.00 |
| 2004 | 5695.77 | 7374 | 790 | 82.80 | 83.01 | 82.08 | 83.95 | 11.13 | 10.39 | 6.60 | 0.21 |
| 2005 | 6889.22 | 8745 | 790 | 99.44 | 99.65 | 99.55 | 99.83 | 0.34 | 0.34 | 0.01 | 0.22 |
| 2006 | 5283.88 | 6791 | 790 | 76.37 | 76.58 | 76.31 | 77.52 | 4.47 | 5.14 | 18.28 | 0.20 |
| 2007 | 6485.25 | 8341 | 795 | 93.39 | 94.04 | 93.12 | 95.22 | 2.41 | 2.32 | 3.64 | 0.65 |
| 2008 | 6514.39 | 8699 | 782 | 94.30 | 94.52 | 94.84 | 99.03 | 5.43 | 5.42 | 0.06 | 0.22 |
| 2009 | 5266.44 | 6906 | 782 | 80.58 | 80.58 | 76.88 | 78.84 | 1.79 | 4.43 | 14.99 | 0.00 |
| 2010 | 6930.19 | 8760 | 817 | 98.61 | 98.78 | 98.93 | 100.00 | 0.75 | 0.74 | 0.48 | 0.16 |
| 2011 | 6453.40 | 8015 | 817 | 91.37 | 91.44 | 90.17 | 91.50 | 1.81 | 2.81 | 5.75 | 0.07 |
| 2012 | 5682.67 | 7161 | 817 | 85.48 | 85.62 | 79.18 | 81.52 | 1.87 | 3.88 | 10.51 | 0.14 |
| 2013 | 5656.62 | 7141 | 817 | 80.58 | 80.64 | 79.04 | 81.52 | 7.01 | 6.08 | 13.28 | 0.07 |
| 2014 | 6873.54 | 8760 | 817 | 99.87 | 99.87 | 96.04 | 100.00 | 0.13 | 0.13 | 0.00 | 0.00 |
| 2015 | 6288.54 | 8001 | 817 | 90.66 | 90.66 | 87.87 | 91.34 | 2.36 | 2.19 | 7.15 | 0.00 |
| 2016 | 5038.39 | 6291 | 817 | 71.41 | 71.41 | 70.21 | 71.62 | 1.17 | 0.84 | 27.74 | 0.00 |
| 2017 | 6992.50 | 8760 | 817 | 99.70 | 99.98 | 97.70 | 100.00 | 0.00 | 0.00 | 0.02 | 0.28 |
| 2018 | 4816.88 | 6123 | 817 | 67.07 | 67.14 | 67.30 | 69.90 | 2.68 | 10.62 | 22.25 | 0.07 |
| 2019 | 7082.00 | 8760 | 817 | 99.75 | 99.82 | 98.95 | 100.00 | 0.18 | 0.18 | 0.01 | 0.07 |
| 2020 | 4936.59 | 6141 | 817 | 68.69 | 68.82 | 68.79 | 69.91 | 2.40 | 1.69 | 29.49 | 0.13 |
| 2021 | 6880.50 | 8472 | 817 | 95.80 | 96.12 | 96.14 | 96.71 | 3.81 | 3.81 | 0.07 | 0.32 |
| 2022 | 6985.60 | 8616 | 817 | 97.52 | 97.85 | 97.61 | 98.36 | 2.01 | 2.01 | 0.14 | 0.33 |
| 2023 | 4955.12 | 6248 | 817 | 69.63 | 69.63 | 69.24 | 71.32 | 1.77 | 1.26 | 29.12 | 0.00 |

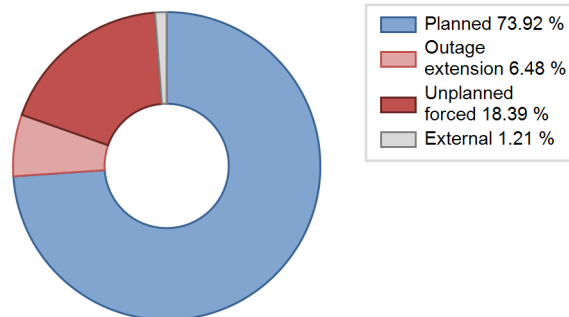
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|--|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 110 | | | 287 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 103 | | |
| D. Inspection, maintenance or repair without refuelling | 2402 | | | 706 | 27 | |
| E. Testing of plant systems or components | | | | 0 | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 21 |
| L. Human factor related | | | | | 5 | |
| Z. Other | | | | | 1 | |
| Subtotal | 2402 | 110 | | 809 | 321 | 21 |
| Total | | 2512 | | | 1151 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 31 |
| 12. Reactor I&C Systems | | 8 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 17 |
| 15. Reactor Cooling Systems | | 50 |
| 16. Steam generation systems | | 137 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 12 |
| 31. Turbine and auxiliaries | 49 | 17 |
| 32. Feedwater and Main Steam System | | 12 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | | 5 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 1 |
| 42. Electrical Power Supply Systems | 61 | 17 |
| Total | 110 | 318 |

2023 Operating Experience

CA-22

DARLINGTON-1

CANADA

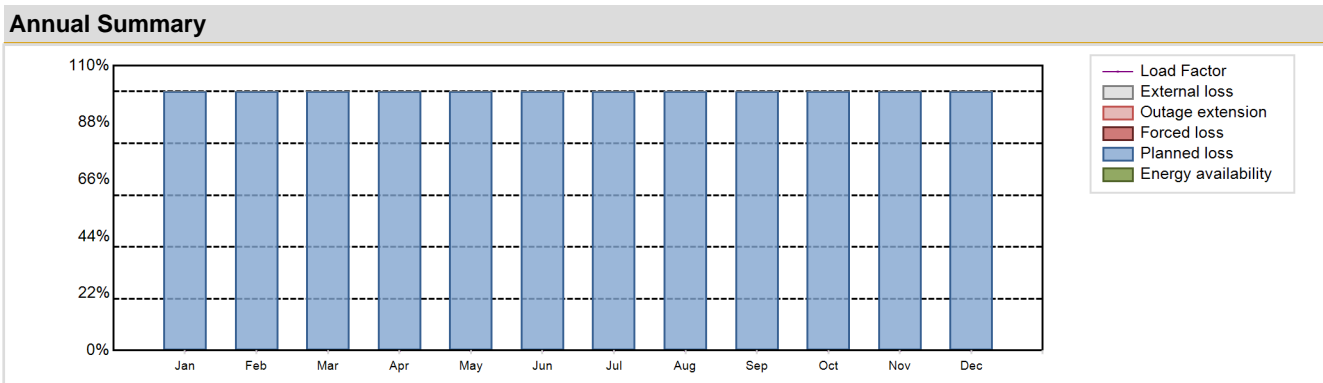
Status at end of year : **Operational**
 Operator : OPG (Ontario Power Generation)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : BBC (BROWN BOVERI ET CIE)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 850 | Construction Date | : 1982-04-01 |
| Thermal power | : 2776 MWth | Grid Date | : 1990-12-19 |
| Gross electrical power | : 934 MWe | Commercial Date | : 1992-11-14 |
| Reference unit power (net) | : 878 MWe | Age at end of year | : 33 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 10 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 310 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 0.0965 |
| Average fuel enrichment [% of U235] | : 0.72 | Secondary systems | |
| Refuelling frequency [month] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : NA | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 8625 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 7.068 | HP cylinder inlet steam pressure [MPa] | : 4.93 |
| Active core height/length [m] | : 6.06 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 6240 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 24 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 24 | Number of FW pumps for full power operation | : 3 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : NA |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------|--|--------------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 100 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : 8760 hours |

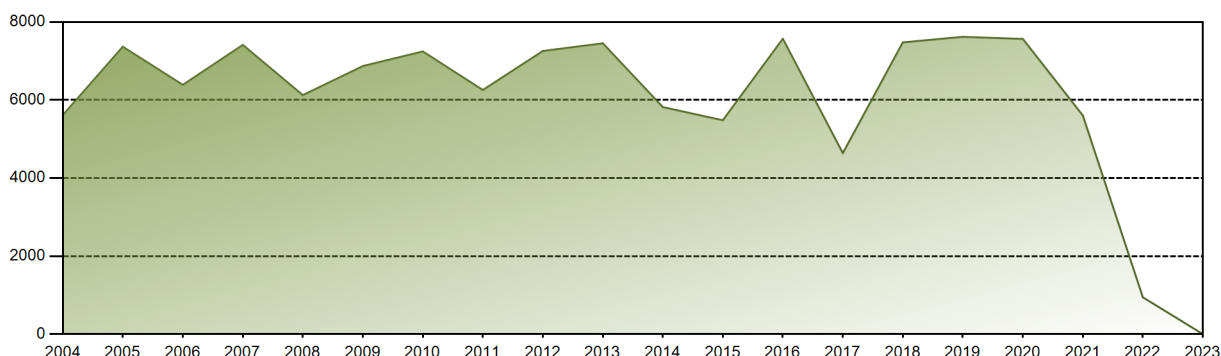


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

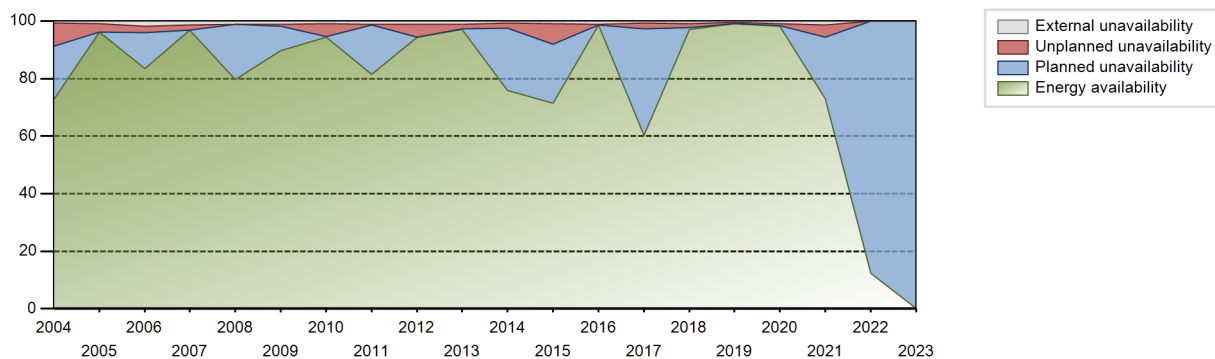
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 196048.69 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.53 % |
| Cumulative Energy Availability Factor (EAF) | : 80.05 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.8 % |
| Cumulative Unit Capability Factor (UCF) | : 80.97 % | Cumulative Planned Unavailability Factor (PUF) | : 14.23 % |
| Cumulative Load Factor (LF) | : 79.66 % | Cumulative Externally cause unavailability (XUF) | : 0.92 % |
| Cumulative Operating Factor (OF) | : 83.43 % | | |

Electricity Production (net) [GWh]

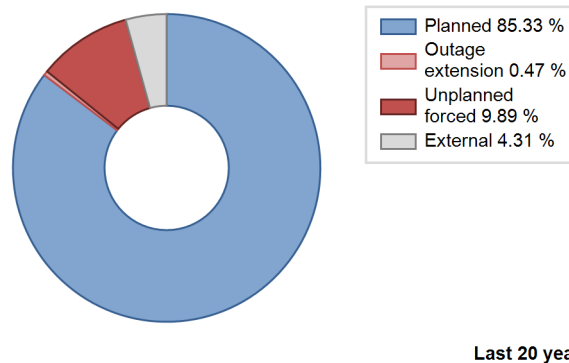
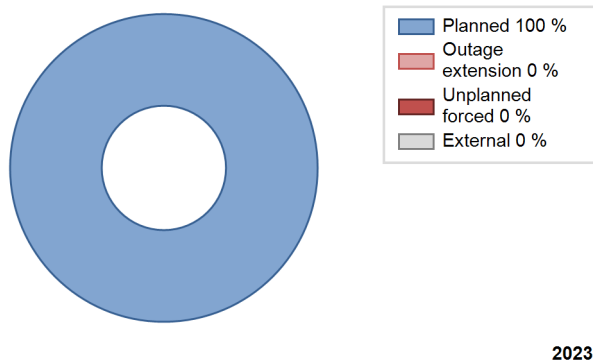


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1992 | 973.98 | 1152 | 881 | 96.83 | 96.83 | 75.51 | 78.69 | 3.17 | 3.17 | 0.00 | 0.00 |
| 1993 | 6016.23 | 7213 | 881 | 78.72 | 79.18 | 77.96 | 82.34 | 9.34 | 8.16 | 12.66 | 0.45 |
| 1994 | 6326.65 | 7446 | 881 | 83.13 | 83.46 | 81.98 | 85.00 | 10.94 | 10.25 | 6.29 | 0.33 |
| 1995 | 6853.27 | 8046 | 881 | 89.72 | 90.65 | 88.80 | 91.85 | 4.41 | 4.19 | 5.16 | 0.94 |
| 1996 | 5745.25 | 6827 | 881 | 75.03 | 75.68 | 74.24 | 77.72 | 20.47 | 19.48 | 4.84 | 0.65 |
| 1997 | 4765.08 | 7236 | 881 | 62.33 | 63.04 | 61.74 | 82.60 | 31.33 | 28.76 | 8.20 | 0.71 |
| 1998 | 6427.46 | 7717 | 881 | 83.28 | 84.27 | 83.28 | 88.09 | 6.58 | 5.94 | 9.79 | 0.99 |
| 1999 | 7175.13 | 8705 | 881 | 92.97 | 94.35 | 92.97 | 99.37 | 5.65 | 5.65 | 0.00 | 1.38 |
| 2000 | 6280.57 | 7615 | 881 | 81.18 | 81.97 | 81.16 | 86.69 | 5.20 | 4.49 | 13.54 | 0.79 |
| 2001 | 6980.80 | 8502 | 881 | 90.45 | 91.17 | 90.45 | 97.05 | 5.81 | 5.62 | 3.21 | 0.71 |
| 2002 | 6532.91 | 7887 | 881 | 84.65 | 85.51 | 84.65 | 90.03 | 7.89 | 7.32 | 7.16 | 0.86 |
| 2003 | 6562.38 | 7846 | 881 | 85.10 | 87.47 | 85.03 | 89.57 | 5.14 | 4.74 | 7.79 | 2.38 |
| 2004 | 5612.12 | 6540 | 881 | 72.82 | 73.58 | 72.52 | 74.45 | 9.72 | 7.92 | 18.50 | 0.76 |
| 2005 | 7366.26 | 8553 | 881 | 96.20 | 97.04 | 95.69 | 97.64 | 2.96 | 2.96 | 0.00 | 0.84 |
| 2006 | 6388.89 | 7520 | 878 | 83.43 | 85.16 | 83.07 | 85.84 | 1.85 | 2.36 | 12.47 | 1.73 |
| 2007 | 7412.62 | 8647 | 878 | 96.81 | 98.15 | 96.38 | 98.71 | 1.74 | 1.74 | 0.11 | 1.35 |
| 2008 | 6125.27 | 7125 | 878 | 79.73 | 80.79 | 79.42 | 81.11 | 0.08 | 0.06 | 19.15 | 1.06 |
| 2009 | 6870.24 | 8038 | 878 | 89.79 | 90.98 | 89.33 | 91.76 | 0.66 | 0.60 | 8.42 | 1.19 |
| 2010 | 7244.93 | 8660 | 878 | 94.48 | 95.47 | 94.20 | 98.86 | 4.48 | 4.48 | 0.04 | 1.00 |
| 2011 | 6256.80 | 7313 | 878 | 81.55 | 82.66 | 81.35 | 83.48 | 0.44 | 0.36 | 16.98 | 1.11 |
| 2012 | 7256.40 | 8468 | 878 | 94.31 | 95.50 | 94.09 | 96.40 | 4.44 | 4.44 | 0.06 | 1.19 |
| 2013 | 7454.01 | 8760 | 878 | 97.12 | 98.37 | 96.92 | 100.00 | 1.37 | 1.37 | 0.26 | 1.25 |
| 2014 | 5818.57 | 6848 | 878 | 75.86 | 76.51 | 75.65 | 78.17 | 2.22 | 1.74 | 21.75 | 0.65 |
| 2015 | 5480.95 | 6449 | 878 | 71.43 | 72.33 | 71.26 | 73.62 | 8.35 | 7.09 | 20.58 | 0.90 |
| 2016 | 7570.79 | 8784 | 878 | 98.62 | 99.69 | 98.16 | 100.00 | 0.25 | 0.25 | 0.07 | 1.07 |
| 2017 | 4638.42 | 6181 | 878 | 60.26 | 60.87 | 60.31 | 70.56 | 3.49 | 2.20 | 36.93 | 0.61 |
| 2018 | 7477.90 | 8606 | 878 | 97.02 | 97.92 | 97.23 | 98.24 | 0.69 | 1.43 | 0.64 | 0.90 |
| 2019 | 7619.17 | 8760 | 878 | 99.13 | 99.70 | 99.06 | 100.00 | 0.29 | 0.29 | 0.01 | 0.57 |
| 2020 | 7565.81 | 8784 | 878 | 98.22 | 99.08 | 98.10 | 100.00 | 0.81 | 0.81 | 0.11 | 0.85 |
| 2021 | 5603.75 | 6621 | 878 | 72.88 | 74.29 | 72.86 | 75.58 | 5.32 | 4.17 | 21.54 | 1.41 |
| 2022 | 943.49 | 1080 | 878 | 12.26 | 12.26 | 12.27 | 12.33 | 0.40 | 0.05 | 87.69 | 0.00 |
| 2023 | 0.00 | 0 | 878 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1992 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 373 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 60 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 637 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | 8760 | | | 562 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 0 | |
| Z. Other | | | | | 1 | |
| Subtotal | 8760 | | | 1259 | 374 | 3 |
| Total | | 8760 | | | 1636 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1992 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 27 |
| 12. Reactor I&C Systems | | 32 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 12 |
| 15. Reactor Cooling Systems | | 162 |
| 21. Fuel Handling and Storage Facilities | | 22 |
| 31. Turbine and auxiliaries | | 15 |
| 32. Feedwater and Main Steam System | | 1 |
| 34. Miscellaneous Systems | | 7 |
| 35. All other I&C Systems | | 20 |
| 41. Main Generator Systems | | 43 |
| 42. Electrical Power Supply Systems | | 10 |
| Total | | 354 |

Highlights (2023)

Darlington Unit 1 continued its Refurbishment.

2023 Operating Experience

CA-23

DARLINGTON-2

CANADA

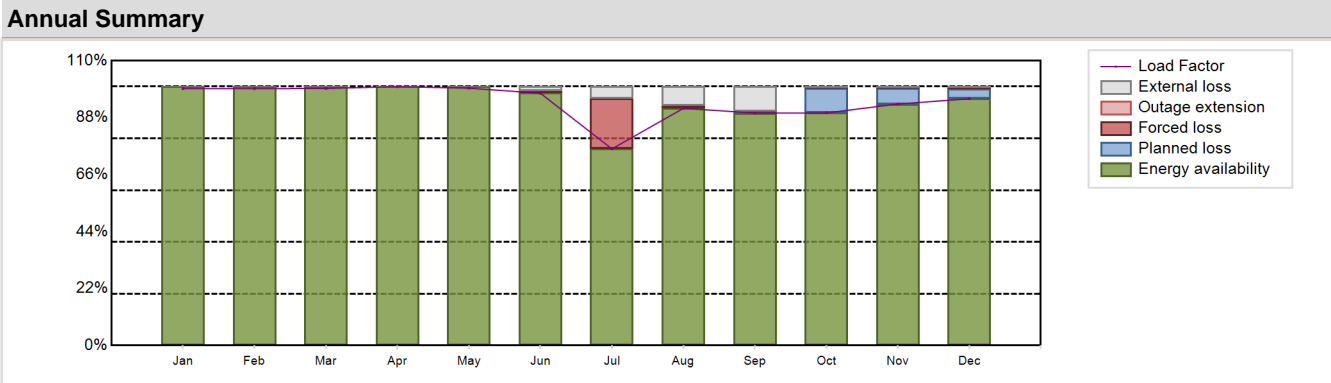
Status at end of year : **Operational**
 Operator : OPG (Ontario Power Generation)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : BBC (BROWN BOVERI ET CIE)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 850 | Construction Date | : 1981-09-01 |
| Thermal power | : 2776 MWth | Grid Date | : 1990-01-15 |
| Gross electrical power | : 934 MWe | Commercial Date | : 1990-10-09 |
| Reference unit power (net) | : 878 MWe | Age at end of year | : 33 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 10 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 310 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 0.0965 |
| Average fuel enrichment [% of U235] | : 0.72 | Secondary systems | |
| Refuelling frequency [month] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : NA | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 8625 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 7.068 | HP cylinder inlet steam pressure [MPa] | : 4.93 |
| Active core height/length [m] | : 6.06 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 6240 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 24 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 24 | Number of FW pumps for full power operation | : 3 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : NA |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 7240.39 GW(e).h | Forced Loss Rate (FLR) | : 1.94 % |
| Energy Availability Factor (EAF) | : 94.4 % | Unplanned Capability Loss Factor (UCL) | : 1.91 % |
| Unit Capability Factor (UCF) | : 96.4 % | Planned Unavailability Factor (PUF) | : 1.69 % |
| Load Factor (LF) | : 94.14 % | Externally cause unavailability (XUF) | : 2 % |
| Operating Factor (OF) | : 98.41 % | Total off-line time | : 139 hours |

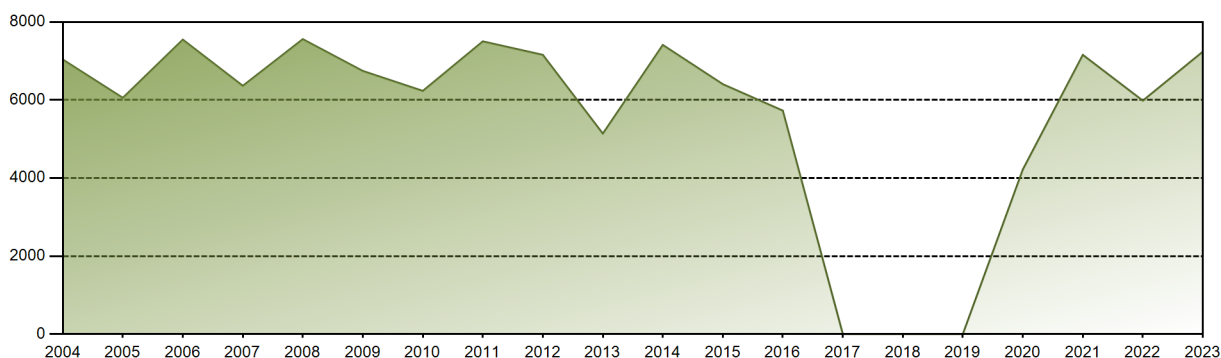


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 648.22 | 585.44 | 648.51 | 631.99 | 649.27 | 615.94 | 496.08 | 598.36 | 567.63 | 586.72 | 589.69 | 622.54 | 7240.39 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.69 | 75.94 | 91.60 | 89.79 | 89.82 | 93.28 | 95.30 | 94.40 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.34 | 80.55 | 98.82 | 99.37 | 90.14 | 93.56 | 95.60 | 96.40 |
| LF [%] | 99.23 | 99.22 | 99.28 | 99.97 | 99.39 | 97.43 | 75.94 | 91.60 | 89.79 | 89.82 | 93.28 | 95.30 | 94.14 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 81.32 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.41 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.66 | 19.45 | 1.18 | 0.06 | 0.25 | 0.36 | 0.58 | 1.94 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.66 | 19.45 | 1.18 | 0.06 | 0.23 | 0.34 | 0.56 | 1.91 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.57 | 9.64 | 6.09 | 3.84 | 1.69 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.65 | 4.61 | 7.22 | 9.58 | 0.32 | 0.28 | 0.30 | 2.00 |

Historical Summary

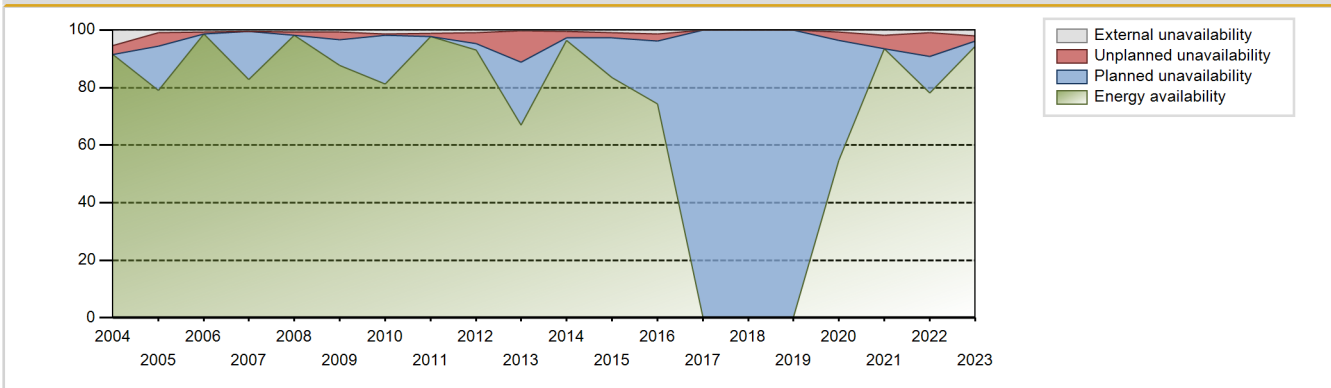
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 185933.44 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 11.99 % |
| Cumulative Energy Availability Factor (EAF) | : 72.13 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 10.26 % |
| Cumulative Unit Capability Factor (UCF) | : 73.07 % | Cumulative Planned Unavailability Factor (PUF) | : 16.67 % |
| Cumulative Load Factor (LF) | : 71.94 % | Cumulative Externally cause unavailability (XUF) | : 0.94 % |
| Cumulative Operating Factor (OF) | : 75.57 % | | |

Electricity Production (net) [GWh]

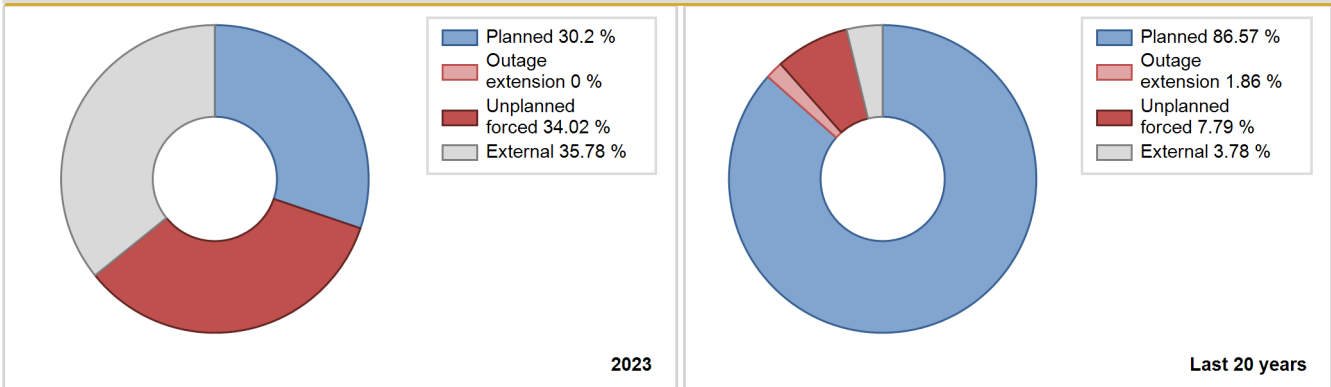


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1990 | 1153.47 | 1608 | 881 | 64.94 | 64.94 | 65.73 | 80.72 | 35.03 | 35.02 | 0.04 | 0.00 |
| 1991 | 51.48 | 102 | 881 | 0.67 | 0.67 | 0.67 | 1.16 | 99.33 | 99.33 | 0.00 | 0.00 |
| 1992 | 1290.16 | 2418 | 881 | 16.68 | 16.68 | 16.67 | 27.53 | 83.32 | 83.32 | 0.00 | 0.00 |
| 1993 | 6370.16 | 7594 | 881 | 82.74 | 83.28 | 82.54 | 86.69 | 8.13 | 7.37 | 9.34 | 0.54 |
| 1994 | 6750.76 | 8069 | 881 | 88.52 | 88.90 | 87.47 | 92.11 | 5.87 | 5.54 | 5.56 | 0.38 |
| 1995 | 6952.96 | 8104 | 881 | 90.65 | 91.30 | 90.09 | 92.51 | 5.07 | 4.88 | 3.82 | 0.65 |
| 1996 | 6705.75 | 7752 | 881 | 87.22 | 87.76 | 86.65 | 88.25 | 5.55 | 5.15 | 7.09 | 0.53 |
| 1997 | 4710.39 | 7069 | 881 | 61.53 | 61.73 | 61.03 | 80.70 | 29.89 | 26.32 | 11.95 | 0.20 |
| 1998 | 6227.93 | 7492 | 881 | 80.70 | 81.91 | 80.70 | 85.53 | 18.09 | 18.09 | 0.00 | 1.21 |
| 1999 | 6469.08 | 7824 | 881 | 83.82 | 85.13 | 83.82 | 89.32 | 5.12 | 4.60 | 10.27 | 1.31 |
| 2000 | 6885.42 | 8221 | 881 | 88.97 | 90.14 | 88.97 | 93.59 | 9.86 | 9.86 | 0.00 | 1.17 |
| 2001 | 5826.45 | 7030 | 881 | 75.50 | 76.30 | 75.50 | 80.25 | 6.64 | 5.43 | 18.27 | 0.81 |
| 2002 | 7268.93 | 8627 | 881 | 94.19 | 95.43 | 94.19 | 98.48 | 4.57 | 4.57 | 0.00 | 1.25 |
| 2003 | 6084.10 | 7245 | 881 | 79.29 | 81.59 | 78.83 | 82.71 | 5.71 | 4.94 | 13.47 | 2.30 |
| 2004 | 7038.38 | 8737 | 881 | 91.42 | 96.71 | 90.95 | 99.46 | 3.29 | 3.29 | 0.00 | 5.29 |
| 2005 | 6056.21 | 7031 | 878 | 78.93 | 79.75 | 78.67 | 80.26 | 0.98 | 4.72 | 15.53 | 0.82 |
| 2006 | 7548.39 | 8745 | 878 | 98.59 | 99.38 | 98.14 | 99.83 | 0.62 | 0.62 | 0.00 | 0.79 |
| 2007 | 6364.83 | 7327 | 878 | 82.85 | 83.37 | 82.75 | 83.64 | 0.01 | 0.01 | 16.62 | 0.52 |
| 2008 | 7560.94 | 8696 | 878 | 98.15 | 98.82 | 98.04 | 99.00 | 1.18 | 1.18 | 0.00 | 0.67 |
| 2009 | 6745.27 | 7769 | 878 | 87.67 | 88.37 | 87.70 | 88.69 | 2.03 | 2.71 | 8.91 | 0.70 |
| 2010 | 6234.30 | 7248 | 878 | 81.14 | 82.48 | 81.06 | 82.74 | 0.67 | 0.56 | 16.96 | 1.34 |
| 2011 | 7503.51 | 8719 | 878 | 97.74 | 98.90 | 97.56 | 99.53 | 1.06 | 1.06 | 0.04 | 1.16 |
| 2012 | 7157.95 | 8467 | 878 | 92.97 | 93.92 | 92.81 | 96.39 | 3.86 | 3.77 | 2.30 | 0.96 |
| 2013 | 5138.76 | 6131 | 878 | 66.97 | 67.33 | 66.81 | 69.99 | 7.39 | 10.77 | 21.91 | 0.36 |
| 2014 | 7412.53 | 8522 | 878 | 96.38 | 96.90 | 96.38 | 97.28 | 2.22 | 2.21 | 0.89 | 0.52 |
| 2015 | 6405.95 | 7428 | 878 | 83.41 | 84.28 | 83.29 | 84.79 | 2.05 | 1.77 | 13.95 | 0.87 |
| 2016 | 5728.84 | 6793 | 878 | 74.41 | 75.73 | 74.28 | 77.33 | 3.13 | 2.45 | 21.82 | 1.32 |
| 2017 | 0.00 | 0 | 878 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2018 | 0.00 | 0 | 878 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2019 | 0.00 | 0 | 878 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2020 | 4218.91 | 5144 | 878 | 54.74 | 55.41 | 54.70 | 58.56 | 5.06 | 2.95 | 41.64 | 0.67 |
| 2021 | 7158.02 | 8568 | 878 | 93.52 | 95.29 | 93.07 | 97.81 | 4.67 | 4.66 | 0.04 | 1.77 |
| 2022 | 5985.00 | 7018 | 878 | 78.08 | 79.06 | 77.82 | 80.11 | 9.49 | 8.29 | 12.65 | 0.98 |
| 2023 | 7240.39 | 8621 | 878 | 94.40 | 96.40 | 94.14 | 98.41 | 1.94 | 1.91 | 1.69 | 2.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1990 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 139 | | | 486 | |
| D. Inspection, maintenance or repair without refuelling | | | | 488 | 10 | |
| E. Testing of plant systems or components | | | | 12 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 943 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| Z. Other | | | | | 197 | |
| Subtotal | | 139 | | 1443 | 693 | 2 |
| Total | | 139 | | | 2138 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1990 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 33 |
| 12. Reactor I&C Systems | | 24 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 7 |
| 15. Reactor Cooling Systems | 139 | 288 |
| 16. Steam generation systems | | 37 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 20 |
| 31. Turbine and auxiliaries | | 23 |
| 32. Feedwater and Main Steam System | | 8 |
| 34. Miscellaneous Systems | | 5 |
| 35. All other I&C Systems | | 10 |
| 41. Main Generator Systems | | 6 |
| 42. Electrical Power Supply Systems | | 24 |
| Total | 139 | 487 |

Highlights (2023)

In July 2023, there was an automatic reactor trip on U2. The turbine was manually tripped per procedure following the reactor trip.

2023 Operating Experience

CA-24

DARLINGTON-3

CANADA

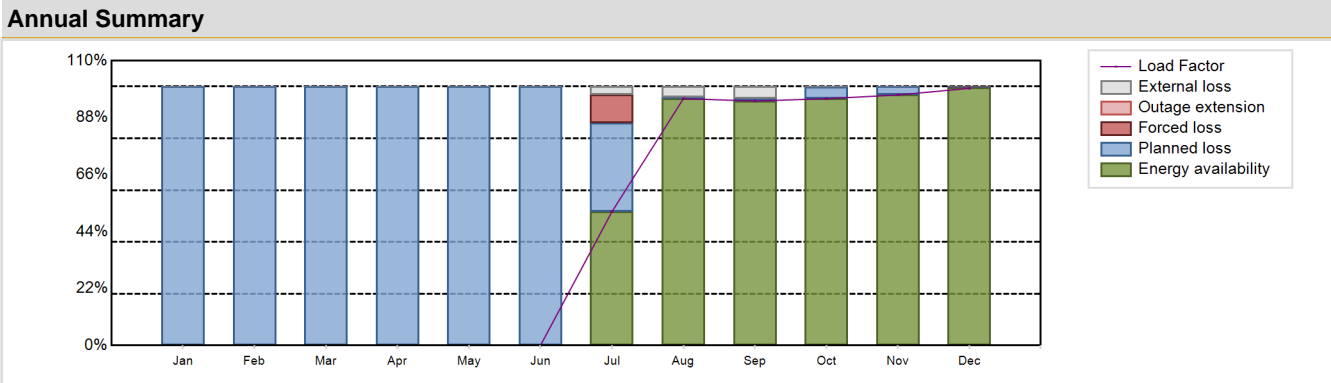
Status at end of year : **Operational**
 Operator : OPG (Ontario Power Generation)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : BBC (BROWN BOVERI ET CIE)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 850 | Construction Date | : 1984-09-01 |
| Thermal power | : 2776 MWth | Grid Date | : 1992-12-07 |
| Gross electrical power | : 934 MWe | Commercial Date | : 1993-02-14 |
| Reference unit power (net) | : 878 MWe | Age at end of year | : 31 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 10 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 310 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 0.0965 |
| Average fuel enrichment [% of U235] | : 0.72 | Secondary systems | |
| Refuelling frequency [month] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : NA | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 8625 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 7.068 | HP cylinder inlet steam pressure [MPa] | : 4.93 |
| Active core height/length [m] | : 6.06 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 6240 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 24 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 24 | Number of FW pumps for full power operation | : 3 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : NA |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 3440.42 GW(e).h | Forced Loss Rate (FLR) | : 2.01 % |
| Energy Availability Factor (EAF) | : 44.74 % | Unplanned Capability Loss Factor (UCL) | : 0.94 % |
| Unit Capability Factor (UCF) | : 45.74 % | Planned Unavailability Factor (PUF) | : 53.32 % |
| Load Factor (LF) | : 44.73 % | Externally cause unavailability (XUF) | : 1 % |
| Operating Factor (OF) | : 47.68 % | Total off-line time | : 4583 hours |

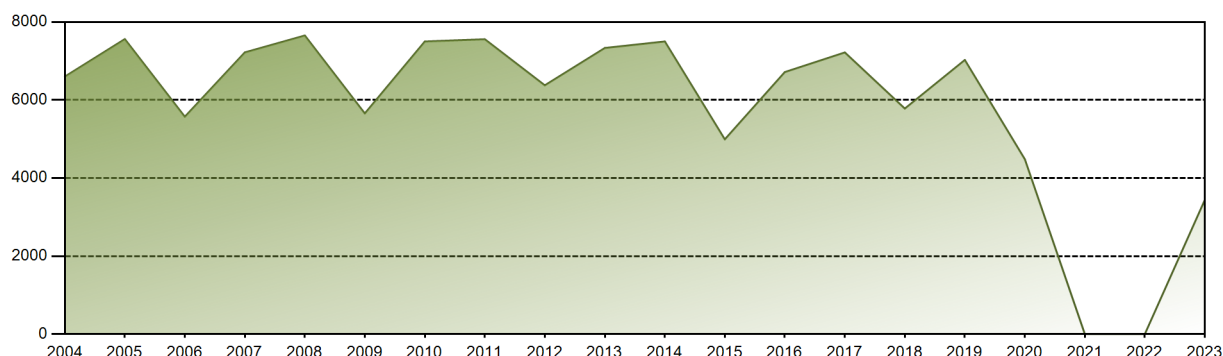


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 337.47 | 622.83 | 596.94 | 622.66 | 611.74 | 648.78 | 3440.42 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 51.61 | 95.35 | 94.43 | 95.32 | 96.77 | 99.50 | 44.74 |
| UCF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 54.74 | 99.49 | 98.97 | 95.43 | 96.77 | 99.50 | 45.74 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 51.66 | 95.35 | 94.43 | 95.32 | 96.77 | 99.32 | 44.73 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 67.88 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 47.68 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 2.01 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.94 |
| PUF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 34.34 | 0.51 | 1.03 | 4.57 | 3.23 | 0.36 | 53.32 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.13 | 4.15 | 4.54 | 0.11 | 0.00 | 0.00 | 1.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 186699.03 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.89 % |
| Cumulative Energy Availability Factor (EAF) | : 78.49 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.43 % |
| Cumulative Unit Capability Factor (UCF) | : 79.26 % | Cumulative Planned Unavailability Factor (PUF) | : 16.31 % |
| Cumulative Load Factor (LF) | : 78.23 % | Cumulative Externally cause unavailability (XUF) | : 0.77 % |
| Cumulative Operating Factor (OF) | : 80.98 % | | |

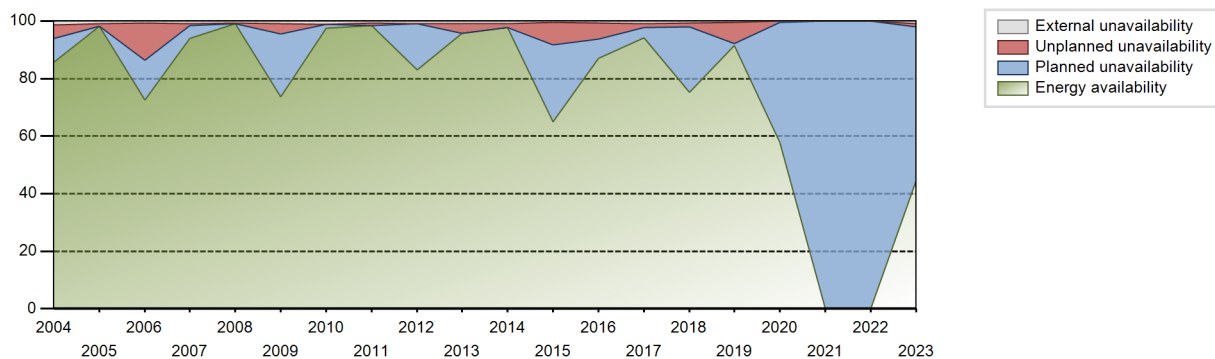
Electricity Production (net) [GWh]



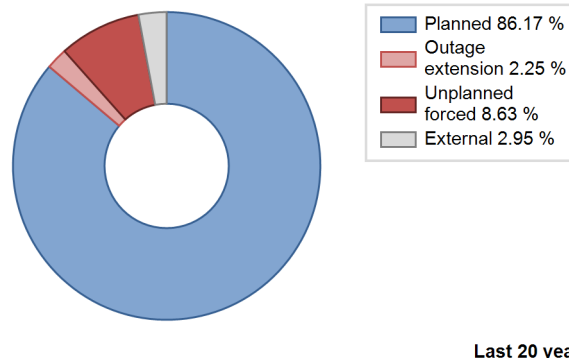
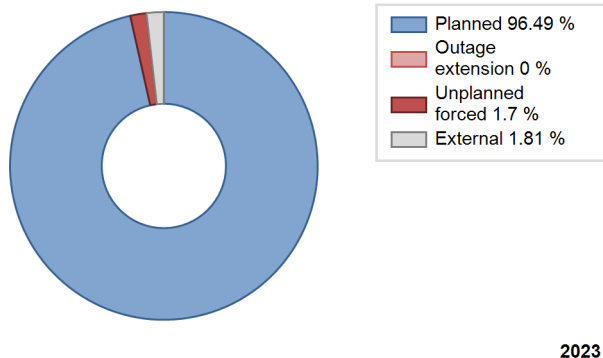
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1993 | 6003.39 | 7141 | 881 | 89.24 | 89.81 | 85.01 | 89.08 | 10.05 | 10.04 | 0.15 | 0.57 |
| 1994 | 6528.54 | 7642 | 881 | 85.26 | 85.64 | 84.59 | 87.24 | 2.11 | 1.85 | 12.51 | 0.38 |
| 1995 | 7061.53 | 8219 | 881 | 92.22 | 92.93 | 91.50 | 93.82 | 3.05 | 2.92 | 4.15 | 0.71 |
| 1996 | 7391.57 | 8574 | 881 | 96.66 | 97.34 | 95.51 | 97.61 | 2.65 | 2.65 | 0.01 | 0.68 |
| 1997 | 4010.78 | 6314 | 881 | 52.10 | 52.35 | 51.97 | 72.08 | 40.36 | 35.42 | 12.22 | 0.25 |
| 1998 | 7244.91 | 8593 | 881 | 93.88 | 94.68 | 93.88 | 98.09 | 4.05 | 4.00 | 1.32 | 0.80 |
| 1999 | 5629.08 | 6929 | 881 | 72.94 | 75.09 | 72.94 | 79.10 | 6.57 | 5.28 | 19.63 | 2.15 |
| 2000 | 6517.02 | 7822 | 881 | 84.22 | 85.10 | 84.21 | 89.05 | 8.27 | 7.67 | 7.23 | 0.88 |
| 2001 | 6577.97 | 7901 | 881 | 85.23 | 86.30 | 85.23 | 90.19 | 8.87 | 8.40 | 5.30 | 1.07 |
| 2002 | 6371.77 | 7595 | 881 | 82.58 | 83.68 | 82.56 | 86.70 | 4.81 | 4.23 | 12.09 | 1.10 |
| 2003 | 6827.19 | 8004 | 881 | 88.62 | 89.45 | 88.46 | 91.37 | 2.21 | 2.02 | 8.53 | 0.83 |
| 2004 | 6601.58 | 7649 | 881 | 85.59 | 86.88 | 85.31 | 87.08 | 5.14 | 4.71 | 8.41 | 1.29 |
| 2005 | 7562.05 | 8760 | 878 | 98.26 | 99.08 | 98.24 | 100.00 | 0.89 | 0.89 | 0.02 | 0.83 |
| 2006 | 5573.10 | 6452 | 878 | 72.50 | 73.12 | 72.46 | 73.65 | 8.54 | 13.05 | 13.84 | 0.62 |
| 2007 | 7221.13 | 8311 | 878 | 93.90 | 94.75 | 93.89 | 94.87 | 0.02 | 0.75 | 4.49 | 0.85 |
| 2008 | 7654.59 | 8784 | 878 | 99.15 | 99.93 | 99.25 | 100.00 | 0.04 | 0.04 | 0.03 | 0.78 |
| 2009 | 5657.16 | 6590 | 878 | 73.60 | 74.47 | 73.55 | 75.23 | 2.00 | 3.62 | 21.91 | 0.87 |
| 2010 | 7500.90 | 8643 | 878 | 97.47 | 98.51 | 97.52 | 98.66 | 0.06 | 0.06 | 1.43 | 1.04 |
| 2011 | 7558.56 | 8707 | 878 | 98.37 | 99.17 | 98.27 | 99.39 | 0.78 | 0.78 | 0.04 | 0.81 |
| 2012 | 6377.61 | 7419 | 878 | 83.03 | 83.97 | 82.69 | 84.46 | 0.06 | 0.05 | 15.98 | 0.94 |
| 2013 | 7334.60 | 8470 | 878 | 95.63 | 96.61 | 95.36 | 96.69 | 3.35 | 3.35 | 0.04 | 0.98 |
| 2014 | 7501.60 | 8708 | 878 | 97.75 | 98.75 | 97.53 | 99.41 | 1.23 | 1.23 | 0.02 | 1.00 |
| 2015 | 4992.10 | 5787 | 878 | 65.00 | 65.52 | 64.91 | 66.06 | 8.58 | 7.75 | 26.73 | 0.52 |
| 2016 | 6716.91 | 7832 | 878 | 86.99 | 87.63 | 87.09 | 89.16 | 5.93 | 5.53 | 6.84 | 0.64 |
| 2017 | 7219.88 | 8442 | 878 | 94.27 | 95.20 | 93.87 | 96.37 | 1.42 | 1.37 | 3.43 | 0.93 |
| 2018 | 5781.75 | 6718 | 878 | 75.15 | 75.94 | 75.17 | 76.69 | 1.62 | 1.25 | 22.81 | 0.79 |
| 2019 | 7026.63 | 8178 | 878 | 91.58 | 91.98 | 91.36 | 93.36 | 7.52 | 7.48 | 0.54 | 0.40 |
| 2020 | 4483.41 | 5087 | 878 | 57.75 | 57.88 | 58.13 | 57.91 | 0.04 | 0.37 | 41.75 | 0.13 |
| 2021 | 0.00 | 0 | 878 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2022 | 0.00 | 0 | 878 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2023 | 3440.41 | 4177 | 878 | 44.74 | 45.74 | 44.73 | 47.68 | 2.01 | 0.94 | 53.32 | 1.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1993 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 73 | | | 238 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 64 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 539 | | |
| E. Testing of plant systems or components | | | | | 5 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | 4511 | | | 713 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 93 | | |
| L. Human factor related | | | | | 3 | |
| Subtotal | 4511 | 73 | | 1409 | 246 | |
| Total | | 4584 | | | 1655 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1993 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 20 |
| 12. Reactor I&C Systems | | 24 |
| 13. Reactor Auxiliary Systems | 73 | 31 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 39 |
| 16. Steam generation systems | | 13 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 18 |
| 31. Turbine and auxiliaries | | 51 |
| 32. Feedwater and Main Steam System | | 13 |
| 34. Miscellaneous Systems | | 8 |
| 35. All other I&C Systems | | 17 |
| 42. Electrical Power Supply Systems | | 8 |
| Total | 73 | 245 |

Highlights (2023)

Commissioning activities continued in July 2023 . Official connection to the grid-July 17, 2023
Unit 3 was declared commercially in service on July 18, 2023 .

2023 Operating Experience

CA-25

DARLINGTON-4

CANADA

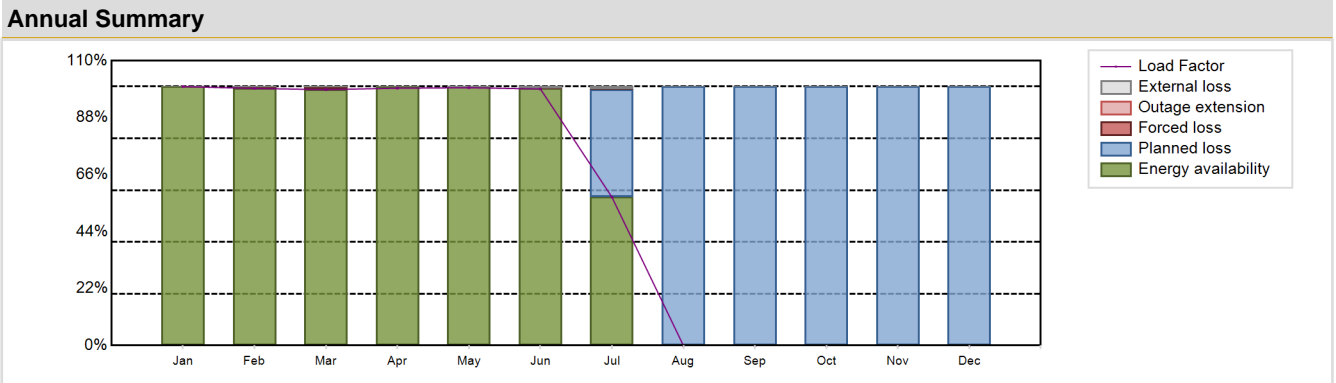
Status at end of year : **Operational**
 Operator : OPG (Ontario Power Generation)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : BBC (BROWN BOVERI ET CIE)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 850 | Construction Date | : 1985-07-01 |
| Thermal power | : 2776 MWth | Grid Date | : 1993-04-17 |
| Gross electrical power | : 934 MWe | Commercial Date | : 1993-06-14 |
| Reference unit power (net) | : 878 MWe | Age at end of year | : 30 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 10 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 310 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 0.0965 |
| Average fuel enrichment [% of U235] | : 0.72 | Secondary systems | |
| Refuelling frequency [month] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : NA | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 8625 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 7.068 | HP cylinder inlet steam pressure [MPa] | : 4.93 |
| Active core height/length [m] | : 6.06 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 6240 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 24 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 24 | Number of FW pumps for full power operation | : 3 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : NA |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4163.79 GW(e).h | Forced Loss Rate (FLR) | : 0.24 % |
| Energy Availability Factor (EAF) | : 54.25 % | Unplanned Capability Loss Factor (UCL) | : 0.13 % |
| Unit Capability Factor (UCF) | : 54.41 % | Planned Unavailability Factor (PUF) | : 45.46 % |
| Load Factor (LF) | : 54.14 % | Externally cause unavailability (XUF) | : 0.16 % |
| Operating Factor (OF) | : 54.54 % | Total off-line time | : 3982 hours |

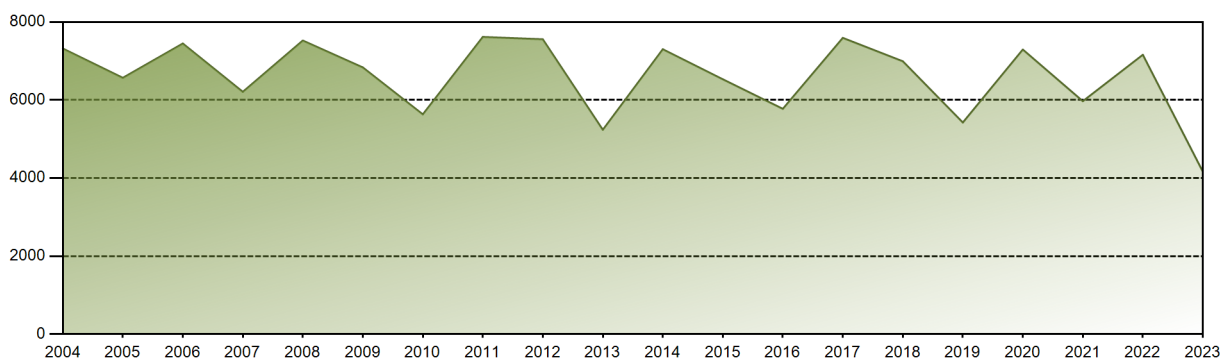


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 653.23 | 585.72 | 645.54 | 628.20 | 650.37 | 626.31 | 374.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4163.79 |
| EAF [%] | 100.00 | 99.46 | 98.79 | 100.00 | 99.98 | 99.24 | 57.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 54.25 |
| UCF [%] | 100.00 | 99.59 | 98.99 | 100.00 | 99.99 | 99.91 | 58.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 54.41 |
| LF [%] | 100.00 | 99.27 | 98.82 | 99.37 | 99.56 | 99.07 | 57.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 54.14 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 58.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 54.54 |
| FLR [%] | 0.00 | 0.41 | 1.01 | 0.00 | 0.01 | 0.09 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 |
| UCL [%] | 0.00 | 0.41 | 1.01 | 0.00 | 0.01 | 0.09 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 41.66 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 45.46 |
| XUF [%] | 0.00 | 0.12 | 0.20 | 0.00 | 0.00 | 0.67 | 0.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 |

Historical Summary

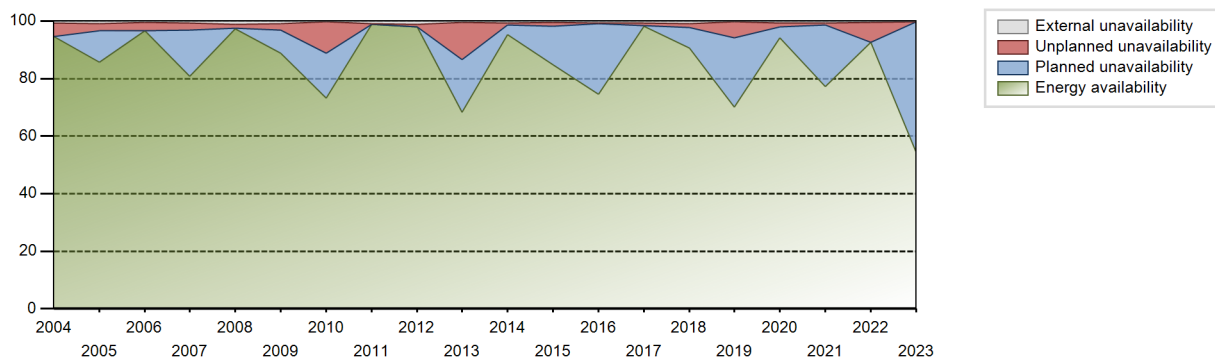
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 200285.66 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.8 % |
| Cumulative Energy Availability Factor (EAF) | : 84.76 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.69 % |
| Cumulative Unit Capability Factor (UCF) | : 85.44 % | Cumulative Planned Unavailability Factor (PUF) | : 9.87 % |
| Cumulative Load Factor (LF) | : 84.69 % | Cumulative Externally cause unavailability (XUF) | : 0.68 % |
| Cumulative Operating Factor (OF) | : 87.02 % | | |

Electricity Production (net) [GWh]

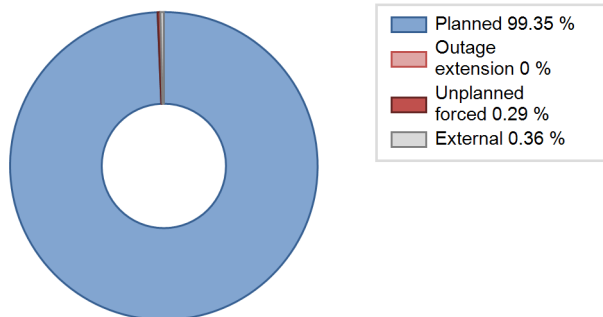


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1993 | 3528.78 | 4447 | 881 | 73.87 | 74.02 | 67.58 | 70.40 | 10.42 | 8.61 | 17.37 | 0.15 |
| 1994 | 7038.67 | 8143 | 881 | 91.85 | 92.19 | 91.20 | 92.96 | 3.36 | 3.21 | 4.60 | 0.35 |
| 1995 | 6750.56 | 7751 | 881 | 87.72 | 88.14 | 87.47 | 88.48 | 2.41 | 2.18 | 9.68 | 0.43 |
| 1996 | 6105.35 | 7023 | 881 | 79.14 | 79.37 | 78.89 | 79.95 | 12.79 | 11.65 | 8.98 | 0.23 |
| 1997 | 5069.64 | 7428 | 881 | 65.71 | 65.97 | 65.69 | 84.79 | 28.56 | 26.37 | 7.65 | 0.27 |
| 1998 | 6520.88 | 7699 | 881 | 84.49 | 85.32 | 84.49 | 87.89 | 11.60 | 11.20 | 3.48 | 0.83 |
| 1999 | 6216.13 | 7431 | 881 | 80.55 | 81.60 | 80.55 | 84.83 | 5.28 | 4.55 | 13.85 | 1.05 |
| 2000 | 6975.02 | 8219 | 881 | 90.13 | 90.78 | 90.13 | 93.57 | 9.22 | 9.22 | 0.00 | 0.65 |
| 2001 | 6836.35 | 8037 | 881 | 88.58 | 89.62 | 88.58 | 91.75 | 3.01 | 2.78 | 7.59 | 1.04 |
| 2002 | 7449.79 | 8760 | 881 | 96.53 | 97.33 | 96.53 | 100.00 | 2.67 | 2.67 | 0.00 | 0.80 |
| 2003 | 5428.86 | 6320 | 881 | 70.64 | 72.28 | 70.34 | 72.15 | 5.81 | 4.46 | 23.26 | 1.64 |
| 2004 | 7321.13 | 8451 | 881 | 94.60 | 95.25 | 94.60 | 96.21 | 4.75 | 4.75 | 0.00 | 0.65 |
| 2005 | 6569.70 | 7617 | 878 | 85.63 | 86.47 | 85.35 | 86.95 | 0.36 | 2.49 | 11.04 | 0.84 |
| 2006 | 7449.44 | 8541 | 878 | 96.54 | 97.08 | 96.86 | 97.50 | 2.92 | 2.92 | 0.00 | 0.54 |
| 2007 | 6210.23 | 7170 | 878 | 80.77 | 81.44 | 80.74 | 81.85 | 2.90 | 2.43 | 16.13 | 0.67 |
| 2008 | 7525.46 | 8652 | 878 | 97.35 | 98.39 | 97.58 | 98.50 | 1.48 | 1.48 | 0.13 | 1.05 |
| 2009 | 6836.15 | 7892 | 878 | 88.71 | 89.71 | 88.88 | 90.09 | 2.12 | 2.23 | 8.06 | 1.00 |
| 2010 | 5633.65 | 6612 | 878 | 73.26 | 73.62 | 73.25 | 75.48 | 8.67 | 10.81 | 15.57 | 0.36 |
| 2011 | 7617.80 | 8760 | 878 | 98.89 | 99.73 | 99.04 | 100.00 | 0.23 | 0.23 | 0.04 | 0.85 |
| 2012 | 7557.72 | 8725 | 878 | 97.88 | 98.99 | 97.99 | 99.33 | 0.87 | 0.87 | 0.14 | 1.11 |
| 2013 | 5237.45 | 6132 | 878 | 68.25 | 68.83 | 68.10 | 70.00 | 9.51 | 12.75 | 18.42 | 0.58 |
| 2014 | 7302.71 | 8476 | 878 | 95.24 | 95.97 | 94.95 | 96.76 | 0.65 | 0.63 | 3.40 | 0.73 |
| 2015 | 6532.11 | 7490 | 878 | 84.72 | 85.13 | 84.93 | 85.50 | 1.53 | 1.32 | 13.55 | 0.40 |
| 2016 | 5774.65 | 6678 | 878 | 74.66 | 75.46 | 74.88 | 76.02 | 0.23 | 0.18 | 24.36 | 0.80 |
| 2017 | 7593.09 | 8684 | 878 | 98.10 | 98.77 | 98.72 | 99.13 | 1.03 | 1.03 | 0.20 | 0.67 |
| 2018 | 6993.41 | 8105 | 878 | 90.71 | 91.56 | 90.93 | 92.52 | 1.42 | 1.32 | 7.12 | 0.85 |
| 2019 | 5423.69 | 6248 | 878 | 70.07 | 70.44 | 70.52 | 71.32 | 7.34 | 5.58 | 23.99 | 0.37 |
| 2020 | 7294.39 | 8784 | 878 | 94.26 | 94.87 | 94.58 | 100.00 | 1.46 | 1.41 | 3.72 | 0.61 |
| 2021 | 5970.37 | 6865 | 878 | 77.24 | 78.00 | 77.63 | 78.37 | 0.74 | 0.58 | 21.42 | 0.76 |
| 2022 | 7159.58 | 8207 | 878 | 92.53 | 93.02 | 93.09 | 93.69 | 6.98 | 6.98 | 0.00 | 0.49 |
| 2023 | 4163.79 | 4778 | 878 | 54.25 | 54.41 | 54.14 | 54.54 | 0.24 | 0.13 | 45.46 | 0.16 |

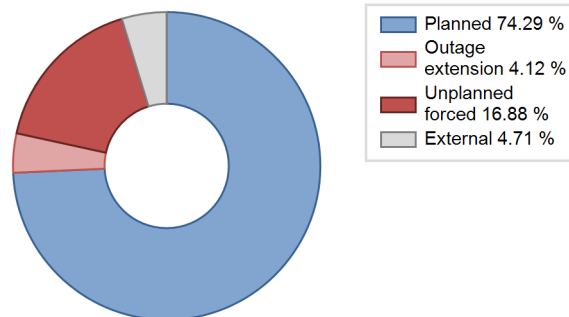
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1993 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 274 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 86 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 615 | | |
| E. Testing of plant systems or components | | | | 11 | 2 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | 3982 | | | 130 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 9 | |
| Subtotal | 3982 | | | 842 | 286 | 4 |
| Total | | 3982 | | | 1132 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1993 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 4 |
| 12. Reactor I&C Systems | | 38 |
| 13. Reactor Auxiliary Systems | | 7 |
| 14. Safety Systems | | 11 |
| 15. Reactor Cooling Systems | | 91 |
| 16. Steam generation systems | | 3 |
| 21. Fuel Handling and Storage Facilities | | 15 |
| 31. Turbine and auxiliaries | | 41 |
| 32. Feedwater and Main Steam System | | 7 |
| 33. Circulating Water System | | 5 |
| 34. Miscellaneous Systems | | 19 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 17 |
| 42. Electrical Power Supply Systems | | 29 |
| Total | | 289 |

Highlights (2023)

Unit 4 entered Refurbishment on July 19th,2023.

2023 Operating Experience

CA-4

PICKERING-1

CANADA

Status at end of year : **Operational**
 Operator : OPG (Ontario Power Generation)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)



| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 500A | Construction Date | : 1966-06-01 |
| Thermal power | : 1744 MWth | Grid Date | : 1971-04-04 |
| Gross electrical power | : 542 MWe | Commercial Date | : 1971-07-29 |
| Reference unit power (net) | : 515 MWe | Age at end of year | : 52 years |

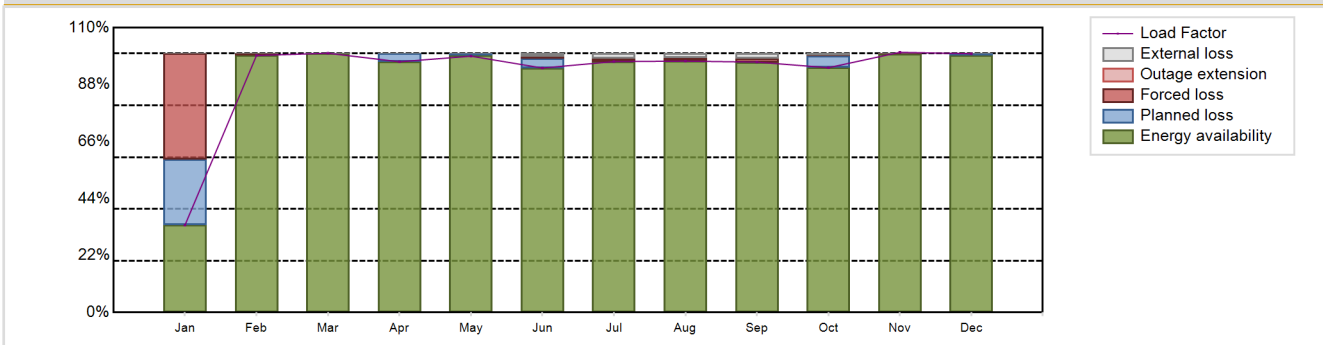
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|-----------------------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 9 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 293 |
| Refuelling type | : ON-line | Number of SG | : 12 |
| Moderator material | : D2O | Containment type | : - |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 1.46 |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 9080 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 5.94 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 5.94 | HP cylinder inlet steam pressure [MPa] | : 3.8 |
| Number of fissile fuel assemblies/bundles | : 4680 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 26.6 | Primary means of condenser cooling | : Lake (once-through) |
| Number of control rod assemblies | : 6 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 4165.01 GW(e).h | Forced Loss Rate (FLR) | : 4.04 % |
| Energy Availability Factor (EAF) | : 92.26 % | Unplanned Capability Loss Factor (UCL) | : 3.91 % |
| Unit Capability Factor (UCF) | : 92.87 % | Planned Unavailability Factor (PUF) | : 3.23 % |
| Load Factor (LF) | : 92.32 % | Externally cause unavailability (XUF) | : 0.61 % |
| Operating Factor (OF) | : 95.18 % | Total off-line time | : 422 hours |

Annual Summary

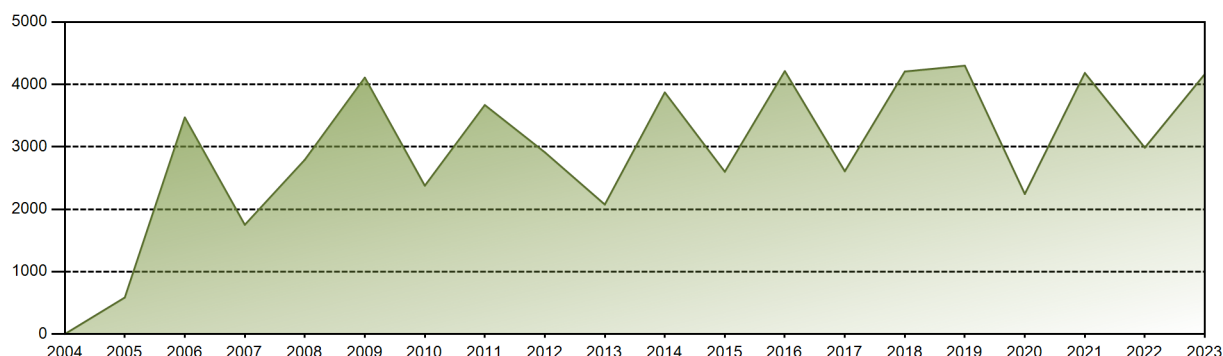


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 129.35 | 343.55 | 383.67 | 359.09 | 379.35 | 350.16 | 371.29 | 372.02 | 358.61 | 362.29 | 372.62 | 383.01 | 4165.01 |
| EAF [%] | 33.81 | 99.26 | 100.00 | 96.96 | 99.28 | 94.43 | 96.90 | 97.19 | 96.71 | 94.62 | 99.95 | 99.28 | 92.26 |
| UCF [%] | 33.81 | 99.26 | 100.00 | 96.96 | 99.28 | 95.64 | 98.83 | 98.83 | 98.64 | 95.16 | 99.95 | 99.28 | 92.87 |
| LF [%] | 33.76 | 99.27 | 100.13 | 96.84 | 99.01 | 94.43 | 96.90 | 97.09 | 96.71 | 94.55 | 100.49 | 99.96 | 92.32 |
| OF [%] | 43.28 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.18 |
| FLR [%] | 54.64 | 0.74 | 0.00 | 0.00 | 0.00 | 0.66 | 1.17 | 1.17 | 1.36 | 0.33 | 0.05 | 0.00 | 4.04 |
| UCL [%] | 40.73 | 0.74 | 0.00 | 0.00 | 0.00 | 0.63 | 1.17 | 1.17 | 1.36 | 0.31 | 0.05 | 0.00 | 3.91 |
| PUF [%] | 25.46 | 0.00 | 0.00 | 3.04 | 0.72 | 3.72 | 0.00 | 0.00 | 0.00 | 4.53 | 0.00 | 0.72 | 3.23 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.21 | 1.93 | 1.64 | 1.93 | 0.53 | 0.00 | 0.00 | 0.61 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 134907.34 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 22.69 % |
| Cumulative Energy Availability Factor (EAF) | : 68.5 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 21.17 % |
| Cumulative Unit Capability Factor (UCF) | : 68.75 % | Cumulative Planned Unavailability Factor (PUF) | : 10.08 % |
| Cumulative Load Factor (LF) | : 66.58 % | Cumulative Externally cause unavailability (XUF) | : 0.25 % |
| Cumulative Operating Factor (OF) | : 69.95 % | | |

Electricity Production (net) [GWh]

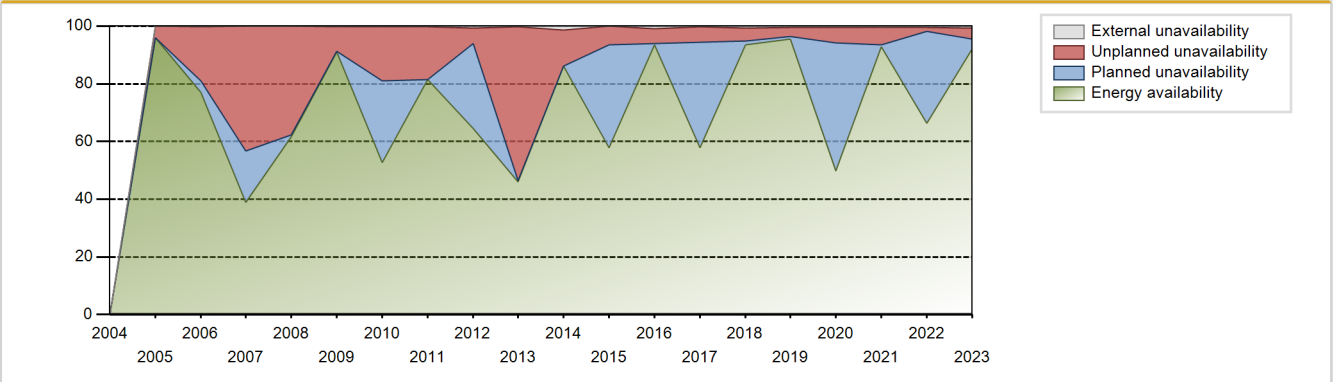


Performance for Years of Commercial Operation

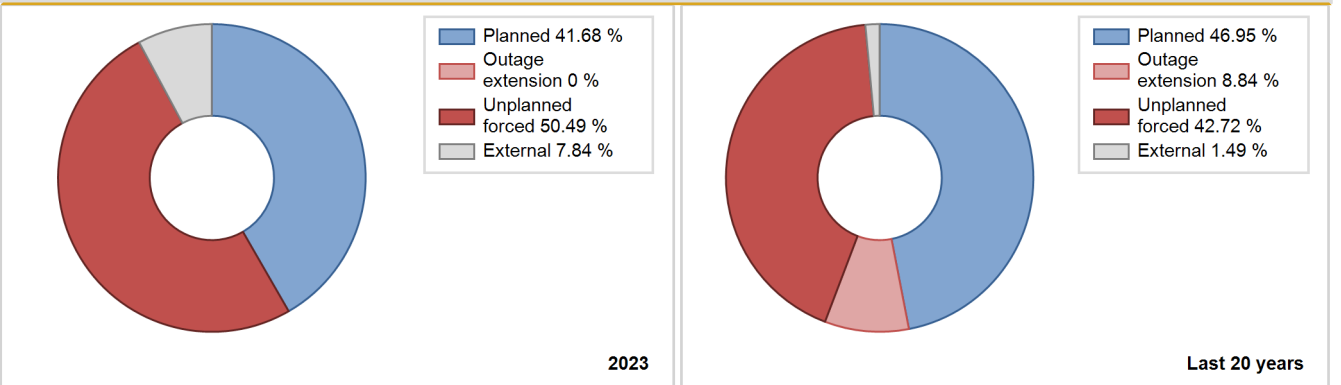
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|--|---------------------------|---------------------------------|--------|--------|-------|-------|--------|--------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1971 | 2302.30 | 4829 | 514 | 100.00 | 100.00 | 80.43 | 78.16 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1972 | 2207.90 | 4117 | 514 | 100.00 | 100.00 | 48.90 | 46.87 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | 4222.40 | 8523 | 514 | 93.98 | 93.98 | 92.26 | 95.72 | 5.19 | 5.15 | 0.88 | 0.00 |
| 1974 | 3232.00 | 6979 | 514 | 71.92 | 71.92 | 71.98 | 79.89 | 20.17 | 18.17 | 9.91 | 0.00 |
| 1975 | 3592.80 | 7234 | 512 | 80.17 | 80.17 | 80.32 | 82.81 | 11.74 | 10.66 | 9.17 | 0.00 |
| 1976 | 4169.70 | 8136 | 514 | 92.73 | 92.73 | 92.61 | 92.88 | 2.07 | 1.96 | 5.31 | 0.00 |
| 1977 | 3852.80 | 7545 | 514 | 85.79 | 85.79 | 85.80 | 86.37 | 6.14 | 5.61 | 8.59 | 0.00 |
| 1978 | 4273.70 | 8359 | 515 | 95.09 | 95.09 | 94.99 | 95.68 | 4.91 | 4.91 | 0.00 | 0.00 |
| 1979 | 3781.40 | 7554 | 515 | 85.29 | 85.29 | 82.91 | 85.30 | 14.71 | 14.71 | 0.00 | 0.00 |
| 1980 | 3356.90 | 6640 | 515 | 73.68 | 73.68 | 74.21 | 75.59 | 14.10 | 12.09 | 14.23 | 0.00 |
| 1981 | 3947.70 | 7795 | 515 | 88.05 | 88.05 | 87.50 | 88.98 | 5.07 | 4.70 | 7.25 | 0.00 |
| 1982 | 3499.30 | 6915 | 515 | 77.80 | 77.80 | 77.57 | 78.94 | 10.00 | 8.65 | 13.55 | 0.00 |
| 1983 | 3070.80 | 6101 | 515 | 68.11 | 68.11 | 68.07 | 69.65 | 27.81 | 26.23 | 5.66 | 0.00 |
| 1984 | 0.00 | 0 | 515 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1985 | 0.00 | 0 | 515 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1986 | 0.00 | 0 | 515 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1987 | 832.79 | 1981 | 515 | 17.35 | 19.69 | 18.46 | 22.61 | 78.69 | 72.71 | 7.60 | 2.33 |
| 1988 | 3986.48 | 8224 | 515 | 89.12 | 89.16 | 88.12 | 93.62 | 10.81 | 10.81 | 0.04 | 0.03 |
| 1989 | 3222.13 | 6943 | 515 | 72.62 | 72.72 | 71.42 | 79.26 | 20.54 | 18.80 | 8.48 | 0.11 |
| 1990 | 3041.75 | 7435 | 515 | 70.56 | 70.86 | 67.42 | 84.87 | 22.19 | 20.21 | 8.93 | 0.30 |
| 1991 | 3051.08 | 6525 | 515 | 67.83 | 67.84 | 67.63 | 74.49 | 18.36 | 15.26 | 16.90 | 0.01 |
| 1992 | 2919.96 | 5798 | 515 | 65.43 | 65.43 | 64.55 | 66.01 | 22.58 | 19.09 | 15.48 | 0.00 |
| 1993 | 3451.16 | 6908 | 515 | 78.39 | 78.43 | 76.50 | 78.86 | 8.82 | 7.59 | 13.98 | 0.04 |
| 1994 | 897.64 | 1835 | 515 | 20.12 | 20.12 | 19.90 | 20.95 | 54.24 | 23.84 | 56.04 | 0.00 |
| 1995 | 2013.23 | 4234 | 515 | 44.85 | 45.71 | 44.63 | 48.33 | 49.07 | 44.04 | 10.25 | 0.86 |
| 1996 | 3011.76 | 6202 | 515 | 66.83 | 66.83 | 66.58 | 70.61 | 31.66 | 30.96 | 2.22 | 0.00 |
| 1997 | 3950.80 | 8205 | 515 | 89.68 | 89.68 | 88.54 | 94.70 | 10.32 | 10.32 | 0.00 | 0.00 |
| 1998 | Data not available - Suspended Operation | | | | | | | | | | |
| 1999 | | | | | | | | | | | |
| 2000 | | | | | | | | | | | |
| 2001 | | | | | | | | | | | |
| 2002 | | | | | | | | | | | |
| 2003 | | | | | | | | | | | |
| 2004 | | | | | | | | | | | |
| 2005 | 584.96 | 1230 | 515 | 95.88 | 95.88 | 51.42 | 55.68 | 4.12 | 4.12 | 0.00 | 0.00 |
| 2006 | 3470.49 | 7260 | 515 | 77.02 | 77.22 | 76.93 | 82.88 | 19.42 | 18.85 | 3.92 | 0.21 |
| 2007 | 1750.26 | 3447 | 515 | 38.91 | 38.94 | 38.80 | 39.35 | 50.80 | 43.22 | 17.84 | 0.04 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|--------|-------|-------|-------|------|
| 2008 | 2792.10 | 6221 | 515 | 61.72 | 61.78 | 61.72 | 70.82 | 37.71 | 37.70 | 0.52 | 0.06 |
| 2009 | 4108.77 | 8436 | 515 | 91.15 | 91.45 | 91.08 | 96.30 | 8.50 | 8.50 | 0.05 | 0.30 |
| 2010 | 2376.13 | 4983 | 515 | 52.73 | 52.90 | 52.67 | 56.88 | 22.60 | 18.82 | 28.28 | 0.17 |
| 2011 | 3669.17 | 7382 | 515 | 81.49 | 81.79 | 81.33 | 84.27 | 18.21 | 18.21 | 0.00 | 0.30 |
| 2012 | 2912.37 | 5799 | 515 | 64.48 | 65.11 | 64.38 | 66.02 | 4.03 | 5.44 | 29.45 | 0.64 |
| 2013 | 2074.98 | 4344 | 515 | 45.99 | 46.20 | 45.99 | 49.59 | 33.45 | 53.27 | 0.53 | 0.21 |
| 2014 | 3871.29 | 7855 | 515 | 86.08 | 87.40 | 85.81 | 89.67 | 12.55 | 12.55 | 0.05 | 1.32 |
| 2015 | 2599.85 | 5263 | 515 | 57.80 | 57.92 | 57.63 | 60.08 | 2.63 | 6.31 | 35.77 | 0.12 |
| 2016 | 4212.67 | 8784 | 515 | 93.41 | 94.28 | 93.12 | 100.00 | 5.25 | 5.22 | 0.50 | 0.87 |
| 2017 | 2608.49 | 5323 | 515 | 57.91 | 58.07 | 57.82 | 60.76 | 8.48 | 5.38 | 36.56 | 0.16 |
| 2018 | 4206.18 | 8503 | 515 | 93.41 | 94.09 | 93.23 | 97.07 | 4.63 | 4.57 | 1.34 | 0.68 |
| 2019 | 4299.59 | 8583 | 515 | 95.53 | 95.91 | 95.30 | 97.98 | 3.30 | 3.27 | 0.82 | 0.38 |
| 2020 | 2244.06 | 4660 | 515 | 49.73 | 50.11 | 49.61 | 53.05 | 9.73 | 5.40 | 44.49 | 0.38 |
| 2021 | 4183.00 | 8407 | 515 | 92.81 | 93.35 | 92.72 | 95.97 | 6.01 | 5.97 | 0.68 | 0.54 |
| 2022 | 2986.96 | 6046 | 515 | 66.29 | 66.78 | 66.21 | 69.02 | 2.09 | 1.42 | 31.79 | 0.50 |
| 2023 | 4165.01 | 8338 | 515 | 92.26 | 92.87 | 92.32 | 95.18 | 4.04 | 3.91 | 3.23 | 0.61 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1971 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 292 | | | 1557 | |
| D. Inspection, maintenance or repair without refuelling | 130 | | | 885 | | |
| E. Testing of plant systems or components | | | | 5 | 5 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 52 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| P. Fire | | | | | 32 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 67 |
| Z. Other | | | | | 10 | |
| Subtotal | 130 | 292 | | 890 | 1656 | 70 |
| Total | | 422 | | | 2616 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1971 to 2023 | |
|--|------------|-----|-------------------------------------|------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 806 |
| 12. Reactor I&C Systems | | | | 73 |
| 13. Reactor Auxiliary Systems | | | | 57 |
| 14. Safety Systems | | | | 55 |
| 15. Reactor Cooling Systems | | | | 130 |
| 16. Steam generation systems | | | | 56 |
| 21. Fuel Handling and Storage Facilities | | | | 71 |
| 31. Turbine and auxiliaries | | 292 | | 118 |
| 32. Feedwater and Main Steam System | | | | 47 |
| 33. Circulating Water System | | | | 2 |
| 34. Miscellaneous Systems | | | | 10 |
| 35. All other I&C Systems | | | | 6 |
| 41. Main Generator Systems | | | | 47 |
| 42. Electrical Power Supply Systems | | | | 108 |
| Total | | 292 | | 1586 |

Highlights (2023)

Forced Outage due to governor valve oscillations. Manual turbine trip.

2023 Operating Experience

CA-7

PICKERING-4

CANADA

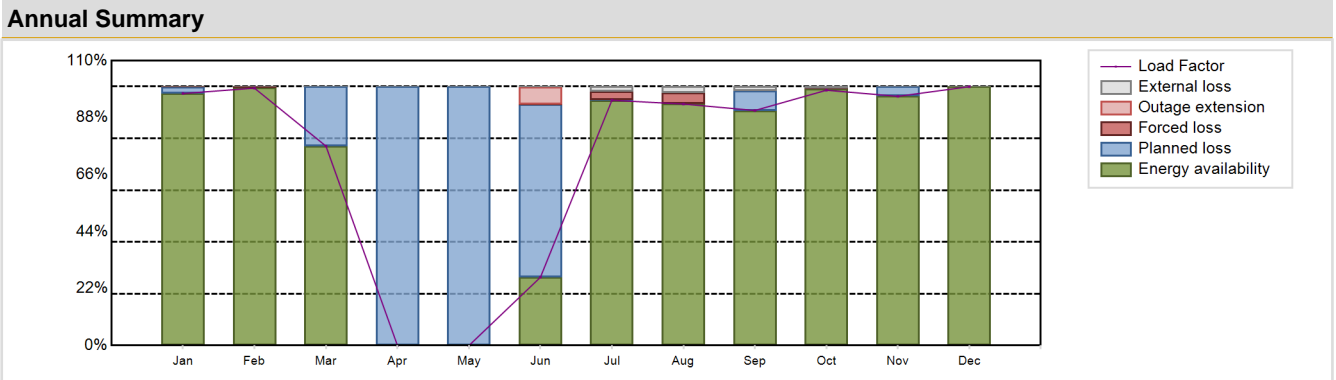
Status at end of year : **Operational**
 Operator : OPG (Ontario Power Generation)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)



| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 500A | Construction Date | : 1968-05-01 |
| Thermal power | : 1744 MWth | Grid Date | : 1973-05-21 |
| Gross electrical power | : 542 MWe | Commercial Date | : 1973-06-17 |
| Reference unit power (net) | : 515 MWe | Age at end of year | : 50 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 9 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 293 |
| Fuel material | : UO2 | Number of SG | : 12 |
| Refuelling type | : ON-line | Containment type | : - |
| Moderator material | : D2O | Containment design pressure [MPa] | : 1.46 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 9080 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 5.94 | HP cylinder inlet steam pressure [MPa] | : 3.8 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 4560 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 26.6 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 6 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 3284.29 GW(e).h | Forced Loss Rate (FLR) | : 0.93 % |
| Energy Availability Factor (EAF) | : 72.89 % | Unplanned Capability Loss Factor (UCL) | : 1.24 % |
| Unit Capability Factor (UCF) | : 73.46 % | Planned Unavailability Factor (PUF) | : 25.3 % |
| Load Factor (LF) | : 72.8 % | Externally cause unavailability (XUF) | : 0.57 % |
| Operating Factor (OF) | : 75.84 % | Total off-line time | : 2116 hours |

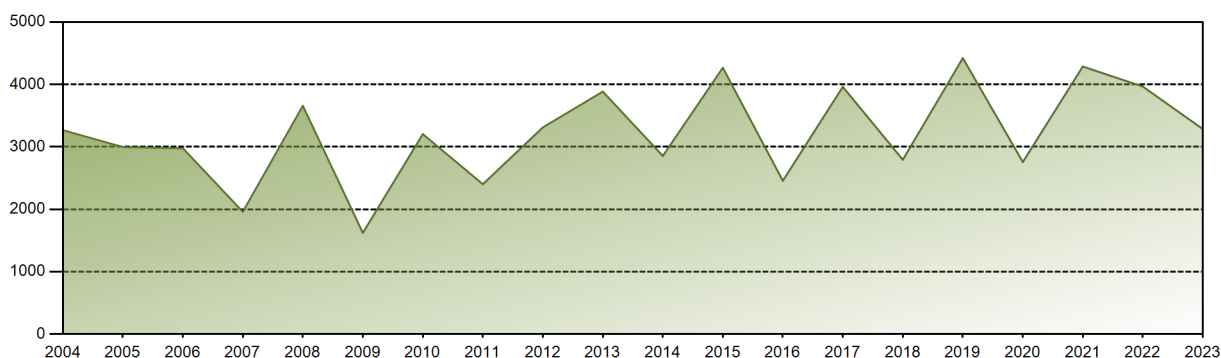


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 372.93 | 344.02 | 295.09 | 0.00 | 0.00 | 97.73 | 362.91 | 357.32 | 336.60 | 377.76 | 356.88 | 383.05 | 3284.29 |
| EAF [%] | 97.34 | 99.60 | 76.91 | 0.00 | 0.00 | 26.36 | 94.71 | 93.38 | 90.78 | 99.20 | 96.41 | 100.00 | 72.89 |
| UCF [%] | 97.34 | 99.60 | 76.91 | 0.00 | 0.00 | 26.51 | 96.65 | 95.80 | 92.38 | 99.88 | 96.41 | 100.00 | 73.46 |
| LF [%] | 97.33 | 99.40 | 77.02 | 0.00 | 0.00 | 26.36 | 94.71 | 93.26 | 90.78 | 98.59 | 96.25 | 99.97 | 72.80 |
| OF [%] | 100.00 | 100.00 | 80.24 | 0.00 | 0.00 | 29.86 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 75.84 |
| FLR [%] | 0.17 | 0.40 | 0.00 | 0.00 | 0.00 | 0.13 | 3.23 | 4.20 | 0.00 | 0.12 | 0.00 | 0.00 | 0.93 |
| UCL [%] | 0.17 | 0.40 | 0.00 | 0.00 | 0.00 | 6.78 | 3.22 | 4.20 | 0.00 | 0.12 | 0.00 | 0.00 | 1.24 |
| PUF [%] | 2.49 | 0.00 | 23.09 | 100.00 | 100.00 | 66.71 | 0.13 | 0.00 | 7.62 | 0.00 | 3.59 | 0.00 | 25.30 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 1.94 | 2.41 | 1.61 | 0.68 | 0.00 | 0.00 | 0.57 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 139083.77 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 16.67 % |
| Cumulative Energy Availability Factor (EAF) | : 68.71 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 15.06 % |
| Cumulative Unit Capability Factor (UCF) | : 69.13 % | Cumulative Planned Unavailability Factor (PUF) | : 15.8 % |
| Cumulative Load Factor (LF) | : 68.58 % | Cumulative Externally cause unavailability (XUF) | : 0.42 % |
| Cumulative Operating Factor (OF) | : 71.7 % | | |

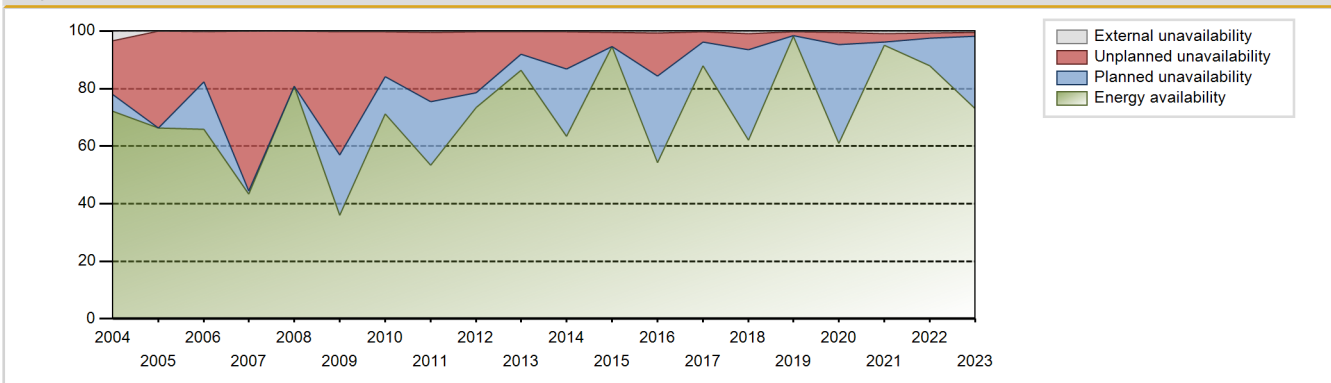
Electricity Production (net) [GWh]



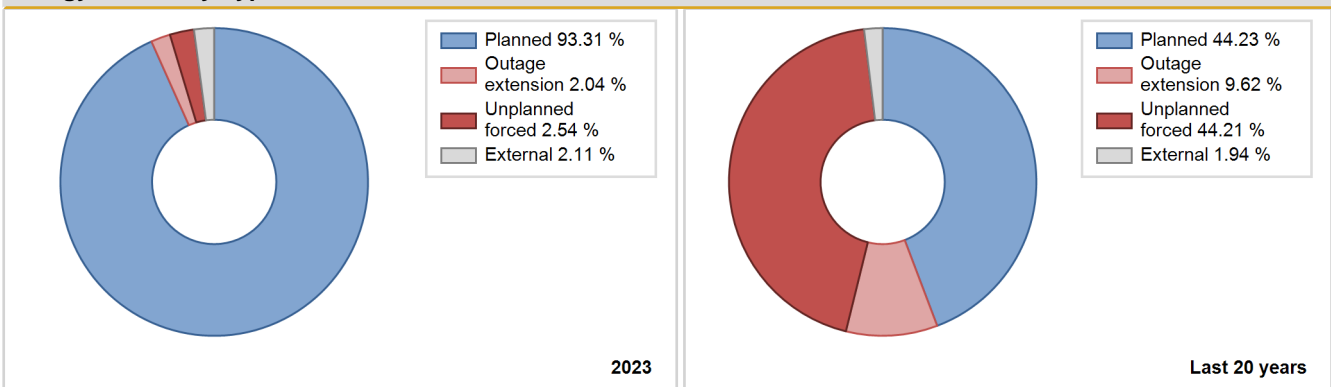
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1973 | 2226.60 | 4402 | 514 | 90.59 | 90.59 | 90.40 | 91.75 | 6.12 | 5.91 | 3.50 | 0.00 |
| 1974 | 4221.00 | 8356 | 514 | 94.00 | 94.00 | 94.00 | 95.65 | 5.22 | 5.18 | 0.82 | 0.00 |
| 1975 | 1094.20 | 2201 | 513 | 24.24 | 24.24 | 24.42 | 25.19 | 73.53 | 67.34 | 8.42 | 0.00 |
| 1976 | 3089.00 | 6063 | 514 | 68.23 | 68.23 | 68.60 | 69.21 | 31.44 | 31.29 | 0.49 | 0.00 |
| 1977 | 4107.20 | 7975 | 514 | 90.30 | 90.30 | 91.47 | 91.29 | 4.38 | 4.13 | 5.57 | 0.00 |
| 1978 | 4033.90 | 7876 | 515 | 89.70 | 89.70 | 89.66 | 90.16 | 3.07 | 2.84 | 7.46 | 0.00 |
| 1979 | 4102.20 | 8059 | 515 | 91.00 | 91.00 | 89.94 | 91.00 | 4.67 | 4.45 | 4.55 | 0.00 |
| 1980 | 3700.50 | 7321 | 515 | 81.76 | 81.76 | 81.80 | 83.34 | 8.38 | 7.48 | 10.77 | 0.00 |
| 1981 | 4142.00 | 8078 | 515 | 91.65 | 91.65 | 91.81 | 92.21 | 3.83 | 3.65 | 4.70 | 0.00 |
| 1982 | 4137.90 | 8087 | 515 | 91.76 | 91.76 | 91.72 | 92.32 | 2.61 | 2.46 | 5.78 | 0.00 |
| 1983 | 4170.20 | 8183 | 515 | 92.32 | 92.32 | 92.44 | 93.41 | 5.55 | 5.43 | 2.25 | 0.00 |
| 1984 | 3733.30 | 7425 | 515 | 82.75 | 82.75 | 82.53 | 84.53 | 4.49 | 3.89 | 13.36 | 0.00 |
| 1985 | 3438.86 | 6824 | 515 | 77.47 | 83.50 | 76.23 | 77.90 | 16.50 | 16.50 | 0.00 | 6.03 |
| 1986 | 3687.37 | 7410 | 515 | 83.16 | 83.16 | 81.73 | 84.59 | 7.06 | 6.32 | 10.52 | 0.00 |
| 1987 | 3770.41 | 7495 | 515 | 83.96 | 84.33 | 83.58 | 85.56 | 2.74 | 2.37 | 13.29 | 0.37 |
| 1988 | 3166.17 | 6525 | 515 | 70.11 | 70.11 | 69.99 | 74.28 | 17.91 | 15.29 | 14.60 | 0.00 |
| 1989 | 2255.49 | 5468 | 515 | 50.00 | 50.00 | 50.00 | 62.42 | 34.52 | 26.35 | 23.65 | 0.00 |
| 1990 | 1070.83 | 2851 | 515 | 23.74 | 23.74 | 23.74 | 32.55 | 43.49 | 18.27 | 58.00 | 0.00 |
| 1991 | 2130.76 | 5185 | 515 | 47.34 | 47.34 | 47.23 | 59.19 | 21.40 | 12.89 | 39.77 | 0.00 |
| 1992 | 0.00 | 0 | 515 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1993 | 3309.63 | 6711 | 515 | 73.76 | 74.21 | 73.36 | 76.61 | 7.77 | 6.25 | 19.55 | 0.45 |
| 1994 | 4009.64 | 7915 | 515 | 89.51 | 89.71 | 88.88 | 90.35 | 10.20 | 10.19 | 0.09 | 0.21 |
| 1995 | 2806.96 | 5684 | 515 | 63.33 | 63.84 | 62.22 | 64.89 | 36.16 | 36.16 | 0.00 | 0.50 |
| 1996 | 1134.91 | 2230 | 515 | 25.13 | 25.13 | 25.09 | 25.39 | 72.71 | 66.95 | 7.92 | 0.00 |
| 1997 | 0.00 | 0 | 515 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1998 | | | | Data not provided | | | | | | | |
| 1999 | | | | Data not available - Suspended Operation | | | | | | | |
| 2000 | | | | | | | | | | | |
| 2001 | | | | | | | | | | | |
| 2002 | | | | | | | | | | | |
| 2003 | 844.81 | 1880 | 515 | 72.27 | 72.27 | 72.27 | 82.70 | 27.73 | 27.73 | 0.00 | 0.00 |
| 2004 | 3266.76 | 6739 | 515 | 72.10 | 75.58 | 72.21 | 76.72 | 19.76 | 18.61 | 5.81 | 3.48 |
| 2005 | 2996.45 | 5900 | 515 | 66.40 | 66.52 | 66.42 | 67.35 | 33.48 | 33.48 | 0.00 | 0.13 |
| 2006 | 2976.54 | 6149 | 515 | 65.96 | 66.30 | 65.98 | 70.19 | 15.05 | 17.26 | 16.44 | 0.34 |
| 2007 | 1959.14 | 4086 | 515 | 43.44 | 43.44 | 43.43 | 46.64 | 49.23 | 55.59 | 0.96 | 0.00 |
| 2008 | 3656.45 | 7765 | 515 | 80.83 | 80.91 | 80.83 | 88.40 | 19.04 | 19.03 | 0.07 | 0.08 |
| 2009 | 1620.17 | 3845 | 515 | 35.91 | 36.15 | 35.91 | 43.89 | 48.47 | 42.90 | 20.95 | 0.24 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|--------|-------|-------|-------|------|
| 2010 | 3203.51 | 6583 | 515 | 71.13 | 71.37 | 71.01 | 75.15 | 17.89 | 15.55 | 13.08 | 0.24 |
| 2011 | 2401.12 | 4919 | 515 | 53.28 | 53.66 | 53.22 | 56.15 | 29.34 | 24.15 | 22.18 | 0.38 |
| 2012 | 3310.83 | 6592 | 515 | 73.42 | 73.73 | 73.19 | 75.05 | 20.62 | 21.17 | 5.10 | 0.31 |
| 2013 | 3884.54 | 7798 | 515 | 86.29 | 86.60 | 86.10 | 89.02 | 7.00 | 7.76 | 5.64 | 0.31 |
| 2014 | 2853.53 | 5772 | 515 | 63.30 | 63.49 | 63.25 | 65.89 | 5.37 | 13.00 | 23.51 | 0.19 |
| 2015 | 4266.31 | 8604 | 515 | 94.66 | 95.12 | 94.57 | 98.22 | 4.87 | 4.87 | 0.01 | 0.47 |
| 2016 | 2455.22 | 5169 | 515 | 54.32 | 54.91 | 54.27 | 58.85 | 10.39 | 15.07 | 30.01 | 0.60 |
| 2017 | 3961.10 | 7978 | 515 | 87.94 | 88.20 | 87.80 | 91.07 | 3.91 | 3.59 | 8.20 | 0.27 |
| 2018 | 2792.32 | 5901 | 515 | 62.06 | 62.92 | 61.89 | 67.36 | 8.24 | 5.65 | 31.43 | 0.87 |
| 2019 | 4421.44 | 8760 | 515 | 98.17 | 98.52 | 98.01 | 100.00 | 1.21 | 1.20 | 0.27 | 0.36 |
| 2020 | 2755.54 | 5555 | 515 | 60.92 | 61.42 | 60.91 | 63.24 | 1.20 | 4.29 | 34.29 | 0.50 |
| 2021 | 4286.99 | 8684 | 515 | 95.08 | 96.11 | 95.03 | 99.13 | 2.91 | 2.88 | 1.01 | 1.03 |
| 2022 | 3965.81 | 8020 | 515 | 87.88 | 88.68 | 87.91 | 91.55 | 1.90 | 1.71 | 9.61 | 0.80 |
| 2023 | 3284.29 | 6644 | 515 | 72.89 | 73.46 | 72.80 | 75.84 | 0.93 | 1.24 | 25.30 | 0.57 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1973 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 49 | | | 1078 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 59 | | |
| D. Inspection, maintenance or repair without refuelling | 2068 | | | 1267 | | |
| E. Testing of plant systems or components | | | | 50 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 5 |
| L. Human factor related | | | | | 3 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 12 |
| Z. Other | | | | | 6 | |
| Subtotal | 2068 | 49 | | 1376 | 1087 | 17 |
| Total | | 2117 | | | 2480 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1973 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 53 |
| 12. Reactor I&C Systems | | 126 |
| 13. Reactor Auxiliary Systems | | 141 |
| 14. Safety Systems | | 16 |
| 15. Reactor Cooling Systems | 49 | 402 |
| 16. Steam generation systems | | 37 |
| 21. Fuel Handling and Storage Facilities | | 10 |
| 31. Turbine and auxiliaries | | 104 |
| 32. Feedwater and Main Steam System | | 26 |
| 34. Miscellaneous Systems | | 15 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 42 |
| 42. Electrical Power Supply Systems | | 99 |
| Total | 49 | 1075 |

2023 Operating Experience

CA-13

PICKERING-5

CANADA

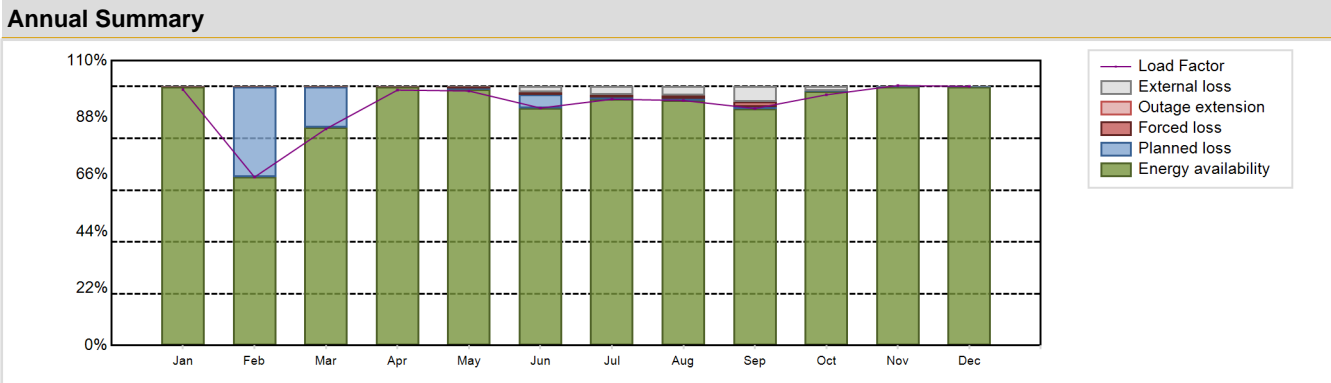
Status at end of year : **Operational**
 Operator : OPG (Ontario Power Generation)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)



| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 500B | Construction Date | : 1974-11-01 |
| Thermal power | : 1744 MWth | Grid Date | : 1982-12-19 |
| Gross electrical power | : 540 MWe | Commercial Date | : 1983-05-10 |
| Reference unit power (net) | : 516 MWe | Age at end of year | : 41 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 9 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 293.4 |
| Fuel material | : UO2 | Number of SG | : 12 |
| Refuelling type | : ON-line | Containment type | : - |
| Moderator material | : D2O | Containment design pressure [MPa] | : 1.46 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 8330 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 5.94 | HP cylinder inlet steam pressure [MPa] | : 3.8 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 4560 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 27.3 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 21 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 4208.08 GW(e).h | Forced Loss Rate (FLR) | : 0.53 % |
| Energy Availability Factor (EAF) | : 93.47 % | Unplanned Capability Loss Factor (UCL) | : 0.5 % |
| Unit Capability Factor (UCF) | : 94.82 % | Planned Unavailability Factor (PUF) | : 4.68 % |
| Load Factor (LF) | : 93.1 % | Externally cause unavailability (XUF) | : 1.35 % |
| Operating Factor (OF) | : 96.31 % | Total off-line time | : 323 hours |

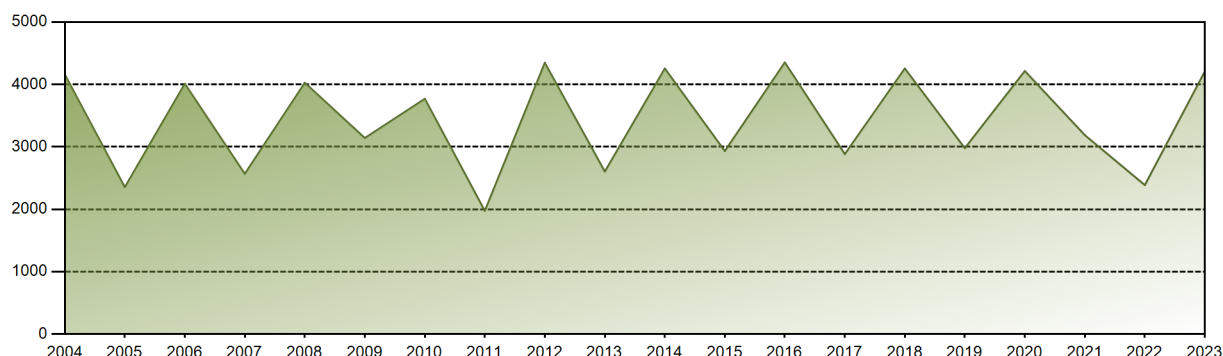


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 379.42 | 225.47 | 321.15 | 366.47 | 377.39 | 340.74 | 365.10 | 363.26 | 340.11 | 371.70 | 373.08 | 384.19 | 4208.07 |
| EAF [%] | 99.96 | 65.08 | 84.26 | 99.98 | 98.81 | 91.72 | 95.10 | 94.62 | 91.55 | 98.18 | 99.90 | 99.99 | 93.47 |
| UCF [%] | 99.96 | 65.08 | 84.26 | 99.98 | 98.81 | 93.89 | 98.33 | 97.88 | 97.38 | 99.86 | 99.90 | 99.99 | 94.82 |
| LF [%] | 98.83 | 65.02 | 83.65 | 98.64 | 98.30 | 91.72 | 95.10 | 94.62 | 91.55 | 96.82 | 100.42 | 100.07 | 93.10 |
| OF [%] | 100.00 | 65.18 | 88.04 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.31 |
| FLR [%] | 0.04 | 0.05 | 0.10 | 0.02 | 0.60 | 1.02 | 0.93 | 1.40 | 2.00 | 0.00 | 0.00 | 0.00 | 0.53 |
| UCL [%] | 0.04 | 0.03 | 0.08 | 0.02 | 0.59 | 0.96 | 0.92 | 1.39 | 1.99 | 0.00 | 0.00 | 0.00 | 0.50 |
| PUF [%] | 0.00 | 34.89 | 15.65 | 0.00 | 0.59 | 5.14 | 0.74 | 0.73 | 0.63 | 0.14 | 0.10 | 0.01 | 4.68 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.18 | 3.23 | 3.26 | 5.84 | 1.68 | 0.00 | 0.00 | 1.35 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 137022.69 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 11.88 % |
| Cumulative Energy Availability Factor (EAF) | : 74.51 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 11.49 % |
| Cumulative Unit Capability Factor (UCF) | : 75.24 % | Cumulative Planned Unavailability Factor (PUF) | : 13.27 % |
| Cumulative Load Factor (LF) | : 74.26 % | Cumulative Externally cause unavailability (XUF) | : 0.73 % |
| Cumulative Operating Factor (OF) | : 78.05 % | | |

Electricity Production (net) [GWh]

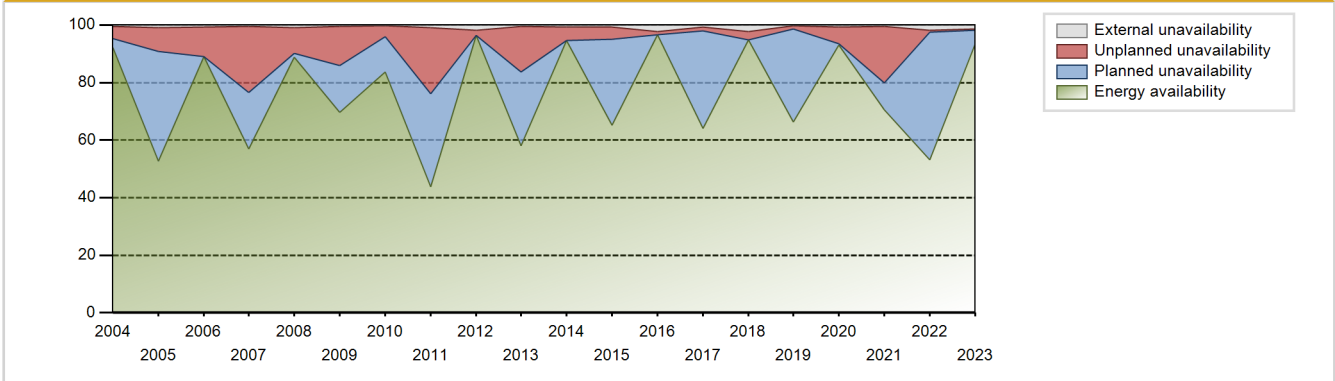


Performance for Years of Commercial Operation

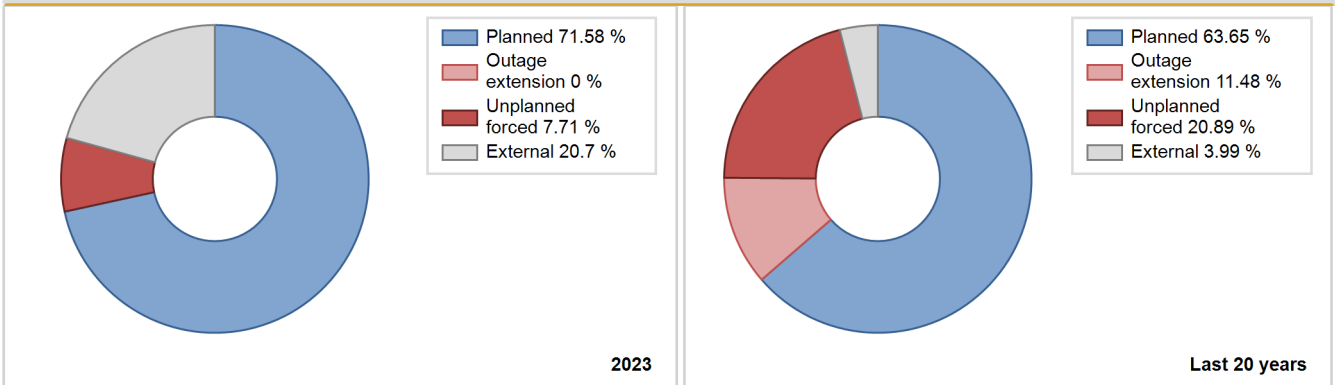
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 3202.40 | 6968 | 516 | 90.29 | 90.29 | 89.64 | 92.62 | 9.69 | 9.69 | 0.02 | 0.00 |
| 1984 | 3517.52 | 7035 | 516 | 77.75 | 77.75 | 77.61 | 80.09 | 11.82 | 10.42 | 11.83 | 0.00 |
| 1985 | 3366.50 | 6989 | 516 | 77.74 | 83.10 | 74.48 | 79.78 | 8.79 | 8.01 | 8.89 | 5.36 |
| 1986 | 4068.64 | 8057 | 516 | 90.70 | 91.16 | 90.01 | 91.97 | 2.33 | 2.18 | 6.66 | 0.46 |
| 1987 | 3600.10 | 7148 | 516 | 79.56 | 80.33 | 79.65 | 81.60 | 7.82 | 6.82 | 12.85 | 0.77 |
| 1988 | 4397.16 | 8683 | 516 | 97.52 | 97.55 | 97.01 | 98.85 | 2.09 | 2.09 | 0.37 | 0.03 |
| 1989 | 3400.76 | 6862 | 516 | 75.42 | 75.67 | 75.24 | 78.33 | 9.36 | 7.81 | 16.52 | 0.25 |
| 1990 | 3885.00 | 7821 | 516 | 86.36 | 86.44 | 85.95 | 89.28 | 4.06 | 3.65 | 9.90 | 0.08 |
| 1991 | 2887.06 | 5724 | 516 | 64.36 | 64.56 | 63.87 | 65.34 | 28.95 | 26.30 | 9.14 | 0.20 |
| 1992 | 1345.25 | 2621 | 516 | 29.76 | 29.76 | 29.68 | 29.84 | 70.24 | 70.24 | 0.00 | 0.00 |
| 1993 | 3841.81 | 8307 | 516 | 85.40 | 85.57 | 84.99 | 94.83 | 14.25 | 14.22 | 0.22 | 0.16 |
| 1994 | 3074.41 | 6196 | 516 | 68.53 | 68.53 | 68.02 | 70.73 | 9.15 | 6.90 | 24.57 | 0.00 |
| 1995 | 3372.87 | 7008 | 516 | 74.76 | 75.01 | 74.62 | 80.00 | 13.00 | 11.21 | 13.77 | 0.25 |
| 1996 | 3042.63 | 6429 | 516 | 67.13 | 67.13 | 67.13 | 73.19 | 32.87 | 32.87 | 0.00 | 0.00 |
| 1997 | 3924.89 | 7908 | 516 | 86.83 | 86.83 | 86.83 | 90.27 | 13.17 | 13.17 | 0.00 | 0.00 |
| 1998 | 3490.58 | 7296 | 516 | 77.22 | 77.22 | 77.22 | 83.29 | 8.70 | 7.36 | 15.42 | 0.00 |
| 1999 | 2511.57 | 5302 | 516 | 55.56 | 55.63 | 55.56 | 60.53 | 20.16 | 14.04 | 30.33 | 0.06 |
| 2000 | 2631.49 | 5457 | 516 | 58.03 | 58.12 | 58.06 | 62.12 | 32.58 | 28.09 | 13.79 | 0.09 |
| 2001 | 2980.21 | 5986 | 516 | 65.87 | 66.57 | 65.93 | 68.33 | 6.95 | 4.97 | 28.46 | 0.71 |
| 2002 | 2655.74 | 5565 | 516 | 58.75 | 59.17 | 58.75 | 63.53 | 11.96 | 8.03 | 32.80 | 0.41 |
| 2003 | 3294.96 | 6566 | 516 | 69.14 | 71.14 | 72.89 | 74.95 | 28.29 | 28.07 | 0.79 | 2.00 |
| 2004 | 4159.81 | 8264 | 516 | 92.16 | 92.60 | 91.78 | 94.08 | 4.45 | 4.31 | 3.09 | 0.44 |
| 2005 | 2352.79 | 4818 | 516 | 52.63 | 53.56 | 52.05 | 55.00 | 9.80 | 8.30 | 38.14 | 0.93 |
| 2006 | 4010.87 | 8113 | 516 | 88.95 | 89.66 | 88.73 | 92.61 | 10.34 | 10.34 | 0.00 | 0.71 |
| 2007 | 2567.59 | 5637 | 516 | 56.96 | 57.51 | 56.80 | 64.35 | 21.85 | 22.84 | 19.66 | 0.55 |
| 2008 | 4026.82 | 8357 | 516 | 88.86 | 89.80 | 88.84 | 95.14 | 7.64 | 8.89 | 1.31 | 0.94 |
| 2009 | 3140.88 | 6631 | 516 | 69.60 | 70.12 | 69.49 | 75.70 | 7.81 | 13.53 | 16.35 | 0.51 |
| 2010 | 3769.85 | 7645 | 516 | 83.73 | 84.08 | 83.40 | 87.27 | 4.21 | 3.69 | 12.23 | 0.36 |
| 2011 | 1973.46 | 4258 | 516 | 43.87 | 44.83 | 43.66 | 48.61 | 10.88 | 22.97 | 32.20 | 0.96 |
| 2012 | 4347.31 | 8725 | 516 | 96.34 | 98.24 | 95.91 | 99.33 | 1.69 | 1.69 | 0.07 | 1.89 |
| 2013 | 2603.23 | 5371 | 516 | 58.06 | 58.57 | 57.59 | 61.31 | 1.98 | 15.82 | 25.61 | 0.51 |
| 2014 | 4255.09 | 8760 | 516 | 94.57 | 95.35 | 94.14 | 100.00 | 4.50 | 4.49 | 0.15 | 0.78 |
| 2015 | 2932.28 | 5865 | 516 | 65.29 | 65.91 | 64.87 | 66.95 | 0.62 | 4.44 | 29.66 | 0.62 |
| 2016 | 4352.12 | 8784 | 516 | 96.56 | 98.79 | 96.02 | 100.00 | 1.11 | 1.10 | 0.10 | 2.23 |
| 2017 | 2883.68 | 5841 | 516 | 64.14 | 64.82 | 63.80 | 66.68 | 1.92 | 1.27 | 33.91 | 0.69 |
| 2018 | 4255.38 | 8615 | 516 | 94.81 | 97.08 | 94.14 | 98.34 | 2.88 | 2.87 | 0.04 | 2.28 |
| 2019 | 2978.82 | 5934 | 516 | 66.30 | 66.58 | 65.90 | 67.74 | 1.67 | 1.13 | 32.28 | 0.28 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2020 | 4215.36 | 8520 | 516 | 93.12 | 93.85 | 93.00 | 96.99 | 5.72 | 5.70 | 0.45 | 0.73 |
| 2021 | 3187.45 | 6438 | 516 | 70.59 | 71.14 | 70.52 | 73.49 | 21.62 | 19.62 | 9.24 | 0.55 |
| 2022 | 2386.74 | 4852 | 516 | 53.15 | 54.86 | 52.80 | 55.39 | 0.88 | 0.78 | 44.36 | 1.71 |
| 2023 | 4208.07 | 8437 | 516 | 93.47 | 94.82 | 93.10 | 96.31 | 0.53 | 0.50 | 4.68 | 1.35 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 758 | |
| D. Inspection, maintenance or repair without refuelling | 323 | | | 1077 | | |
| E. Testing of plant systems or components | | | | 0 | 1 | |
| L. Human factor related | | | | | 47 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 7 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 14 |
| Z. Other | | | | 24 | 18 | |
| Subtotal | 323 | | | 1101 | 824 | 21 |
| Total | | 323 | | | 1946 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 51 |
| 12. Reactor I&C Systems | | 60 |
| 13. Reactor Auxiliary Systems | | 49 |
| 14. Safety Systems | | 16 |
| 15. Reactor Cooling Systems | | 104 |
| 16. Steam generation systems | | 240 |
| 21. Fuel Handling and Storage Facilities | | 15 |
| 31. Turbine and auxiliaries | | 41 |
| 32. Feedwater and Main Steam System | | 8 |
| 33. Circulating Water System | | 10 |
| 35. All other I&C Systems | | 7 |
| 41. Main Generator Systems | | 101 |
| 42. Electrical Power Supply Systems | | 76 |
| Total | | 778 |

2023 Operating Experience

CA-14

PICKERING-6

CANADA

Status at end of year : **Operational**
 Operator : OPG (Ontario Power Generation)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)



Reactor Unit Details

Reactor type and model : PHWR / CANDU 500B
 Thermal power : 1744 MWth
 Gross electrical power : 540 MWe
 Reference unit power (net) : 516 MWe

Key Dates

Construction Date : 1975-10-01
 Grid Date : 1983-11-08
 Commercial Date : 1984-02-01
 Age at end of year : 40 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 8330
 Active core diameter [m] : 5.94
 Active core height/length [m] : 5.94
 Number of fissile fuel assemblies/bundles : 4560
 Fuel linear heat generation rate [kW/m] : 27.3
 Number of control rod assemblies : 21
 Number of external reactor coolant loops : 2
 Coolant type : D2O

Operating coolant pressure [MPa] : 9
 Reactor outlet temperature [°C] : 293.4
 Number of SG : 12
 Containment type : -
 Containment design pressure [MPa] : 1.46

Secondary systems

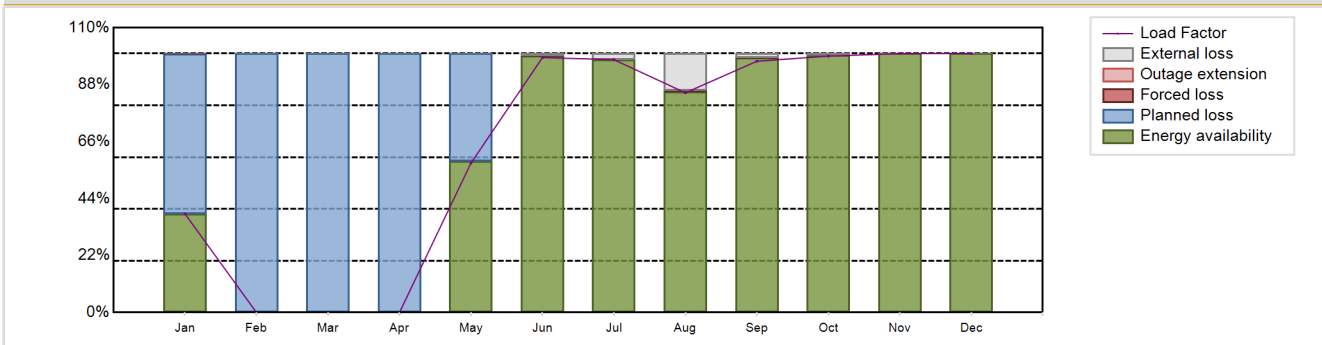
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 3.8
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 2930.52 GW(e).h
 Energy Availability Factor (EAF) : 65.12 %
 Unit Capability Factor (UCF) : 66.79 %
 Load Factor (LF) : 64.83 %
 Operating Factor (OF) : 66.51 %
 Forced Loss Rate (FLR) : 0.07 %
 Unplanned Capability Loss Factor (UCL) : 0.05 %
 Planned Unavailability Factor (PUF) : 33.16 %
 Externally cause unavailability (XUF) : 1.67 %
 Total off-line time : 2934 hours

Annual Summary

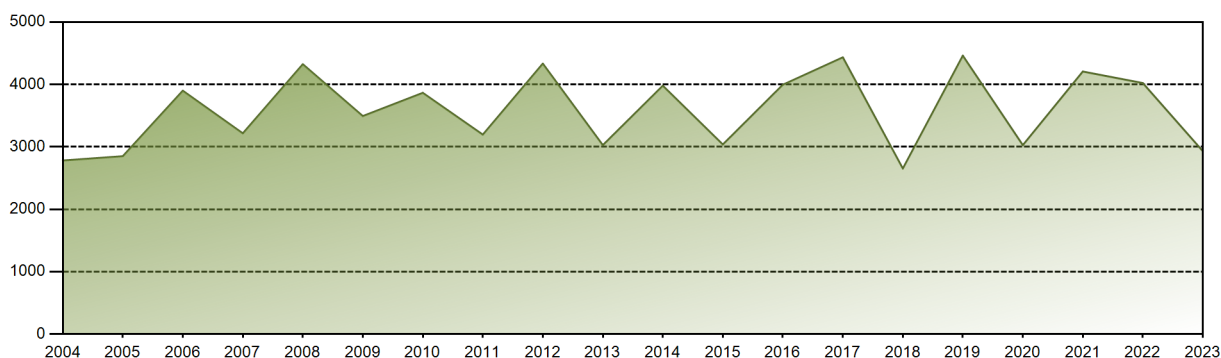


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 146.36 | 0.00 | 0.00 | 0.00 | 221.51 | 365.81 | 374.88 | 325.81 | 360.52 | 380.20 | 371.52 | 383.90 | 2930.52 |
| EAF [%] | 38.17 | 0.00 | 0.00 | 0.00 | 58.47 | 99.15 | 97.65 | 85.31 | 98.28 | 99.37 | 100.00 | 100.00 | 65.12 |
| UCF [%] | 38.17 | 0.00 | 0.00 | 0.00 | 58.47 | 99.99 | 100.00 | 99.57 | 99.94 | 100.00 | 100.00 | 100.00 | 66.79 |
| LF [%] | 38.12 | 0.00 | 0.00 | 0.00 | 57.70 | 98.46 | 97.65 | 84.87 | 97.04 | 99.03 | 100.00 | 100.00 | 64.83 |
| OF [%] | 39.11 | 0.00 | 0.00 | 0.00 | 62.10 | 100.00 | 100.00 | 91.53 | 100.00 | 100.00 | 100.00 | 100.00 | 66.51 |
| FLR [%] | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.43 | 0.06 | 0.00 | 0.00 | 0.00 | 0.07 |
| UCL [%] | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.43 | 0.06 | 0.00 | 0.00 | 0.00 | 0.05 |
| PUF [%] | 61.77 | 100.00 | 100.00 | 100.00 | 41.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.16 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.84 | 2.35 | 14.26 | 1.66 | 0.63 | 0.00 | 0.00 | 1.67 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 142172.41 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.45 % |
| Cumulative Energy Availability Factor (EAF) | : 78.51 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.84 % |
| Cumulative Unit Capability Factor (UCF) | : 79.25 % | Cumulative Planned Unavailability Factor (PUF) | : 12.91 % |
| Cumulative Load Factor (LF) | : 78.46 % | Cumulative Externally cause unavailability (XUF) | : 0.74 % |
| Cumulative Operating Factor (OF) | : 81.19 % | | |

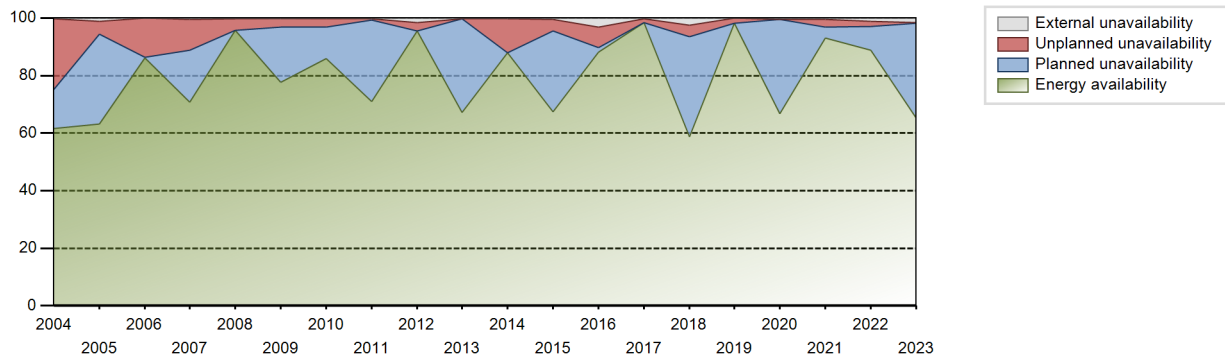
Electricity Production (net) [GWh]



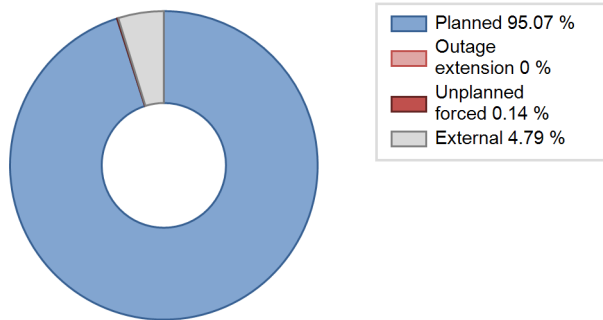
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 3816.08 | 7636 | 516 | 86.09 | 86.09 | 85.88 | 87.66 | 13.78 | 13.76 | 0.16 | 0.00 |
| 1985 | 3289.09 | 6540 | 516 | 73.11 | 79.48 | 72.76 | 74.66 | 6.72 | 5.73 | 14.80 | 6.37 |
| 1986 | 3395.22 | 6763 | 516 | 75.84 | 76.11 | 75.11 | 77.20 | 18.81 | 17.63 | 6.25 | 0.28 |
| 1987 | 3949.93 | 7791 | 516 | 86.60 | 88.53 | 87.38 | 88.94 | 3.42 | 3.13 | 8.33 | 1.94 |
| 1988 | 4496.76 | 8775 | 516 | 98.42 | 98.49 | 99.21 | 99.90 | 1.51 | 1.51 | 0.00 | 0.07 |
| 1989 | 3950.21 | 7794 | 516 | 87.57 | 87.89 | 87.39 | 88.97 | 5.86 | 5.47 | 6.64 | 0.31 |
| 1990 | 3473.45 | 7017 | 516 | 76.92 | 77.74 | 76.84 | 80.10 | 7.76 | 6.54 | 15.72 | 0.82 |
| 1991 | 4469.68 | 8721 | 516 | 98.97 | 99.21 | 98.88 | 99.55 | 0.79 | 0.79 | 0.00 | 0.24 |
| 1992 | 4050.47 | 7936 | 516 | 89.29 | 89.32 | 89.36 | 90.35 | 10.54 | 10.53 | 0.15 | 0.03 |
| 1993 | 2689.19 | 5506 | 516 | 59.88 | 60.38 | 59.49 | 62.85 | 11.28 | 7.68 | 31.94 | 0.50 |
| 1994 | 4043.00 | 8036 | 516 | 90.14 | 90.15 | 89.44 | 91.74 | 9.71 | 9.70 | 0.15 | 0.01 |
| 1995 | 3493.34 | 6962 | 516 | 77.19 | 77.51 | 77.28 | 79.47 | 5.67 | 4.66 | 17.83 | 0.32 |
| 1996 | 2591.65 | 5707 | 516 | 57.18 | 57.18 | 57.18 | 64.97 | 31.11 | 25.82 | 17.00 | 0.00 |
| 1997 | 3386.16 | 6841 | 516 | 74.91 | 74.91 | 74.91 | 78.09 | 16.79 | 15.11 | 9.98 | 0.00 |
| 1998 | 3130.15 | 6384 | 516 | 69.25 | 69.73 | 69.25 | 72.88 | 14.14 | 11.48 | 18.78 | 0.49 |
| 1999 | 3353.71 | 6863 | 516 | 74.18 | 74.42 | 74.19 | 78.34 | 25.38 | 25.31 | 0.27 | 0.24 |
| 2000 | 2738.74 | 6449 | 516 | 60.46 | 60.60 | 60.42 | 73.42 | 19.46 | 14.64 | 24.76 | 0.14 |
| 2001 | 2618.08 | 5286 | 516 | 57.68 | 57.68 | 57.92 | 60.34 | 21.61 | 15.90 | 26.42 | 0.00 |
| 2002 | 3982.31 | 7985 | 516 | 88.29 | 88.90 | 88.10 | 91.15 | 7.01 | 6.71 | 4.39 | 0.61 |
| 2003 | 3267.37 | 6566 | 516 | 72.46 | 74.27 | 72.28 | 74.95 | 12.71 | 10.81 | 14.92 | 1.81 |
| 2004 | 2780.80 | 5597 | 516 | 61.51 | 61.68 | 61.35 | 63.72 | 28.61 | 24.72 | 13.60 | 0.17 |
| 2005 | 2850.13 | 5596 | 516 | 63.14 | 64.25 | 63.05 | 63.88 | 3.16 | 4.41 | 31.34 | 1.12 |
| 2006 | 3899.46 | 7635 | 516 | 86.05 | 86.14 | 86.27 | 87.16 | 4.26 | 13.54 | 0.32 | 0.10 |
| 2007 | 3216.52 | 6588 | 516 | 70.75 | 71.26 | 71.16 | 75.21 | 8.36 | 10.77 | 17.97 | 0.51 |
| 2008 | 4323.78 | 8521 | 516 | 95.64 | 95.79 | 95.39 | 97.01 | 4.21 | 4.21 | 0.00 | 0.15 |
| 2009 | 3493.23 | 7051 | 516 | 77.60 | 77.97 | 77.28 | 80.49 | 3.36 | 2.71 | 19.32 | 0.36 |
| 2010 | 3865.26 | 7659 | 516 | 85.83 | 86.01 | 85.51 | 87.43 | 3.22 | 2.86 | 11.12 | 0.19 |
| 2011 | 3195.82 | 6334 | 516 | 70.96 | 71.33 | 70.70 | 72.31 | 0.60 | 0.43 | 28.24 | 0.38 |
| 2012 | 4333.57 | 8550 | 516 | 95.50 | 97.08 | 95.61 | 97.34 | 2.92 | 2.92 | 0.00 | 1.58 |
| 2013 | 3027.43 | 6047 | 516 | 67.19 | 67.42 | 66.98 | 69.03 | 0.14 | 0.10 | 32.49 | 0.23 |
| 2014 | 3979.30 | 8397 | 516 | 87.91 | 88.18 | 88.03 | 95.86 | 11.82 | 11.82 | 0.00 | 0.27 |
| 2015 | 3037.96 | 6064 | 516 | 67.32 | 67.86 | 67.21 | 69.22 | 5.43 | 3.89 | 28.25 | 0.54 |
| 2016 | 3995.28 | 8259 | 516 | 88.20 | 91.33 | 88.15 | 94.02 | 2.89 | 7.15 | 1.52 | 3.13 |
| 2017 | 4434.18 | 8686 | 516 | 98.31 | 98.57 | 98.10 | 99.16 | 1.43 | 1.43 | 0.00 | 0.27 |
| 2018 | 2652.58 | 5392 | 516 | 58.68 | 61.18 | 58.68 | 61.55 | 6.08 | 3.96 | 34.87 | 2.49 |
| 2019 | 4461.28 | 8681 | 516 | 98.28 | 98.40 | 98.70 | 99.10 | 1.59 | 1.59 | 0.01 | 0.12 |
| 2020 | 3027.01 | 5918 | 516 | 66.72 | 67.10 | 66.78 | 67.37 | 0.07 | 0.05 | 32.85 | 0.39 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 4206.84 | 8455 | 516 | 92.99 | 93.52 | 93.07 | 96.52 | 2.70 | 2.60 | 3.88 | 0.53 |
| 2022 | 4022.03 | 7845 | 516 | 88.91 | 90.17 | 88.98 | 89.55 | 1.91 | 1.76 | 8.07 | 1.26 |
| 2023 | 2930.52 | 5826 | 516 | 65.12 | 66.79 | 64.83 | 66.51 | 0.07 | 0.05 | 33.16 | 1.67 |

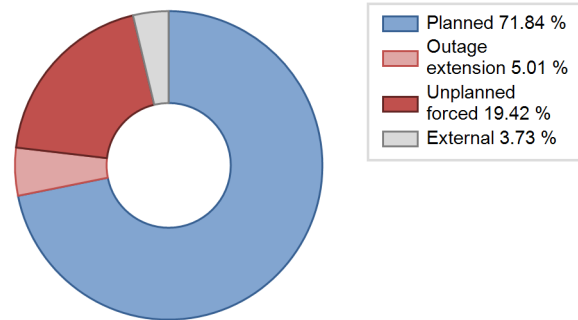
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 483 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 75 | | |
| D. Inspection, maintenance or repair without refuelling | 2871 | | | 1024 | | |
| E. Testing of plant systems or components | | | | 0 | 3 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 16 |
| L. Human factor related | | | | | 33 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 63 | | | 12 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 15 |
| Z. Other | | | | | 2 | |
| Subtotal | 2871 | | 63 | 1099 | 521 | 43 |
| Total | | 2934 | | | 1663 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 52 |
| 12. Reactor I&C Systems | | 43 |
| 13. Reactor Auxiliary Systems | | 27 |
| 14. Safety Systems | | 35 |
| 15. Reactor Cooling Systems | | 46 |
| 16. Steam generation systems | | 91 |
| 21. Fuel Handling and Storage Facilities | | 12 |
| 31. Turbine and auxiliaries | | 49 |
| 32. Feedwater and Main Steam System | | 32 |
| 33. Circulating Water System | 63 | 14 |
| 34. Miscellaneous Systems | | 18 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 59 |
| 42. Electrical Power Supply Systems | | 23 |
| Total | 63 | 506 |

Highlights (2023)

Unit 6 experienced an outage due to debris run in the screenhouse through a manual Turbine trip.

2023 Operating Experience

CA-15

PICKERING-7

CANADA

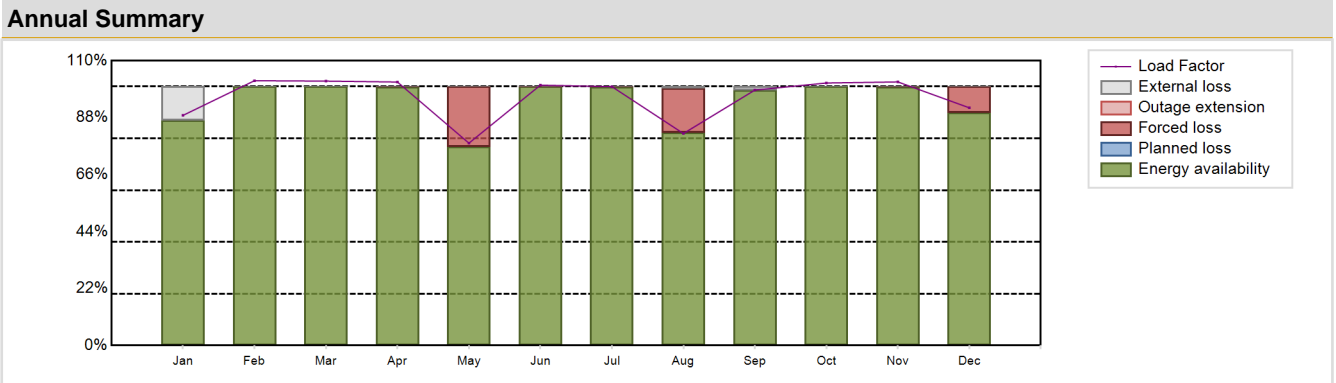
Status at end of year : **Operational**
 Operator : OPG (Ontario Power Generation)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)



| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 500B | Construction Date | : 1976-03-01 |
| Thermal power | : 1744 MWth | Grid Date | : 1984-11-17 |
| Gross electrical power | : 540 MWe | Commercial Date | : 1985-01-01 |
| Reference unit power (net) | : 516 MWe | Age at end of year | : 39 years |

| Design Characteristics | | | |
|---|--------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 9 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 293.4 |
| Fuel material | : UO2/PuO2 | Number of SG | : 12 |
| Refuelling type | : ON-line | Containment type | : - |
| Moderator material | : D2O | Containment design pressure [MPa] | : 1.46 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 8330 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 5.94 | HP cylinder inlet steam pressure [MPa] | : 3.8 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 4560 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 27.3 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 21 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 4324.26 GW(e).h | Forced Loss Rate (FLR) | : 4.3 % |
| Energy Availability Factor (EAF) | : 94.4 % | Unplanned Capability Loss Factor (UCL) | : 4.3 % |
| Unit Capability Factor (UCF) | : 95.7 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 95.67 % | Externally cause unavailability (XUF) | : 1.3 % |
| Operating Factor (OF) | : 95.21 % | Total off-line time | : 420 hours |

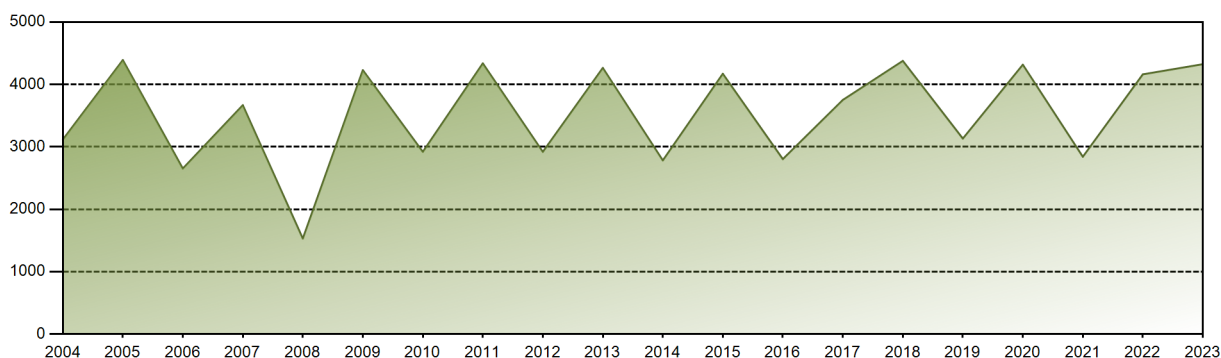


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 341.22 | 354.64 | 392.05 | 378.07 | 300.05 | 373.60 | 383.83 | 314.33 | 366.55 | 389.22 | 378.24 | 352.46 | 4324.26 |
| EAF [%] | 86.91 | 100.00 | 100.00 | 99.92 | 76.72 | 100.00 | 99.98 | 82.12 | 98.51 | 100.00 | 99.97 | 89.92 | 94.40 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 99.92 | 76.72 | 100.00 | 99.98 | 82.84 | 100.00 | 100.00 | 99.97 | 89.92 | 95.70 |
| LF [%] | 88.88 | 102.28 | 102.12 | 101.76 | 78.16 | 100.56 | 99.98 | 81.88 | 98.66 | 101.38 | 101.81 | 91.81 | 95.67 |
| OF [%] | 88.71 | 100.00 | 100.00 | 100.00 | 79.30 | 100.00 | 100.00 | 84.54 | 100.00 | 100.00 | 100.00 | 90.99 | 95.21 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.08 | 23.28 | 0.00 | 0.02 | 17.16 | 0.00 | 0.00 | 0.03 | 10.08 | 4.30 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.08 | 23.28 | 0.00 | 0.02 | 17.16 | 0.00 | 0.00 | 0.03 | 10.08 | 4.30 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 13.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.72 | 1.49 | 0.00 | 0.00 | 0.00 | 1.30 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 138955.43 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 9.78 % |
| Cumulative Energy Availability Factor (EAF) | : 78.67 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 9.4 % |
| Cumulative Unit Capability Factor (UCF) | : 79.28 % | Cumulative Planned Unavailability Factor (PUF) | : 11.32 % |
| Cumulative Load Factor (LF) | : 78.56 % | Cumulative Externally cause unavailability (XUF) | : 0.61 % |
| Cumulative Operating Factor (OF) | : 81.29 % | | |

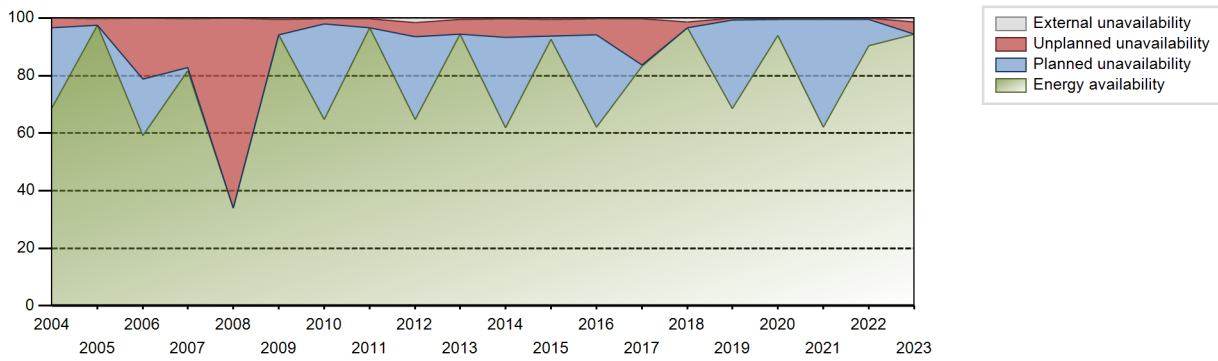
Electricity Production (net) [GWh]



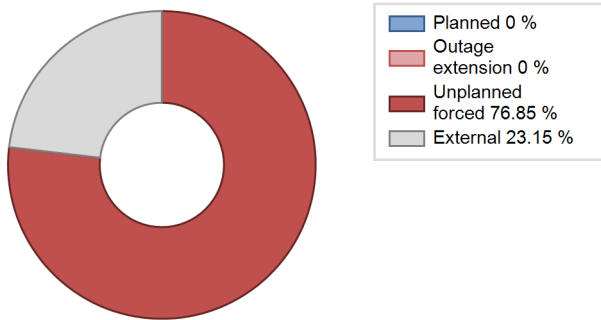
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 4093.95 | 8277 | 516 | 92.65 | 99.03 | 90.57 | 94.49 | 0.86 | 0.86 | 0.11 | 6.39 |
| 1986 | 3373.30 | 7002 | 516 | 75.20 | 75.45 | 74.63 | 79.93 | 8.27 | 6.80 | 17.75 | 0.25 |
| 1987 | 4339.89 | 8642 | 516 | 95.99 | 97.44 | 96.01 | 98.65 | 2.50 | 2.50 | 0.05 | 1.45 |
| 1988 | 4340.42 | 8519 | 516 | 95.39 | 95.94 | 95.76 | 96.98 | 4.06 | 4.06 | 0.00 | 0.55 |
| 1989 | 3408.69 | 6939 | 516 | 75.37 | 77.13 | 75.41 | 79.21 | 10.45 | 9.00 | 13.87 | 1.76 |
| 1990 | 3500.80 | 7420 | 516 | 77.73 | 78.35 | 77.45 | 84.70 | 13.66 | 12.39 | 9.25 | 0.62 |
| 1991 | 4258.77 | 8436 | 516 | 94.52 | 94.93 | 94.22 | 96.30 | 4.76 | 4.74 | 0.33 | 0.42 |
| 1992 | 3727.45 | 7349 | 516 | 82.40 | 82.41 | 82.24 | 83.66 | 2.52 | 2.13 | 15.46 | 0.01 |
| 1993 | 4415.95 | 8760 | 516 | 99.01 | 99.88 | 97.69 | 100.00 | 0.12 | 0.12 | 0.00 | 0.87 |
| 1994 | 3709.91 | 7386 | 516 | 83.40 | 83.40 | 82.07 | 84.32 | 1.67 | 1.41 | 15.18 | 0.00 |
| 1995 | 4056.79 | 8140 | 516 | 90.05 | 90.43 | 89.75 | 92.92 | 9.57 | 9.57 | 0.00 | 0.38 |
| 1996 | 2050.69 | 4416 | 516 | 45.37 | 45.37 | 45.24 | 50.27 | 54.63 | 54.63 | 0.00 | 0.00 |
| 1997 | 2936.16 | 6208 | 516 | 64.96 | 64.96 | 64.96 | 70.87 | 20.17 | 16.41 | 18.63 | 0.00 |
| 1998 | 3084.73 | 6495 | 516 | 68.24 | 68.87 | 68.24 | 74.14 | 20.36 | 17.61 | 13.52 | 0.63 |
| 1999 | 4433.82 | 8751 | 516 | 98.04 | 98.82 | 98.09 | 99.90 | 1.18 | 1.18 | 0.00 | 0.78 |
| 2000 | 2099.00 | 4445 | 516 | 46.29 | 46.37 | 46.31 | 50.60 | 14.46 | 7.84 | 45.79 | 0.08 |
| 2001 | 4020.78 | 7968 | 516 | 88.71 | 89.03 | 88.95 | 90.96 | 10.97 | 10.97 | 0.00 | 0.32 |
| 2002 | 4246.89 | 8538 | 516 | 93.85 | 94.45 | 93.95 | 97.47 | 5.55 | 5.55 | 0.00 | 0.59 |
| 2003 | 1790.66 | 3811 | 516 | 39.66 | 39.81 | 39.62 | 43.50 | 40.88 | 27.53 | 32.67 | 0.15 |
| 2004 | 3116.06 | 6127 | 516 | 68.86 | 68.93 | 68.75 | 69.75 | 4.64 | 3.36 | 27.72 | 0.07 |
| 2005 | 4390.76 | 8658 | 516 | 97.44 | 97.79 | 97.14 | 98.84 | 2.21 | 2.21 | 0.00 | 0.34 |
| 2006 | 2652.57 | 5311 | 516 | 59.06 | 59.11 | 58.68 | 60.63 | 10.24 | 21.12 | 19.77 | 0.05 |
| 2007 | 3667.91 | 7540 | 516 | 81.69 | 82.04 | 81.15 | 86.07 | 9.97 | 16.75 | 1.21 | 0.35 |
| 2008 | 1530.27 | 3084 | 516 | 33.98 | 33.99 | 33.76 | 35.11 | 66.01 | 66.01 | 0.00 | 0.00 |
| 2009 | 4229.46 | 8492 | 516 | 94.10 | 94.53 | 93.57 | 96.94 | 5.47 | 5.47 | 0.00 | 0.43 |
| 2010 | 2920.66 | 5895 | 516 | 64.78 | 65.13 | 64.61 | 67.29 | 1.64 | 1.69 | 33.18 | 0.35 |
| 2011 | 4337.70 | 8673 | 516 | 96.58 | 96.83 | 95.96 | 99.01 | 3.17 | 3.17 | 0.00 | 0.25 |
| 2012 | 2920.02 | 5965 | 516 | 64.76 | 66.28 | 64.42 | 67.91 | 6.84 | 4.87 | 28.85 | 1.52 |
| 2013 | 4264.55 | 8760 | 516 | 94.44 | 94.92 | 94.35 | 100.00 | 5.04 | 5.04 | 0.04 | 0.48 |
| 2014 | 2783.08 | 5489 | 516 | 61.95 | 62.18 | 61.57 | 62.66 | 6.72 | 6.53 | 31.30 | 0.23 |
| 2015 | 4171.04 | 8336 | 516 | 92.57 | 93.11 | 92.28 | 95.16 | 3.43 | 5.65 | 1.25 | 0.54 |
| 2016 | 2803.59 | 5574 | 516 | 61.97 | 62.32 | 61.85 | 63.46 | 6.62 | 5.50 | 32.18 | 0.35 |
| 2017 | 3751.37 | 7512 | 516 | 83.14 | 83.35 | 82.99 | 85.75 | 13.44 | 16.11 | 0.55 | 0.20 |
| 2018 | 4377.16 | 8687 | 516 | 96.67 | 98.11 | 96.84 | 99.17 | 1.89 | 1.89 | 0.00 | 1.45 |
| 2019 | 3132.65 | 6131 | 516 | 68.52 | 68.53 | 69.30 | 69.99 | 1.03 | 0.71 | 30.76 | 0.01 |
| 2020 | 4316.41 | 8321 | 516 | 94.04 | 94.20 | 95.23 | 94.73 | 0.35 | 0.33 | 5.47 | 0.15 |
| 2021 | 2840.99 | 5532 | 516 | 62.13 | 62.44 | 62.85 | 63.15 | 0.14 | 0.09 | 37.48 | 0.31 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|------|------|
| 2022 | 4161.58 | 7970 | 516 | 90.47 | 90.60 | 92.07 | 90.98 | 0.30 | 0.27 | 9.13 | 0.13 |
| 2023 | 4324.26 | 8340 | 516 | 94.40 | 95.70 | 95.67 | 95.21 | 4.30 | 4.30 | 0.00 | 1.30 |

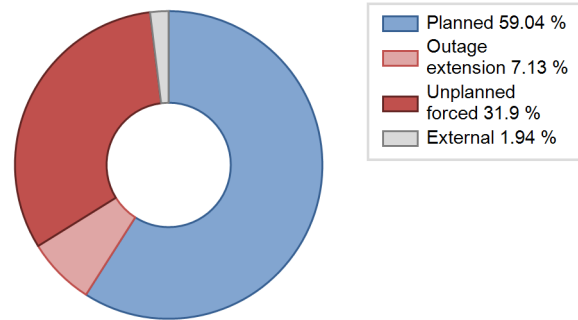
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 337 | | | 520 | |
| D. Inspection, maintenance or repair without refuelling | | | | 957 | | |
| E. Testing of plant systems or components | | | | 1 | 8 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 109 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 84 | | | 6 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 12 |
| Z. Other | | | | | 30 | |
| Subtotal | | 337 | 84 | 958 | 667 | 20 |
| Total | | 421 | | | 1645 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 90 |
| 12. Reactor I&C Systems | | 52 |
| 13. Reactor Auxiliary Systems | | 13 |
| 14. Safety Systems | | 29 |
| 15. Reactor Cooling Systems | 67 | 82 |
| 16. Steam generation systems | | 52 |
| 21. Fuel Handling and Storage Facilities | | 21 |
| 31. Turbine and auxiliaries | | 31 |
| 32. Feedwater and Main Steam System | | 17 |
| 33. Circulating Water System | | 12 |
| 34. Miscellaneous Systems | | 42 |
| 41. Main Generator Systems | | 62 |
| 42. Electrical Power Supply Systems | 270 | 52 |
| Total | 337 | 555 |

Highlights (2023)

Unit Outage due to an issue with line protection scheme on the 078 ring bus directed by the Independent Electricity System Operator (IESO)-manual turbine trip.
 2 forced outages due to a gas protection relay trip on the Main Output Transformer-automatic turbine trip.
 One forced outage due to a gas protection relay trip on the Main Output Transformer-manual turbine trip.

2023 Operating Experience

CA-16

PICKERING-8

CANADA

Status at end of year : **Operational**
 Operator : OPG (Ontario Power Generation)
 Owner : OPG (Ontario Power Generation)
 Reactor Supplier : OH/AECL (ONTARIO HYDRO / ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)



Reactor Unit Details

Reactor type and model : PHWR / CANDU 500B
 Thermal power : 1744 MWth
 Gross electrical power : 540 MWe
 Reference unit power (net) : 516 MWe

Key Dates

Construction Date : 1976-09-01
 Grid Date : 1986-01-21
 Commercial Date : 1986-02-28
 Age at end of year : 37 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 8330
 Active core diameter [m] : 5.94
 Active core height/length [m] : 5.94
 Number of fissile fuel assemblies/bundles : 4560
 Fuel linear heat generation rate [kW/m] : 27.3
 Number of control rod assemblies : 21
 Number of external reactor coolant loops : 2
 Coolant type : D2O

Operating coolant pressure [MPa] : 9
 Reactor outlet temperature [°C] : 293.4
 Number of SG : 12
 Containment type : -
 Containment design pressure [MPa] : 1.46

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 3.8
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

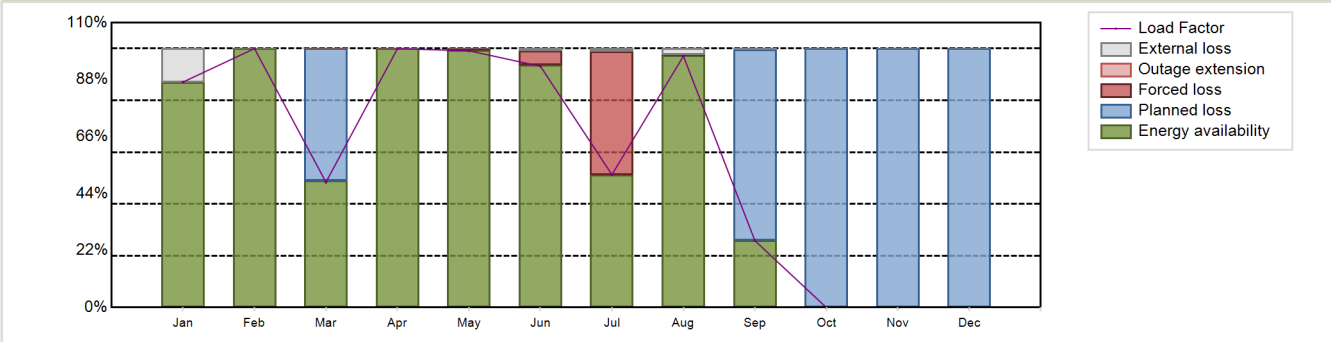
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 2630.89 GW(e).h
 Energy Availability Factor (EAF) : 58.31 %
 Unit Capability Factor (UCF) : 59.82 %
 Load Factor (LF) : 58.2 %
 Operating Factor (OF) : 60.27 %

Forced Loss Rate (FLR) : 7.12 %
 Unplanned Capability Loss Factor (UCL) : 4.58 %
 Planned Unavailability Factor (PUF) : 35.6 %
 Externally cause unavailability (XUF) : 1.5 %
 Total off-line time : 3480 hours

Annual Summary

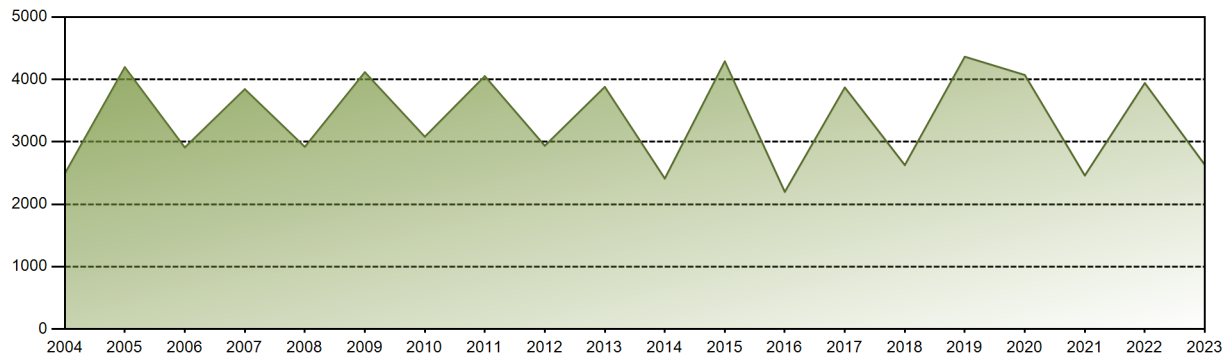


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|---------|
| GW(e)-h | 334.33 | 346.75 | 185.83 | 371.52 | 380.62 | 346.19 | 196.99 | 372.73 | 95.93 | 0.00 | 0.00 | 0.00 | 2630.89 |
| EAF [%] | 87.03 | 100.00 | 48.96 | 99.99 | 99.27 | 93.66 | 51.31 | 97.28 | 25.82 | 0.00 | 0.00 | 0.00 | 58.31 |
| UCF [%] | 100.00 | 100.00 | 48.96 | 99.99 | 99.27 | 94.52 | 52.53 | 99.56 | 26.25 | 0.00 | 0.00 | 0.00 | 59.82 |
| LF [%] | 87.09 | 100.00 | 48.41 | 100.00 | 99.14 | 93.18 | 51.31 | 97.09 | 25.82 | 0.00 | 0.00 | 0.00 | 58.20 |
| OF [%] | 89.65 | 100.00 | 51.34 | 100.00 | 100.00 | 94.86 | 63.71 | 100.00 | 26.94 | 0.00 | 0.00 | 0.00 | 60.27 |
| FLR [%] | 0.00 | 0.00 | 0.02 | 0.01 | 0.73 | 5.48 | 47.47 | 0.44 | 0.00 | 0.00 | 0.00 | 0.00 | 7.12 |
| UCL [%] | 0.00 | 0.00 | 0.01 | 0.01 | 0.73 | 5.48 | 47.47 | 0.44 | 0.00 | 0.00 | 0.00 | 0.00 | 4.58 |
| PUF [%] | 0.00 | 0.00 | 51.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 73.75 | 100.00 | 100.00 | 100.00 | 35.60 |
| XUF [%] | 12.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.86 | 1.22 | 2.28 | 0.43 | 0.00 | 0.00 | 0.00 | 1.50 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 128969.48 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 9.61 % |
| Cumulative Energy Availability Factor (EAF) | : 75.4 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.93 % |
| Cumulative Unit Capability Factor (UCF) | : 76.07 % | Cumulative Planned Unavailability Factor (PUF) | : 15 % |
| Cumulative Load Factor (LF) | : 75.26 % | Cumulative Externally cause unavailability (XUF) | : 0.68 % |
| Cumulative Operating Factor (OF) | : 78.51 % | | |

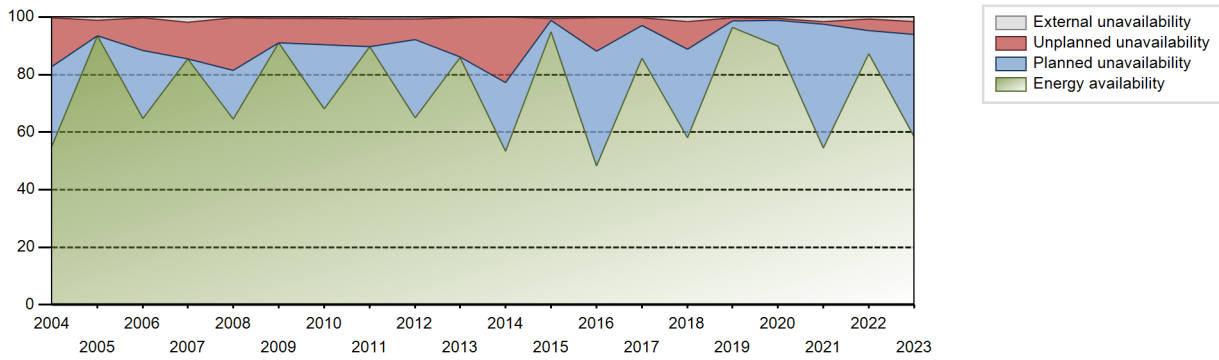
Electricity Production (net) [GWh]



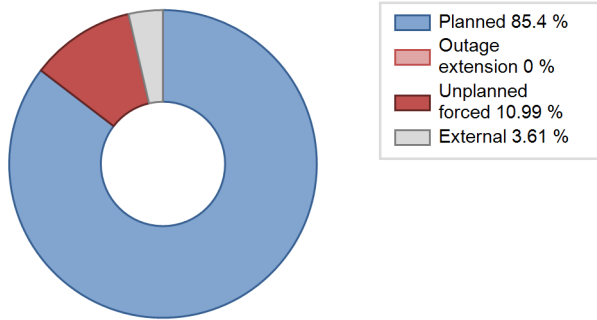
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 3792.31 | 8086 | 516 | 96.32 | 96.67 | 95.69 | 97.69 | 3.33 | 3.33 | 0.00 | 0.35 |
| 1987 | 3759.36 | 7585 | 516 | 83.31 | 84.70 | 83.17 | 86.59 | 2.09 | 1.81 | 13.49 | 1.38 |
| 1988 | 3710.38 | 7296 | 516 | 82.25 | 82.50 | 81.86 | 83.06 | 2.16 | 1.82 | 15.68 | 0.25 |
| 1989 | 4295.19 | 8569 | 516 | 95.37 | 96.61 | 95.02 | 97.82 | 3.29 | 3.29 | 0.10 | 1.24 |
| 1990 | 3014.65 | 6743 | 516 | 66.63 | 66.72 | 66.69 | 76.97 | 19.23 | 15.89 | 17.39 | 0.09 |
| 1991 | 4484.97 | 8759 | 516 | 98.89 | 99.52 | 99.22 | 99.99 | 0.48 | 0.48 | 0.00 | 0.63 |
| 1992 | 4211.99 | 8280 | 516 | 92.95 | 92.98 | 92.93 | 94.26 | 6.81 | 6.79 | 0.22 | 0.03 |
| 1993 | 3670.54 | 7233 | 516 | 81.73 | 82.15 | 81.20 | 82.57 | 2.50 | 2.11 | 15.74 | 0.41 |
| 1994 | 4341.88 | 8579 | 516 | 96.85 | 96.85 | 96.06 | 97.93 | 3.14 | 3.14 | 0.01 | 0.00 |
| 1995 | 4012.08 | 8066 | 516 | 89.04 | 89.42 | 88.76 | 92.08 | 10.58 | 10.58 | 0.00 | 0.38 |
| 1996 | 1300.26 | 2597 | 516 | 28.73 | 28.73 | 28.69 | 29.57 | 68.79 | 63.34 | 7.92 | 0.00 |
| 1997 | 360.81 | 995 | 516 | 7.96 | 7.96 | 7.96 | 11.33 | 44.06 | 6.27 | 85.77 | 0.00 |
| 1998 | 3493.62 | 7009 | 516 | 77.29 | 78.02 | 77.29 | 80.01 | 10.55 | 9.20 | 12.78 | 0.73 |
| 1999 | 3509.06 | 7077 | 516 | 77.63 | 78.44 | 77.63 | 80.79 | 2.49 | 2.00 | 19.56 | 0.81 |
| 2000 | 2711.21 | 5508 | 516 | 59.92 | 60.83 | 59.82 | 62.70 | 16.52 | 12.04 | 27.13 | 0.91 |
| 2001 | 3502.19 | 6999 | 516 | 77.47 | 78.22 | 77.48 | 79.90 | 8.46 | 7.23 | 14.55 | 0.75 |
| 2002 | 3605.36 | 7244 | 516 | 80.03 | 81.06 | 79.76 | 82.69 | 9.27 | 8.28 | 10.66 | 1.02 |
| 2003 | 3921.29 | 8026 | 516 | 86.90 | 89.68 | 86.75 | 91.62 | 10.32 | 10.32 | 0.00 | 2.78 |
| 2004 | 2489.46 | 5182 | 516 | 55.13 | 55.35 | 54.92 | 58.99 | 23.42 | 16.93 | 27.71 | 0.23 |
| 2005 | 4195.24 | 8431 | 516 | 93.40 | 94.60 | 92.81 | 96.24 | 5.40 | 5.40 | 0.00 | 1.20 |
| 2006 | 2908.54 | 5853 | 516 | 64.75 | 65.06 | 64.35 | 66.82 | 3.38 | 11.22 | 23.72 | 0.31 |
| 2007 | 3843.21 | 8015 | 516 | 85.51 | 87.28 | 85.02 | 91.50 | 12.72 | 12.72 | 0.00 | 1.77 |
| 2008 | 2918.75 | 6116 | 516 | 64.41 | 64.71 | 64.40 | 69.63 | 18.42 | 18.21 | 17.08 | 0.30 |
| 2009 | 4115.23 | 8520 | 516 | 91.04 | 91.61 | 91.04 | 97.26 | 8.39 | 8.39 | 0.00 | 0.57 |
| 2010 | 3081.07 | 6427 | 516 | 68.16 | 68.53 | 68.16 | 73.37 | 9.60 | 9.19 | 22.27 | 0.37 |
| 2011 | 4051.72 | 8345 | 516 | 89.64 | 90.30 | 89.64 | 95.26 | 9.61 | 9.60 | 0.10 | 0.66 |
| 2012 | 2936.38 | 5967 | 516 | 64.86 | 65.53 | 64.78 | 67.93 | 6.71 | 7.15 | 27.33 | 0.66 |
| 2013 | 3879.06 | 7979 | 516 | 85.97 | 86.34 | 85.82 | 91.08 | 13.57 | 13.55 | 0.11 | 0.37 |
| 2014 | 2411.29 | 5223 | 516 | 53.30 | 53.43 | 53.35 | 59.62 | 26.12 | 22.62 | 23.94 | 0.14 |
| 2015 | 4289.30 | 8440 | 516 | 94.91 | 95.37 | 94.89 | 96.35 | 0.76 | 0.73 | 3.90 | 0.46 |
| 2016 | 2197.88 | 4367 | 516 | 48.35 | 48.60 | 48.49 | 49.72 | 0.61 | 11.62 | 39.78 | 0.25 |
| 2017 | 3870.80 | 7787 | 516 | 85.68 | 85.96 | 85.63 | 88.89 | 2.90 | 2.57 | 11.47 | 0.28 |
| 2018 | 2626.93 | 5427 | 516 | 58.08 | 59.70 | 58.12 | 61.95 | 13.69 | 9.47 | 30.82 | 1.63 |
| 2019 | 4363.55 | 8571 | 516 | 96.44 | 96.71 | 96.54 | 97.84 | 1.03 | 1.01 | 2.28 | 0.27 |
| 2020 | 4070.63 | 8022 | 516 | 89.87 | 90.41 | 89.81 | 91.33 | 0.65 | 0.59 | 9.00 | 0.54 |
| 2021 | 2459.85 | 4932 | 516 | 54.47 | 56.12 | 54.42 | 56.30 | 1.38 | 0.78 | 43.10 | 1.65 |
| 2022 | 3941.06 | 7789 | 516 | 87.35 | 88.03 | 87.19 | 88.92 | 4.31 | 3.97 | 8.00 | 0.68 |

2023 2630.89 5280 516 58.31 59.82 58.20 60.27 7.12 4.58 35.60 1.50

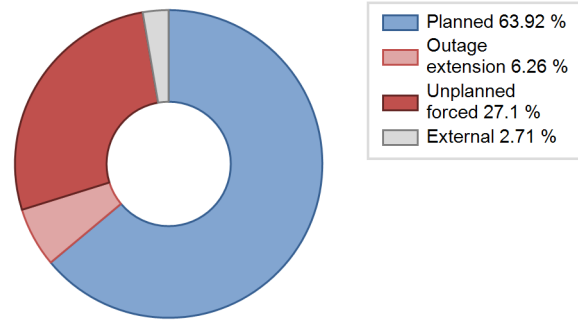
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|-------------|-------------|-----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 306 | | | 444 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 70 | | |
| D. Inspection, maintenance or repair without refuelling | 3095 | | | 1072 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| L. Human factor related | | | | | 279 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 77 | | | 13 |
| Z. Other | | | | | 1 | |
| Subtotal | 3095 | 306 | 77 | 1143 | 724 | 17 |
| Total | | 3478 | | | 1884 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 31 |
| 12. Reactor I&C Systems | | 33 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 34 |
| 15. Reactor Cooling Systems | | 79 |
| 16. Steam generation systems | | 28 |
| 21. Fuel Handling and Storage Facilities | | 89 |
| 31. Turbine and auxiliaries | 114 | 48 |
| 32. Feedwater and Main Steam System | 192 | 30 |
| 33. Circulating Water System | | 24 |
| 34. Miscellaneous Systems | | 12 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 15 |
| 42. Electrical Power Supply Systems | | 27 |
| Total | 306 | 454 |

Highlights (2023)

Unit Outage due to an issue with line protection scheme on the 078 ring bus directed by the Independent Electricity System Operator (IESO)-manual turbine trip.
 One forced outage due to condenser tube leak- manual turbine trip.
 the forced Outage due to boiler level transient-automatic reactor trip

2023 Operating Experience

CA-17

POINT LEPREAU

CANADA

Status at end of year : **Operational**
 Operator : NBEPC (NEW BRUNSWICK ELECTRIC POWER COMMISSION)
 Owner : NBEPC (NEW BRUNSWICK ELECTRIC POWER COMMISSION)
 Reactor Supplier : AECL (ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : NEI/PARS (NEI-PARSONS)



Reactor Unit Details

Reactor type and model : PHWR / CANDU 6
 Thermal power : 2180 MWth
 Gross electrical power : 705 MWe
 Reference unit power (net) : 660 MWe

Key Dates

Construction Date : 1975-05-01
 Grid Date : 1982-09-11
 Commercial Date : 1983-02-01
 Age at end of year : 41 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 8000
 Active core diameter [m] : 6.28
 Active core height/length [m] : 5.94
 Number of fissile fuel assemblies/bundles : 4560
 Fuel linear heat generation rate [kW/m] : 59.5
 Number of control rod assemblies : 21
 Number of external reactor coolant loops : 2
 Coolant type : D2O

Operating coolant pressure [MPa] : 11.55
 Reactor outlet temperature [°C] : 310
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 1.3

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 4.64
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

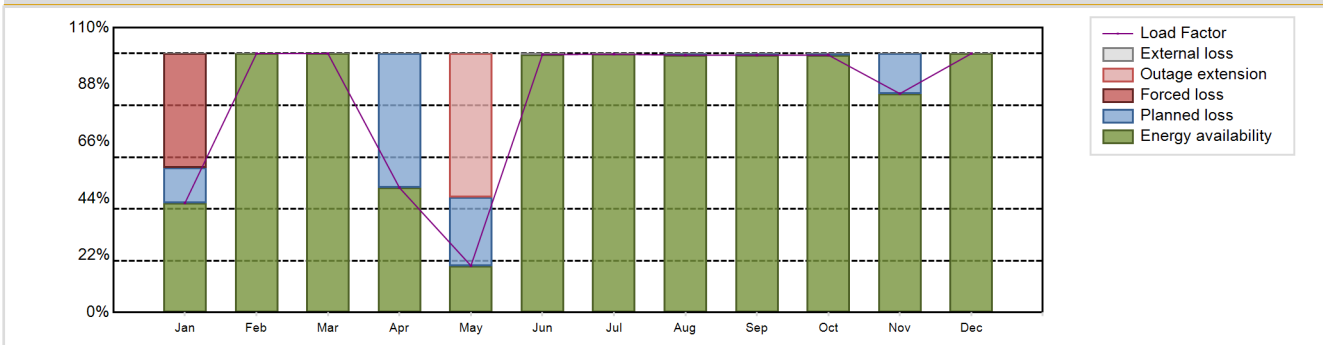
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 4764.67 GW(e).h
 Energy Availability Factor (EAF) : 82.41 %
 Unit Capability Factor (UCF) : 82.46 %
 Load Factor (LF) : 82.41 %
 Operating Factor (OF) : 84.09 %

Forced Loss Rate (FLR) : 4.34 %
 Unplanned Capability Loss Factor (UCL) : 8.46 %
 Planned Unavailability Factor (PUF) : 9.08 %
 Externally cause unavailability (XUF) : 0.05 %
 Total off-line time : 1394 hours

Annual Summary

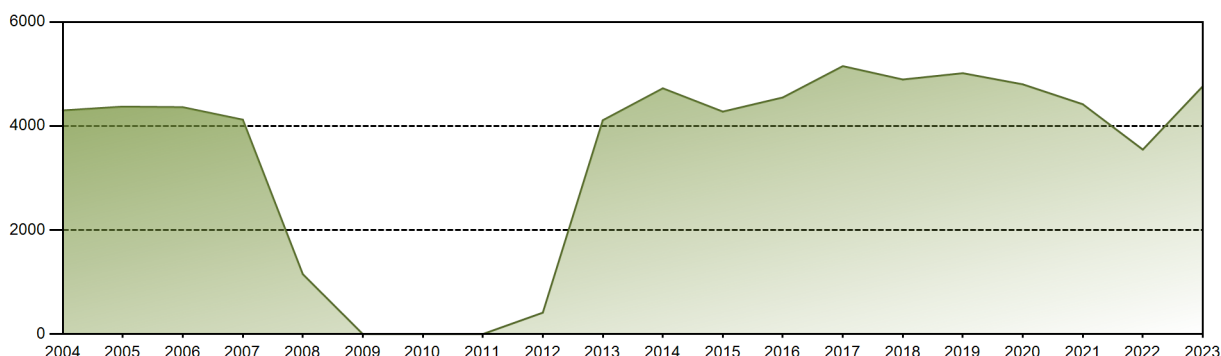


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 207.80 | 443.52 | 491.04 | 229.02 | 88.79 | 473.39 | 489.82 | 488.03 | 472.28 | 488.26 | 401.69 | 491.04 | 4764.67 |
| EAF [%] | 42.32 | 100.00 | 100.00 | 48.19 | 18.08 | 99.62 | 99.75 | 99.39 | 99.39 | 99.43 | 84.53 | 100.00 | 82.41 |
| UCF [%] | 42.32 | 100.00 | 100.00 | 48.19 | 18.08 | 100.00 | 100.00 | 99.39 | 99.39 | 99.43 | 84.53 | 100.00 | 82.46 |
| LF [%] | 42.32 | 100.00 | 100.00 | 48.19 | 18.08 | 99.62 | 99.75 | 99.39 | 99.39 | 99.43 | 84.53 | 100.00 | 82.41 |
| OF [%] | 55.91 | 100.00 | 100.00 | 48.19 | 20.30 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.11 | 100.00 | 84.09 |
| FLR [%] | 51.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.34 |
| UCL [%] | 44.09 | 0.00 | 0.00 | 0.00 | 55.51 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.46 |
| PUF [%] | 13.60 | 0.00 | 0.00 | 51.81 | 26.41 | 0.00 | 0.00 | 0.61 | 0.61 | 0.57 | 15.47 | 0.00 | 9.08 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.38 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 170346.71 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.19 % |
| Cumulative Energy Availability Factor (EAF) | : 72.37 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.04 % |
| Cumulative Unit Capability Factor (UCF) | : 73.08 % | Cumulative Planned Unavailability Factor (PUF) | : 19.88 % |
| Cumulative Load Factor (LF) | : 71.8 % | Cumulative Externally cause unavailability (XUF) | : 0.71 % |
| Cumulative Operating Factor (OF) | : 74.51 % | | |

Electricity Production (net) [GWh]

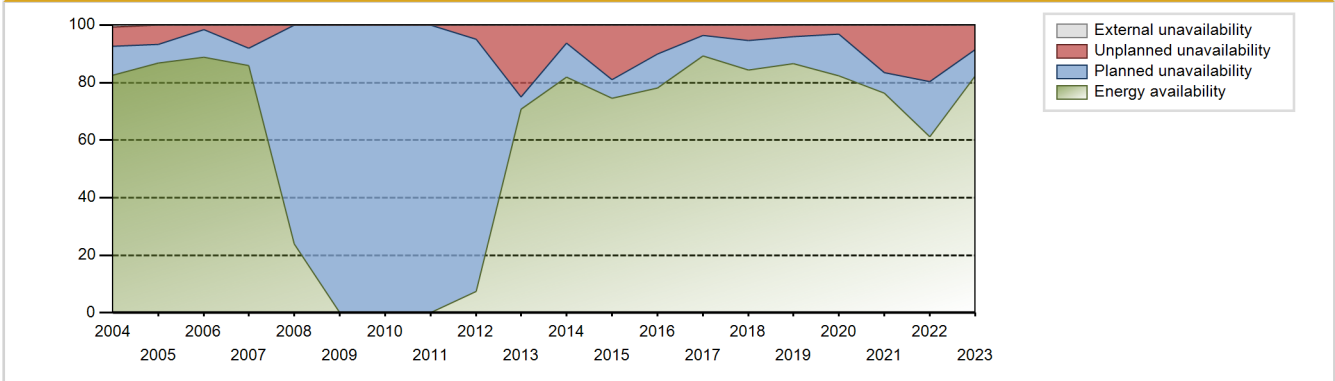


Performance for Years of Commercial Operation

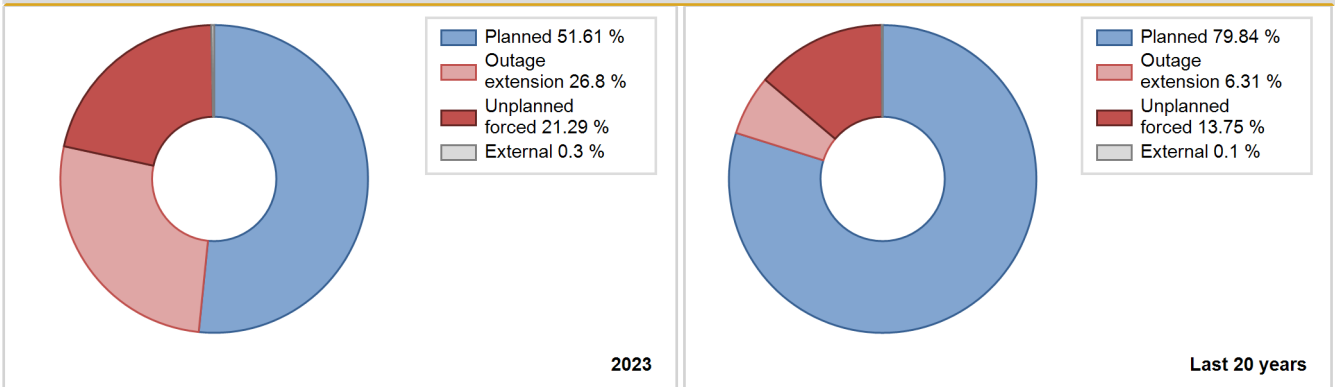
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 4742.90 | 7875 | 640 | 86.03 | 86.03 | 85.85 | 89.37 | 8.10 | 7.58 | 6.39 | 0.00 |
| 1984 | 5000.94 | 7927 | 635 | 88.94 | 88.97 | 89.66 | 90.24 | 3.03 | 2.78 | 8.25 | 0.03 |
| 1985 | 5421.91 | 8547 | 635 | 96.87 | 96.93 | 97.47 | 97.57 | 1.25 | 1.23 | 1.84 | 0.06 |
| 1986 | 5223.09 | 8257 | 635 | 93.41 | 94.00 | 93.90 | 94.26 | 0.90 | 0.85 | 5.15 | 0.59 |
| 1987 | 5107.73 | 8110 | 635 | 91.23 | 91.25 | 91.82 | 92.58 | 3.32 | 3.14 | 5.61 | 0.02 |
| 1988 | 5338.25 | 8383 | 635 | 94.85 | 94.85 | 95.70 | 95.43 | 0.38 | 0.36 | 4.79 | 0.00 |
| 1989 | 5266.67 | 8271 | 635 | 93.60 | 93.81 | 94.68 | 94.42 | 0.89 | 0.84 | 5.34 | 0.22 |
| 1990 | 5333.71 | 8384 | 635 | 94.70 | 94.99 | 95.89 | 95.71 | 2.92 | 2.86 | 2.15 | 0.29 |
| 1991 | 5437.17 | 8500 | 635 | 96.68 | 96.72 | 97.75 | 97.03 | 0.55 | 0.54 | 2.74 | 0.04 |
| 1992 | 4829.78 | 7748 | 635 | 85.76 | 85.76 | 86.59 | 88.21 | 3.99 | 3.57 | 10.67 | 0.00 |
| 1993 | 5320.00 | 8391 | 635 | 95.09 | 95.09 | 95.64 | 95.79 | 1.42 | 1.37 | 3.54 | 0.00 |
| 1994 | 5230.10 | 8270 | 635 | 93.46 | 93.46 | 94.02 | 94.41 | 0.34 | 0.32 | 6.22 | 0.00 |
| 1995 | 1611.40 | 2615 | 635 | 28.98 | 28.98 | 28.97 | 29.85 | 43.54 | 22.34 | 48.68 | 0.00 |
| 1996 | 4587.83 | 7363 | 635 | 81.41 | 81.41 | 82.25 | 83.82 | 13.97 | 13.22 | 5.37 | 0.00 |
| 1997 | 3455.59 | 5564 | 635 | 61.60 | 62.19 | 62.12 | 63.52 | 24.86 | 20.57 | 17.24 | 0.59 |
| 1998 | 3782.35 | 6111 | 635 | 66.04 | 67.11 | 68.00 | 69.76 | 20.20 | 16.99 | 15.90 | 1.06 |
| 1999 | 4082.74 | 6797 | 635 | 71.99 | 75.52 | 73.40 | 77.59 | 11.47 | 9.78 | 14.70 | 3.53 |
| 2000 | 3966.85 | 6792 | 635 | 70.52 | 77.64 | 71.12 | 77.32 | 0.00 | 0.00 | 22.36 | 7.12 |
| 2001 | 4451.33 | 7418 | 635 | 79.08 | 84.61 | 80.02 | 84.68 | 15.33 | 15.31 | 0.08 | 5.53 |
| 2002 | 3760.64 | 6107 | 635 | 67.59 | 71.59 | 67.61 | 69.71 | 6.62 | 10.30 | 18.12 | 4.00 |
| 2003 | 4739.52 | 7869 | 635 | 84.39 | 89.77 | 85.20 | 89.83 | 0.70 | 4.18 | 6.05 | 5.38 |
| 2004 | 4299.74 | 7310 | 635 | 82.58 | 83.32 | 77.09 | 83.22 | 6.13 | 6.56 | 10.12 | 0.74 |
| 2005 | 4372.64 | 7632 | 635 | 86.79 | 86.79 | 78.61 | 87.12 | 2.13 | 6.68 | 6.53 | 0.00 |
| 2006 | 4361.99 | 7755 | 635 | 88.74 | 88.74 | 78.42 | 88.53 | 0.88 | 1.59 | 9.67 | 0.00 |
| 2007 | 4121.82 | 7511 | 635 | 85.95 | 85.95 | 74.10 | 85.74 | 7.79 | 8.02 | 6.04 | 0.00 |
| 2008 | 1150.56 | 2111 | 635 | 24.03 | 24.03 | 20.63 | 24.03 | 0.00 | 0.00 | 75.97 | 0.00 |
| 2009 | 0.00 | 0 | 635 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2010 | 0.00 | 0 | 635 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2011 | 0.00 | 0 | 635 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2012 | 411.48 | 966 | 660 | 7.53 | 7.53 | 7.30 | 11.00 | 39.71 | 4.96 | 87.51 | 0.00 |
| 2013 | 4111.15 | 7879 | 660 | 70.80 | 70.80 | 71.12 | 89.95 | 25.07 | 24.92 | 4.28 | 0.00 |
| 2014 | 4724.62 | 7229 | 660 | 81.86 | 81.86 | 81.72 | 82.52 | 1.50 | 6.29 | 11.85 | 0.00 |
| 2015 | 4277.04 | 6993 | 660 | 74.61 | 74.61 | 73.98 | 79.83 | 20.21 | 18.89 | 6.50 | 0.00 |
| 2016 | 4548.99 | 6989 | 660 | 78.20 | 78.20 | 78.47 | 79.57 | 2.65 | 10.10 | 11.71 | 0.00 |
| 2017 | 5151.32 | 7928 | 660 | 89.25 | 89.25 | 89.10 | 90.50 | 2.44 | 3.65 | 7.10 | 0.00 |
| 2018 | 4894.15 | 7469 | 660 | 84.46 | 84.46 | 84.65 | 85.26 | 0.53 | 5.32 | 10.22 | 0.00 |
| 2019 | 5015.68 | 7663 | 660 | 86.69 | 86.69 | 86.75 | 87.48 | 4.50 | 4.08 | 9.23 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2020 | 4801.00 | 7302 | 660 | 82.46 | 82.46 | 82.81 | 83.13 | 0.23 | 3.08 | 14.45 | 0.00 |
| 2021 | 4418.52 | 7038 | 660 | 76.40 | 76.40 | 76.42 | 80.34 | 17.86 | 16.61 | 6.99 | 0.00 |
| 2022 | 3546.75 | 5499 | 660 | 61.28 | 61.28 | 61.35 | 62.77 | 12.21 | 19.70 | 19.02 | 0.00 |
| 2023 | 4764.67 | 7366 | 660 | 82.41 | 82.46 | 82.41 | 84.09 | 4.34 | 8.46 | 9.08 | 0.05 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 328 | | | 330 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 119 | | |
| D. Inspection, maintenance or repair without refuelling | 553 | | | 397 | | |
| E. Testing of plant systems or components | | | | 30 | 8 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 992 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 22 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | 413 | | | 63 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 3 |
| Z. Other | 100 | | | 2 | 46 | |
| Subtotal | 653 | 741 | | 1562 | 448 | 4 |
| Total | | 1394 | | | 2014 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 19 |
| 12. Reactor I&C Systems | | 17 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 20 |
| 15. Reactor Cooling Systems | | 96 |
| 16. Steam generation systems | | 38 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 4 |
| 21. Fuel Handling and Storage Facilities | | 22 |
| 31. Turbine and auxiliaries | | 52 |
| 32. Feedwater and Main Steam System | | 55 |
| 34. Miscellaneous Systems | 413 | 26 |
| 41. Main Generator Systems | | 29 |
| 42. Electrical Power Supply Systems | 328 | 36 |
| Total | 741 | 424 |

2023 Operating Experience

CN-36

CHANGJIANG-1

CHINA

Status at end of year : **Operational**
 Operator : HNPC (Hainan Nuclear Power Company)
 Owner : HNPC (Hainan Nuclear Power Company)
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)



Reactor Unit Details

Reactor type and model : PWR / CNP-600
 Thermal power : 1930 MWth
 Gross electrical power : 650 MWe
 Reference unit power (net) : 601 MWe

Key Dates

Construction Date : 2010-04-25
 Grid Date : 2015-11-07
 Commercial Date : 2015-12-25
 Age at end of year : 8 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.53
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 29.75
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 2.67
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 16.09
 Number of control rod assemblies : 33
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 326.6
 Number of SG : 2
 Containment type : Double
 Containment design pressure [MPa] : 0.35

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.41
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

Non-electrical applications

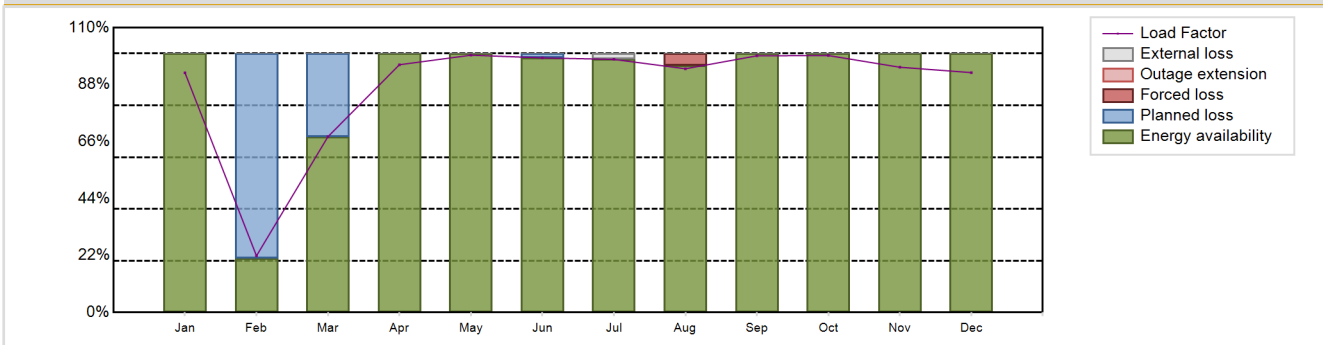
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 4645.34 GW(e).h
 Energy Availability Factor (EAF) : 90.49 %
 Unit Capability Factor (UCF) : 90.68 %
 Load Factor (LF) : 88.23 %
 Operating Factor (OF) : 91.23 %

Forced Loss Rate (FLR) : 0.43 %
 Unplanned Capability Loss Factor (UCL) : 0.39 %
 Planned Unavailability Factor (PUF) : 8.92 %
 Externally cause unavailability (XUF) : 0.19 %
 Total off-line time : 768 hours

Annual Summary

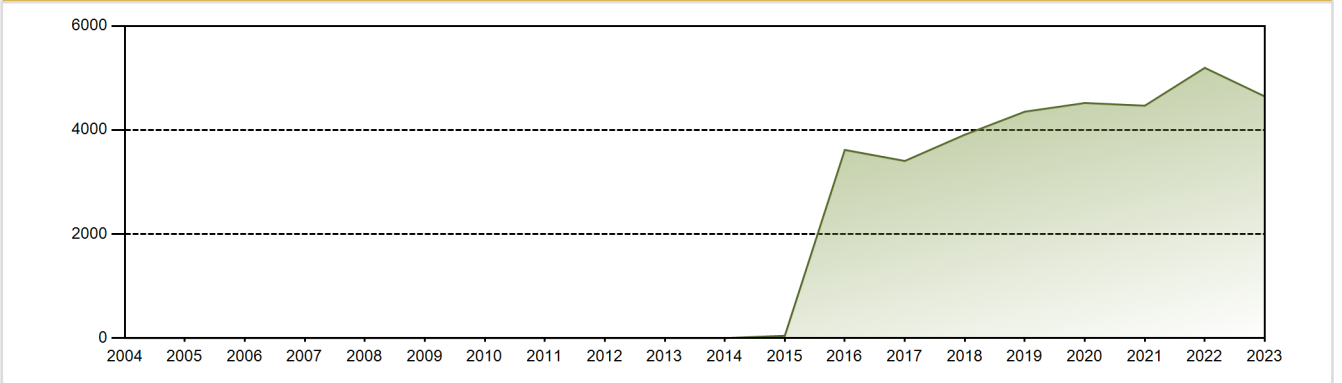


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 413.99 | 88.41 | 303.75 | 414.14 | 444.38 | 425.56 | 437.15 | 420.93 | 429.03 | 443.77 | 409.91 | 414.34 | 4645.34 |
| EAF [%] | 100.00 | 20.94 | 67.93 | 100.00 | 100.00 | 98.35 | 97.76 | 95.39 | 100.00 | 100.00 | 100.00 | 100.00 | 90.49 |
| UCF [%] | 100.00 | 20.94 | 67.93 | 100.00 | 100.00 | 98.35 | 100.00 | 95.39 | 100.00 | 100.00 | 100.00 | 100.00 | 90.68 |
| LF [%] | 92.58 | 21.89 | 67.93 | 95.71 | 99.38 | 98.35 | 97.76 | 94.14 | 99.15 | 99.25 | 94.73 | 92.66 | 88.23 |
| OF [%] | 100.00 | 21.43 | 70.70 | 100.00 | 100.00 | 100.00 | 100.00 | 97.04 | 100.00 | 100.00 | 100.00 | 100.00 | 91.23 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.43 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 |
| PUF [%] | 0.00 | 79.06 | 32.07 | 0.00 | 0.00 | 1.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.92 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 34155.23 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.22 % |
| Cumulative Energy Availability Factor (EAF) | : 90.43 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.2 % |
| Cumulative Unit Capability Factor (UCF) | : 90.45 % | Cumulative Planned Unavailability Factor (PUF) | : 9.35 % |
| Cumulative Load Factor (LF) | : 80.97 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 90.37 % | | |

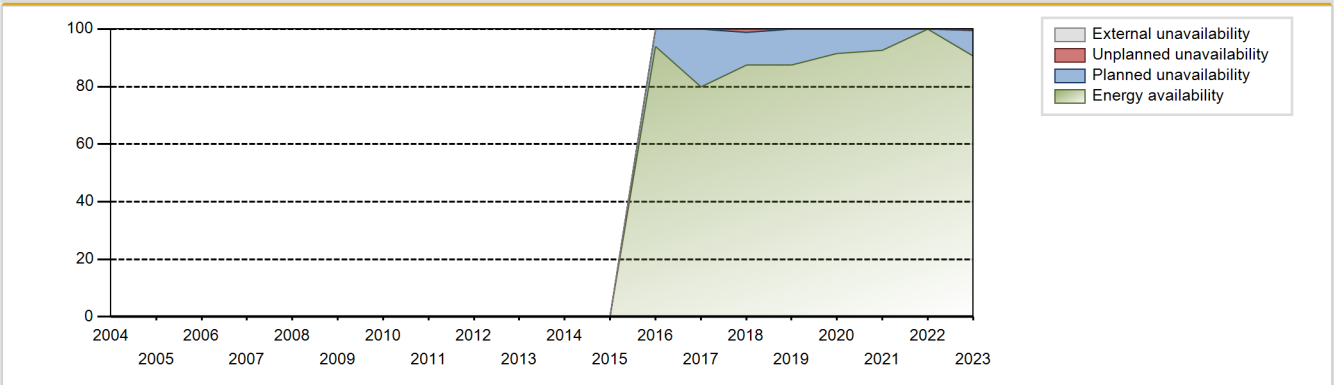
Electricity Production (net) [GWh]



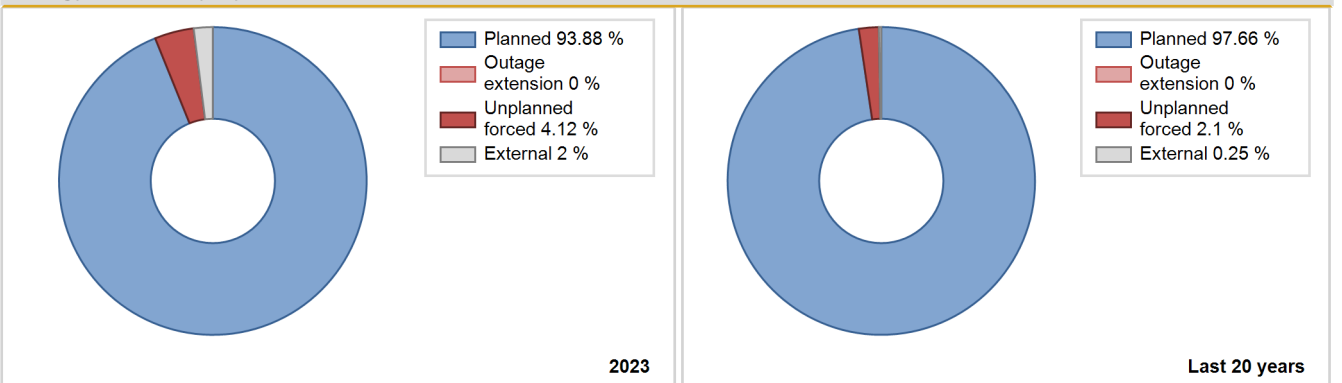
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2015 | 43.73 | 1006 | 610 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 3617.23 | 8185 | 601 | 93.96 | 93.96 | 68.52 | 93.18 | 0.00 | 0.00 | 6.04 | 0.00 |
| 2017 | 3405.19 | 7006 | 601 | 79.95 | 79.95 | 64.68 | 79.98 | 0.00 | 0.00 | 20.05 | 0.00 |
| 2018 | 3909.29 | 7711 | 601 | 87.53 | 87.53 | 74.25 | 88.03 | 1.36 | 1.21 | 11.26 | 0.00 |
| 2019 | 4352.30 | 7741 | 601 | 87.46 | 87.46 | 82.67 | 88.37 | 0.00 | 0.00 | 12.54 | 0.00 |
| 2020 | 4519.05 | 7933 | 601 | 91.48 | 91.48 | 85.86 | 90.31 | 0.00 | 0.00 | 8.52 | 0.00 |
| 2021 | 4467.67 | 8044 | 601 | 92.65 | 92.65 | 84.86 | 91.83 | 0.00 | 0.00 | 7.35 | 0.00 |
| 2022 | 5195.39 | 8760 | 601 | 99.88 | 99.88 | 98.68 | 100.00 | 0.00 | 0.00 | 0.12 | 0.00 |
| 2023 | 4645.34 | 7992 | 601 | 90.49 | 90.68 | 88.23 | 91.23 | 0.43 | 0.39 | 8.92 | 0.19 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2015 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 22 | | | 7 | |
| C. Inspection, maintenance or repair combined with refuelling | 749 | | | 702 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 77 | | |
| I. Grid capacity limitation | | | | | | 13 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 46 |
| Subtotal | 749 | 22 | | 779 | 7 | 59 |
| Total | | 771 | | | 845 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2015 to 2023 |
|------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 31. Turbine and auxiliaries | 22 | 3 |
| 33. Circulating Water System | | 4 |
| 34. Miscellaneous Systems | | 30 |
| Total | 22 | 37 |

2023 Operating Experience

CN-37

CHANGJIANG-2

CHINA

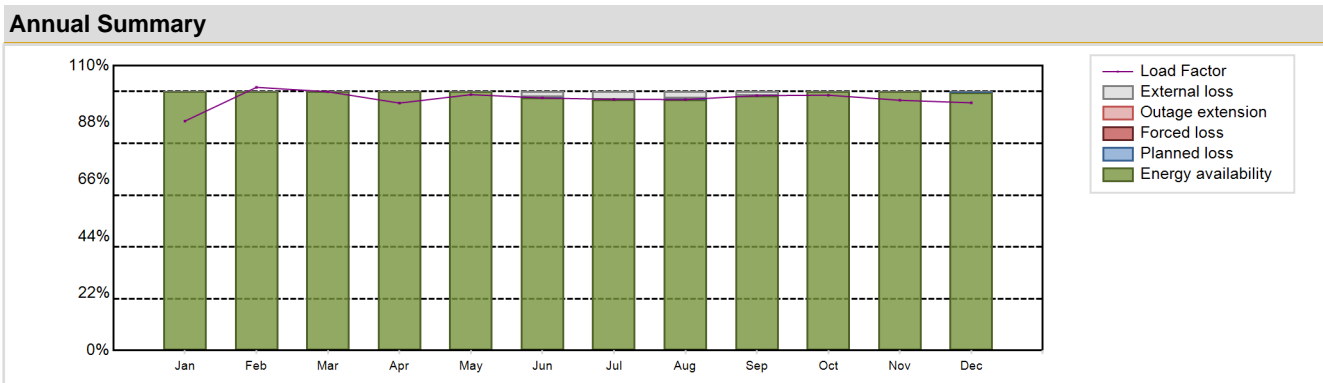
Status at end of year : **Operational**
 Operator : HNPC (Hainan Nuclear Power Company)
 Owner : CNNC (CHINA NATIONAL NUCLEAR CORPORATION)
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-----------------|--------------------|--------------|
| Reactor type and model | : PWR / CNP-600 | Construction Date | : 2010-11-21 |
| Thermal power | : 1930 MWth | Grid Date | : 2016-06-20 |
| Gross electrical power | : 650 MWe | Commercial Date | : 2016-08-12 |
| Reference unit power (net) | : 601 MWe | Age at end of year | : 7 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 326.6 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.35 |
| Average fuel enrichment [% of U235] | : 2.53 | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 29.75 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 2.67 | HP cylinder inlet steam pressure [MPa] | : 6.41 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 121 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 16.09 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 33 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 5110.99 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.12 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 99.9 % | Planned Unavailability Factor (PUF) | : 0.1 % |
| Load Factor (LF) | : 97.08 % | Externally cause unavailability (XUF) | : 0.77 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

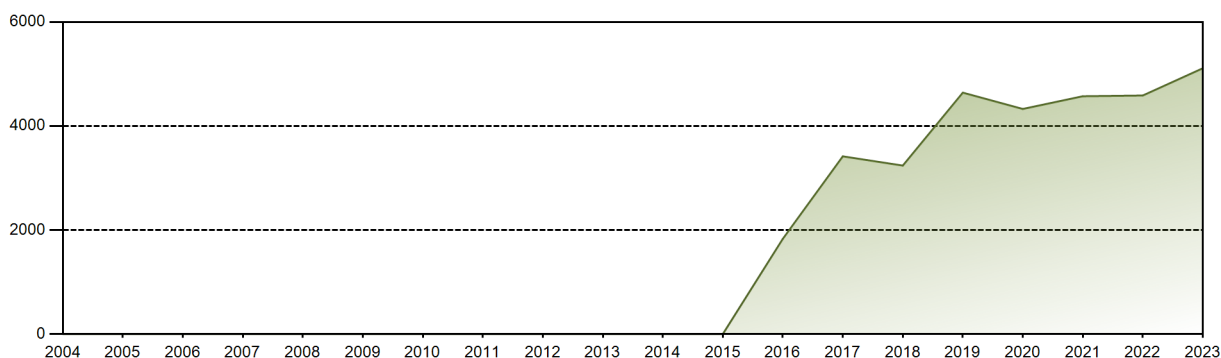


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 396.25 | 410.53 | 446.83 | 413.53 | 441.84 | 422.11 | 433.63 | 433.43 | 425.92 | 440.92 | 418.19 | 427.80 | 5110.99 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.55 | 96.98 | 96.93 | 98.43 | 100.00 | 100.00 | 99.67 | 99.12 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.56 | 100.00 | 99.54 | 100.00 | 100.00 | 100.00 | 99.67 | 99.90 |
| LF [%] | 88.62 | 101.65 | 99.93 | 95.57 | 98.81 | 97.55 | 96.98 | 96.93 | 98.43 | 98.61 | 96.64 | 95.67 | 97.08 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.44 | 0.00 | 0.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.01 | 3.02 | 2.60 | 1.57 | 0.00 | 0.00 | 0.00 | 0.77 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 31727.96 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.39 % |
| Cumulative Energy Availability Factor (EAF) | : 90.57 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.49 % |
| Cumulative Unit Capability Factor (UCF) | : 90.68 % | Cumulative Planned Unavailability Factor (PUF) | : 8.83 % |
| Cumulative Load Factor (LF) | : 80.64 % | Cumulative Externally cause unavailability (XUF) | : 0.1 % |
| Cumulative Operating Factor (OF) | : 90.03 % | | |

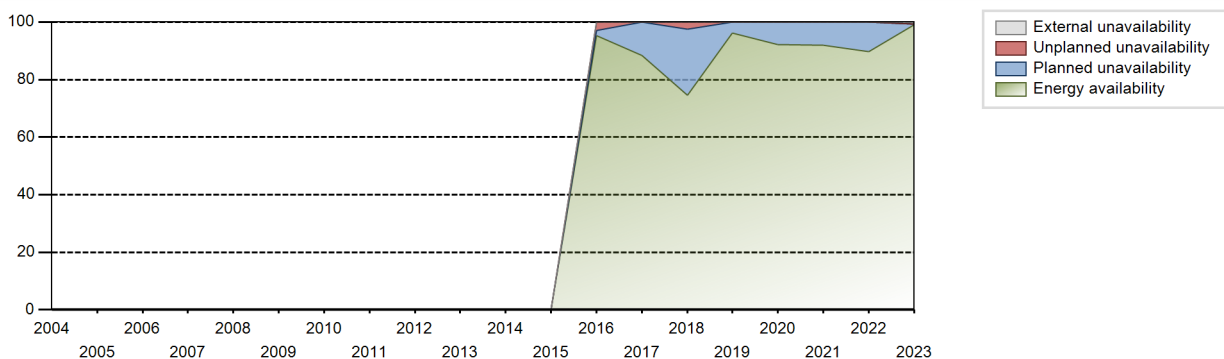
Electricity Production (net) [GWh]



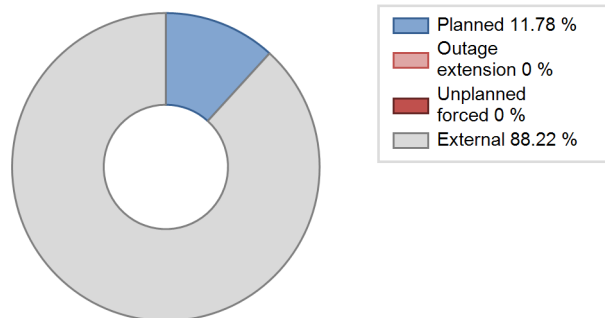
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 1831.25 | 4180 | 601 | 95.30 | 95.30 | 72.98 | 95.89 | 3.07 | 3.02 | 1.68 | 0.00 |
| 2017 | 3417.22 | 7524 | 601 | 88.44 | 88.44 | 64.91 | 85.89 | 0.00 | 0.00 | 11.56 | 0.00 |
| 2018 | 3239.86 | 6531 | 601 | 74.48 | 74.48 | 61.54 | 74.55 | 1.82 | 2.40 | 23.12 | 0.00 |
| 2019 | 4641.87 | 8483 | 601 | 96.23 | 96.23 | 88.17 | 96.84 | 0.00 | 0.00 | 3.77 | 0.00 |
| 2020 | 4328.28 | 7689 | 601 | 92.11 | 92.11 | 81.99 | 87.53 | 0.00 | 0.00 | 7.89 | 0.00 |
| 2021 | 4572.65 | 8147 | 601 | 91.96 | 91.96 | 86.85 | 93.00 | 0.00 | 0.00 | 8.04 | 0.00 |
| 2022 | 4587.19 | 7882 | 601 | 89.67 | 89.67 | 87.13 | 89.98 | 0.00 | 0.00 | 10.33 | 0.00 |
| 2023 | 5110.99 | 8760 | 601 | 99.12 | 99.90 | 97.08 | 100.00 | 0.00 | 0.00 | 0.10 | 0.77 |

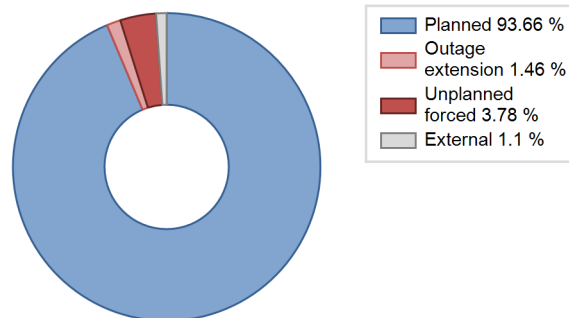
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 40 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 730 | | |
| E. Testing of plant systems or components | | | | 43 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 107 |
| Subtotal | | | | 773 | 40 | 107 |
| Total | 0 | | | 920 | | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|------------------------------|------------|--|-------------------------------------|----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 4 |
| 14. Safety Systems | | | | 12 |
| 16. Steam generation systems | | | | 5 |
| 31. Turbine and auxiliaries | | | | 11 |
| 33. Circulating Water System | | | | 18 |
| 34. Miscellaneous Systems | | | | 51 |
| Total | | | 101 | |

2023 Operating Experience

CN-2 DAYA BAY-1 CHINA

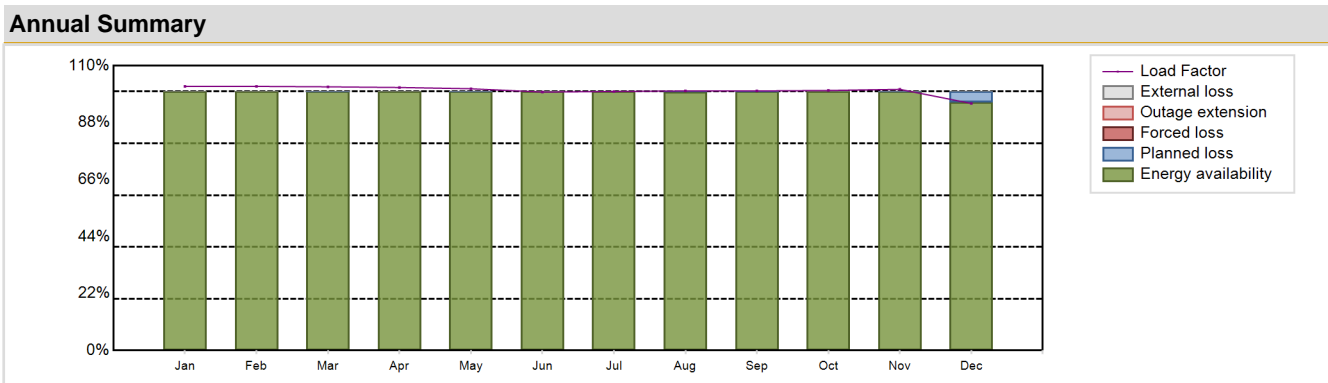
Status at end of year : **Operational**
 Operator : DNMN (Daya Bay Nuclear Power Operations and Management Co, Ltd.)
 Owner : GNPJVC (GUANGDONG NUCLEAR POWER JOINT VENTURE COMPANY LIMITED)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------|--------------------|--------------|
| Reactor type and model | : PWR / M310 | Construction Date | : 1987-08-07 |
| Thermal power | : 2905 MWth | Grid Date | : 1993-08-31 |
| Gross electrical power | : 984 MWe | Commercial Date | : 1994-02-01 |
| Reference unit power (net) | : 944 MWe | Age at end of year | : 30 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.81 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327.6 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.52 |
| Average fuel enrichment [% of U235] | : 4.45 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 46 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 43000 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 6.43 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : 26 |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.6 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 3 |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 8307.47 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.64 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 99.64 % | Planned Unavailability Factor (PUF) | : 0.36 % |
| Load Factor (LF) | : 100.46 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

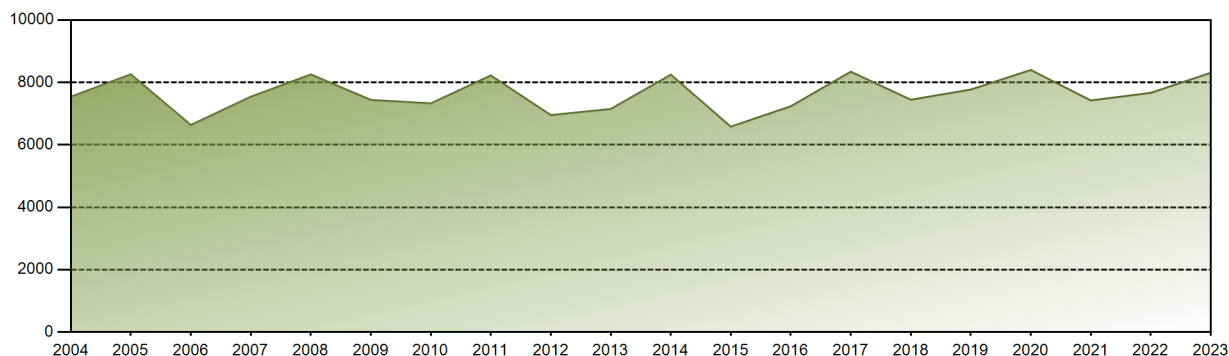


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 716.52 | 647.09 | 715.22 | 690.52 | 710.08 | 678.53 | 702.66 | 704.29 | 681.40 | 705.38 | 685.61 | 670.16 | 8307.47 |
| EAF [%] | 100.00 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 100.00 | 99.94 | 100.00 | 100.00 | 99.99 | 95.86 | 99.64 |
| UCF [%] | 100.00 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 100.00 | 99.94 | 100.00 | 100.00 | 99.99 | 95.86 | 99.64 |
| LF [%] | 102.02 | 102.01 | 101.83 | 101.60 | 101.10 | 99.83 | 100.05 | 100.28 | 100.25 | 100.43 | 100.87 | 95.42 | 100.46 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.01 | 4.14 | 0.36 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

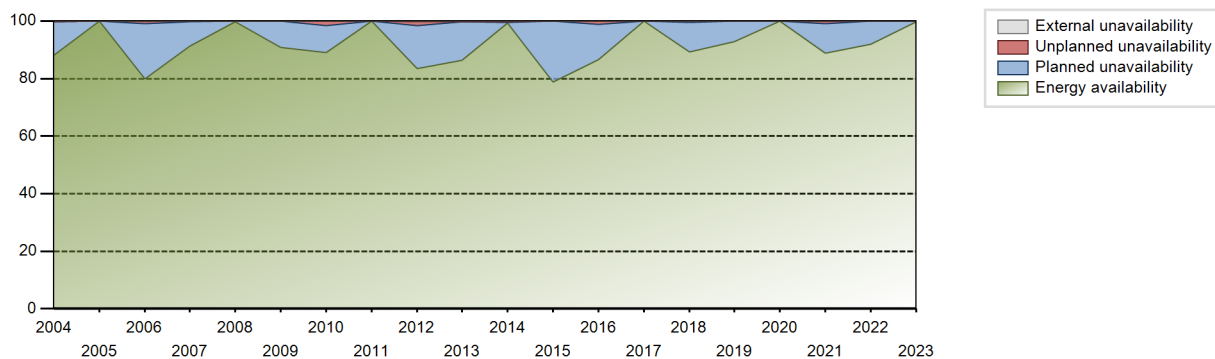
| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 215857.2 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.15 % |
| Cumulative Energy Availability Factor (EAF) | : 87.16 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.2 % |
| Cumulative Unit Capability Factor (UCF) | : 89.33 % | Cumulative Planned Unavailability Factor (PUF) | : 9.46 % |
| Cumulative Load Factor (LF) | : 87.49 % | Cumulative Externally cause unavailability (XUF) | : 2.18 % |
| Cumulative Operating Factor (OF) | : 88.77 % | | |

Electricity Production (net) [GWh]

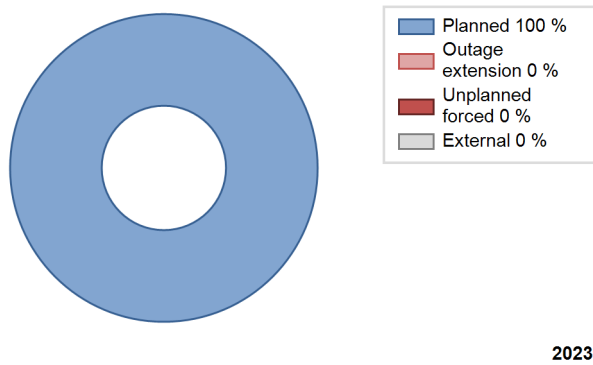


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1994 | 5917.39 | 6539 | 944 | 76.26 | 77.44 | 76.76 | 79.65 | 18.87 | 18.01 | 4.55 | 1.18 |
| 1995 | 3723.63 | 4088 | 944 | 46.21 | 84.61 | 45.03 | 46.67 | 0.45 | 0.38 | 15.00 | 38.40 |
| 1996 | 6252.67 | 6847 | 944 | 76.01 | 76.77 | 75.41 | 77.95 | 5.09 | 4.12 | 19.11 | 0.75 |
| 1997 | 6491.23 | 7272 | 944 | 74.61 | 82.05 | 78.50 | 83.01 | 0.26 | 0.21 | 17.74 | 7.44 |
| 1998 | 6040.47 | 7344 | 944 | 71.99 | 79.64 | 73.05 | 83.84 | 5.64 | 4.76 | 15.60 | 7.65 |
| 1999 | 6723.65 | 7680 | 944 | 82.71 | 87.65 | 81.30 | 87.66 | 0.02 | 0.02 | 12.33 | 4.94 |
| 2000 | 6986.58 | 7641 | 944 | 85.18 | 85.44 | 84.26 | 86.99 | 2.85 | 2.50 | 12.06 | 0.26 |
| 2001 | 7009.34 | 7619 | 944 | 84.81 | 87.49 | 84.76 | 86.97 | 0.36 | 0.32 | 12.19 | 2.68 |
| 2002 | 7387.25 | 7924 | 944 | 89.52 | 89.62 | 89.33 | 90.46 | 0.27 | 0.24 | 10.13 | 0.10 |
| 2003 | 7400.76 | 7958 | 944 | 90.42 | 90.95 | 89.50 | 90.84 | 0.07 | 0.06 | 8.99 | 0.53 |
| 2004 | 7540.90 | 7789 | 944 | 88.21 | 88.45 | 90.94 | 88.67 | 0.00 | 0.00 | 11.55 | 0.24 |
| 2005 | 8260.49 | 8760 | 944 | 99.97 | 99.97 | 99.89 | 100.00 | 0.03 | 0.03 | 0.01 | 0.00 |
| 2006 | 6635.15 | 7133 | 944 | 79.86 | 79.86 | 80.24 | 81.43 | 1.10 | 0.89 | 19.26 | 0.00 |
| 2007 | 7542.13 | 8074 | 944 | 91.20 | 91.20 | 91.20 | 92.17 | 0.22 | 0.20 | 8.59 | 0.00 |
| 2008 | 8255.49 | 8774 | 944 | 99.84 | 99.97 | 99.56 | 99.89 | 0.01 | 0.01 | 0.02 | 0.13 |
| 2009 | 7439.13 | 8055 | 944 | 90.81 | 90.86 | 89.96 | 91.95 | 0.02 | 0.02 | 9.12 | 0.05 |
| 2010 | 7328.51 | 7876 | 944 | 88.95 | 88.95 | 88.62 | 89.91 | 0.00 | 1.61 | 9.44 | 0.00 |
| 2011 | 8222.61 | 8760 | 944 | 99.98 | 99.98 | 99.43 | 100.00 | 0.00 | 0.00 | 0.02 | 0.00 |
| 2012 | 6952.17 | 7452 | 944 | 83.56 | 83.90 | 83.84 | 84.84 | 0.14 | 1.36 | 14.74 | 0.35 |
| 2013 | 7150.01 | 7682 | 944 | 86.41 | 86.68 | 86.46 | 87.69 | 0.01 | 0.01 | 13.31 | 0.26 |
| 2014 | 8247.51 | 8735 | 944 | 99.33 | 99.53 | 99.73 | 99.71 | 0.31 | 0.31 | 0.15 | 0.20 |
| 2015 | 6581.67 | 6954 | 944 | 78.84 | 78.84 | 79.59 | 79.38 | 0.00 | 0.00 | 21.16 | 0.00 |
| 2016 | 7235.87 | 7671 | 944 | 86.58 | 86.58 | 87.26 | 87.33 | 0.04 | 1.24 | 12.18 | 0.00 |
| 2017 | 8343.32 | 8760 | 944 | 99.98 | 99.98 | 100.89 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2018 | 7444.51 | 7871 | 944 | 89.18 | 89.25 | 90.02 | 89.85 | 0.42 | 0.38 | 10.37 | 0.07 |
| 2019 | 7771.68 | 8186 | 944 | 92.94 | 92.94 | 93.98 | 93.45 | 0.00 | 0.00 | 7.06 | 0.00 |
| 2020 | 8398.23 | 8784 | 944 | 99.99 | 99.99 | 101.28 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2021 | 7421.56 | 7834 | 944 | 88.92 | 88.92 | 89.75 | 89.43 | 0.00 | 0.84 | 10.24 | 0.00 |
| 2022 | 7666.03 | 8101 | 944 | 91.84 | 91.84 | 92.70 | 92.48 | 0.00 | 0.00 | 8.16 | 0.00 |
| 2023 | 8307.47 | 8760 | 944 | 99.64 | 99.64 | 100.46 | 100.00 | 0.00 | 0.00 | 0.36 | 0.00 |

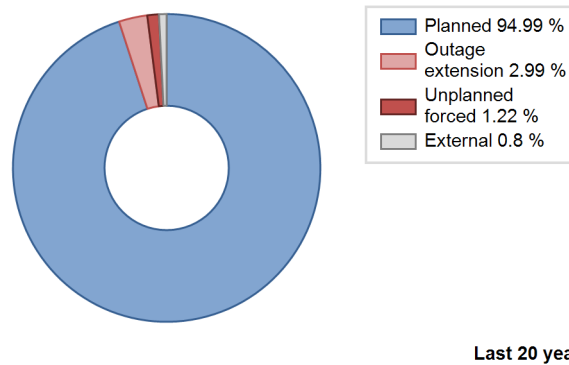
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1994 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 86 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 780 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 10 | | |
| E. Testing of plant systems or components | | | | | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 10 |
| Z. Other | | | | | | 103 |
| Subtotal | | | | 790 | 86 | 113 |
| Total | | 0 | | | 989 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1994 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 3 |
| 15. Reactor Cooling Systems | | 9 |
| 31. Turbine and auxiliaries | | 2 |
| 32. Feedwater and Main Steam System | | 10 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 2 |
| 41. Main Generator Systems | | 32 |
| 42. Electrical Power Supply Systems | | 19 |
| Total | | 86 |

2023 Operating Experience

CN-3

DAYA BAY-2

CHINA

Status at end of year : **Operational**
 Operator : DNM (Daya Bay Nuclear Power Operations and Management Co, Ltd.)
 Owner : GNPJVC (GUANGDONG NUCLEAR POWER JOINT VENTURE COMPANY LIMITED)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------|--------------------|--------------|
| Reactor type and model | : PWR / M310 | Construction Date | : 1988-04-07 |
| Thermal power | : 2905 MWth | Grid Date | : 1994-02-07 |
| Gross electrical power | : 984 MWe | Commercial Date | : 1994-05-06 |
| Reference unit power (net) | : 944 MWe | Age at end of year | : 29 years |

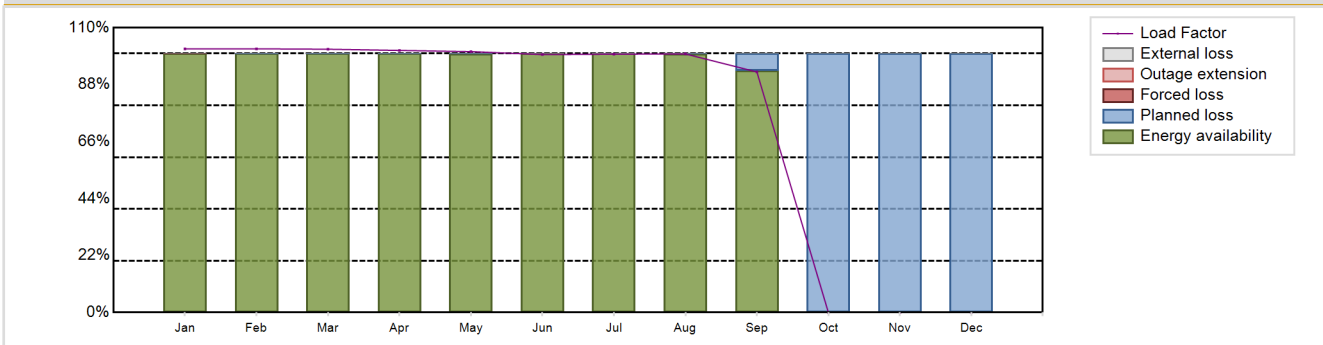
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.81 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 327.6 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 4.45 | Containment design pressure [MPa] | : 0.52 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 46 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 43000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 6.43 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : 26 |
| Fuel linear heat generation rate [kW/m] | : 18.6 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 61 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : 3 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 6181.83 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 74.25 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 74.25 % | Planned Unavailability Factor (PUF) | : 25.75 % |
| Load Factor (LF) | : 74.76 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 74.33 % | Total off-line time | : 2249 hours |

Annual Summary

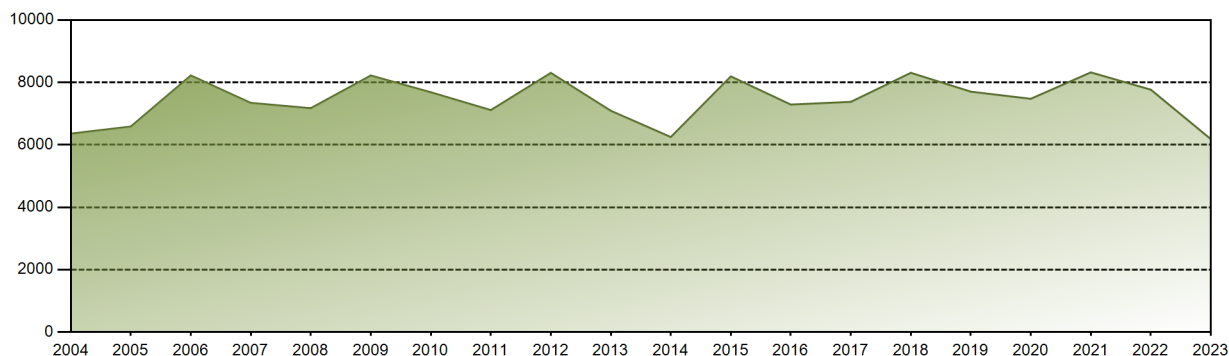


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 715.04 | 646.05 | 714.31 | 687.95 | 707.71 | 677.09 | 700.76 | 701.39 | 631.53 | 0.00 | 0.00 | 0.00 | 6181.83 |
| EAF [%] | 100.00 | 99.99 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 99.92 | 93.50 | 0.00 | 0.00 | 0.00 | 74.25 |
| UCF [%] | 100.00 | 99.99 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 99.92 | 93.50 | 0.00 | 0.00 | 0.00 | 74.25 |
| LF [%] | 101.81 | 101.84 | 101.71 | 101.22 | 100.77 | 99.62 | 99.77 | 99.87 | 92.92 | 0.00 | 0.00 | 0.00 | 74.76 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.03 | 0.00 | 0.00 | 0.27 | 74.33 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.08 | 6.50 | 100.00 | 100.00 | 100.00 | 25.75 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

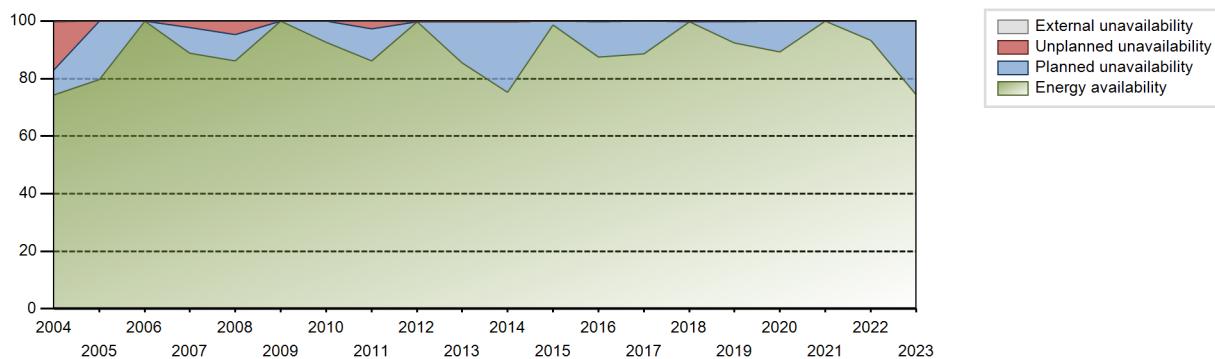
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 212019.23 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.41 % |
| Cumulative Energy Availability Factor (EAF) | : 86.41 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.99 % |
| Cumulative Unit Capability Factor (UCF) | : 87.43 % | Cumulative Planned Unavailability Factor (PUF) | : 10.58 % |
| Cumulative Load Factor (LF) | : 86.6 % | Cumulative Externally cause unavailability (XUF) | : 1.02 % |
| Cumulative Operating Factor (OF) | : 87.81 % | | |

Electricity Production (net) [GWh]

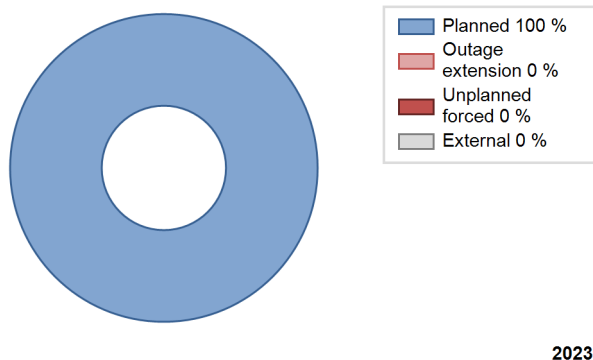


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1994 | 5741.21 | 6889 | 944 | 92.32 | 99.39 | 90.33 | 97.98 | 0.60 | 0.60 | 0.01 | 7.07 |
| 1995 | 6343.33 | 7146 | 944 | 77.48 | 81.09 | 76.71 | 81.58 | 1.35 | 1.11 | 17.80 | 3.60 |
| 1996 | 5276.90 | 5740 | 944 | 63.92 | 67.43 | 63.64 | 65.35 | 13.49 | 10.51 | 22.05 | 3.51 |
| 1997 | 5914.84 | 6194 | 944 | 67.41 | 70.10 | 71.53 | 70.71 | 2.15 | 1.54 | 28.37 | 2.69 |
| 1998 | 6259.05 | 7302 | 944 | 74.71 | 82.90 | 75.69 | 83.36 | 2.15 | 1.82 | 15.27 | 8.19 |
| 1999 | 6789.46 | 7594 | 944 | 83.32 | 86.18 | 82.10 | 86.69 | 0.00 | 0.00 | 13.82 | 2.87 |
| 2000 | 6995.52 | 7840 | 944 | 88.39 | 89.13 | 84.36 | 89.25 | 0.05 | 0.05 | 10.83 | 0.73 |
| 2001 | 7355.47 | 7986 | 944 | 89.46 | 91.12 | 88.95 | 91.16 | 0.19 | 0.18 | 8.70 | 1.66 |
| 2002 | 6728.92 | 7224 | 944 | 81.62 | 82.22 | 81.37 | 82.47 | 15.12 | 14.64 | 3.14 | 0.60 |
| 2003 | 6983.05 | 7503 | 944 | 84.53 | 84.62 | 84.44 | 85.65 | 0.53 | 1.17 | 14.21 | 0.09 |
| 2004 | 6358.88 | 6580 | 944 | 74.23 | 74.39 | 76.69 | 74.91 | 0.10 | 16.74 | 8.87 | 0.17 |
| 2005 | 6586.98 | 7075 | 944 | 79.62 | 79.62 | 79.65 | 80.76 | 0.03 | 0.02 | 20.36 | 0.00 |
| 2006 | 8222.79 | 8760 | 944 | 99.89 | 99.89 | 99.44 | 100.00 | 0.04 | 0.04 | 0.07 | 0.00 |
| 2007 | 7344.17 | 7858 | 944 | 88.81 | 88.81 | 88.81 | 89.70 | 0.90 | 2.27 | 8.92 | 0.00 |
| 2008 | 7174.36 | 7667 | 944 | 86.25 | 86.25 | 86.52 | 87.28 | 5.20 | 4.73 | 9.02 | 0.00 |
| 2009 | 8222.61 | 8760 | 944 | 99.98 | 99.99 | 99.43 | 100.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 2010 | 7685.64 | 8197 | 944 | 92.50 | 92.50 | 92.94 | 93.57 | 0.01 | 0.01 | 7.49 | 0.00 |
| 2011 | 7113.12 | 7649 | 944 | 86.23 | 86.34 | 86.02 | 87.32 | 0.00 | 2.65 | 11.00 | 0.11 |
| 2012 | 8304.98 | 8784 | 944 | 99.66 | 99.97 | 100.16 | 100.00 | 0.00 | 0.00 | 0.03 | 0.31 |
| 2013 | 7091.41 | 7605 | 944 | 85.58 | 85.81 | 85.75 | 86.82 | 0.02 | 0.02 | 14.17 | 0.23 |
| 2014 | 6249.97 | 6629 | 944 | 75.23 | 75.57 | 75.58 | 75.67 | 0.04 | 0.03 | 24.41 | 0.34 |
| 2015 | 8193.18 | 8700 | 944 | 98.65 | 98.65 | 99.08 | 99.32 | 0.01 | 0.01 | 1.34 | 0.01 |
| 2016 | 7290.17 | 7750 | 944 | 87.39 | 87.39 | 87.92 | 88.23 | 0.30 | 0.30 | 12.32 | 0.00 |
| 2017 | 7376.85 | 7819 | 944 | 88.63 | 88.74 | 89.21 | 89.26 | 0.01 | 0.01 | 11.25 | 0.11 |
| 2018 | 8306.97 | 8739 | 944 | 99.65 | 99.72 | 100.45 | 99.76 | 0.27 | 0.27 | 0.01 | 0.06 |
| 2019 | 7704.07 | 8143 | 944 | 92.35 | 92.35 | 93.16 | 92.96 | 0.04 | 0.24 | 7.40 | 0.00 |
| 2020 | 7475.32 | 7889 | 944 | 89.21 | 89.21 | 90.15 | 89.81 | 0.13 | 0.12 | 10.67 | 0.00 |
| 2021 | 8321.42 | 8760 | 944 | 99.89 | 99.98 | 100.63 | 100.00 | 0.00 | 0.00 | 0.02 | 0.09 |
| 2022 | 7767.89 | 8209 | 944 | 93.24 | 93.24 | 93.93 | 93.71 | 0.00 | 0.00 | 6.76 | 0.00 |
| 2023 | 6181.83 | 6511 | 944 | 74.25 | 74.25 | 74.76 | 74.33 | 0.00 | 0.00 | 25.75 | 0.00 |

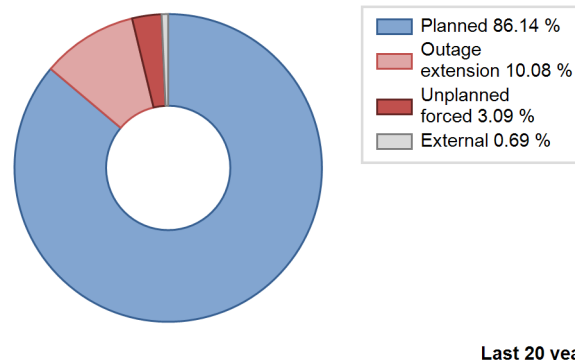
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1994 to 2023 | | |
|--|-------------|-------------|----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 94 | |
| C. Inspection, maintenance or repair combined with refuelling | 1509 | | | 835 | 8 | |
| D. Inspection, maintenance or repair without refuelling | | | | 9 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | 744 | | | 25 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 11 |
| L. Human factor related | | | | | 14 | |
| Subtotal | 2253 | | | 869 | 116 | 11 |
| Total | | 2253 | | | 996 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1994 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 1 |
| 12. Reactor I&C Systems | | 4 |
| 14. Safety Systems | | 0 |
| 15. Reactor Cooling Systems | | 1 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 36 |
| 31. Turbine and auxiliaries | | 2 |
| 32. Feedwater and Main Steam System | | 1 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 44 |
| 42. Electrical Power Supply Systems | | 15 |
| Total | | 106 |

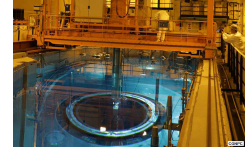
2023 Operating Experience

CN-38

FANGCHENGGANG-1

CHINA

Status at end of year : **Operational**
 Operator : GFNPC (Guangxi Fangchenggang Nuclear Power Company, Ltd.)
 Owner : GFNPC (Guangxi Fangchenggang Nuclear Power Company, Ltd.)
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)



Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1086 MWe
 Reference unit power (net) : 1000 MWe

Key Dates

Construction Date : 2010-07-30
 Grid Date : 2015-10-25
 Commercial Date : 2016-01-01
 Age at end of year : 8 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.43
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 44.6
 Average discharge burnup [MWd/t] : NA
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.6
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

Non-electrical applications

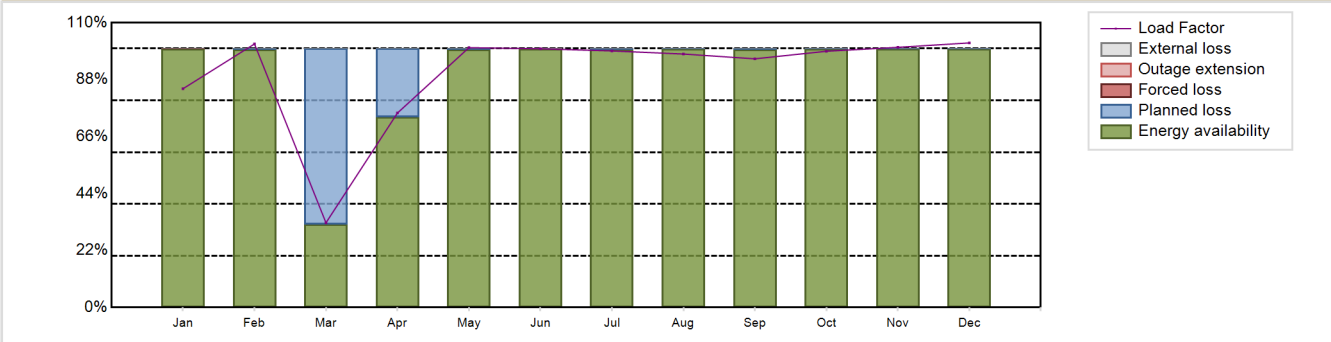
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7940.89 GW(e).h
 Energy Availability Factor (EAF) : 91.84 %
 Unit Capability Factor (UCF) : 91.84 %
 Load Factor (LF) : 90.65 %
 Operating Factor (OF) : 92.44 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 8.16 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 662 hours

Annual Summary

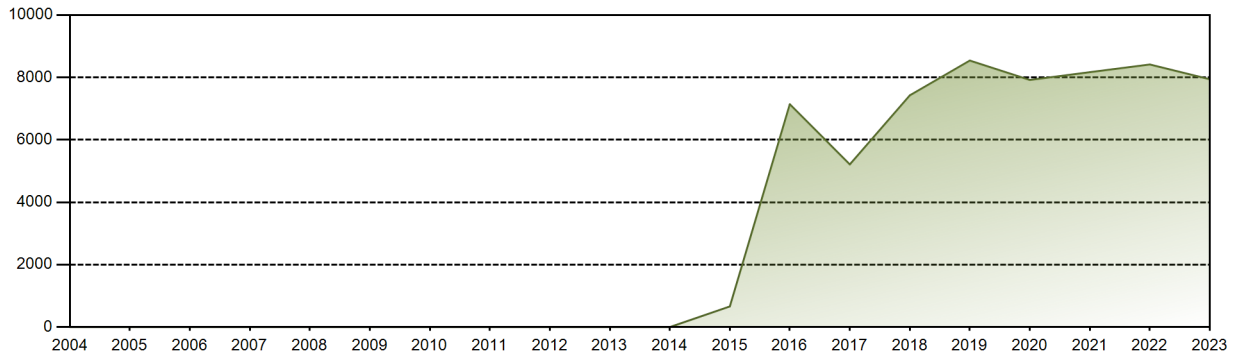


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 628.76 | 684.00 | 243.51 | 540.91 | 746.70 | 719.50 | 737.29 | 728.33 | 691.60 | 736.34 | 723.56 | 760.38 | 7940.89 |
| EAF [%] | 99.75 | 99.68 | 32.05 | 73.51 | 99.73 | 99.75 | 99.73 | 99.75 | 99.73 | 99.75 | 99.75 | 99.85 | 91.84 |
| UCF [%] | 99.75 | 99.68 | 32.05 | 73.51 | 99.73 | 99.75 | 99.73 | 99.75 | 99.73 | 99.75 | 99.75 | 99.85 | 91.84 |
| LF [%] | 84.51 | 101.79 | 32.73 | 75.13 | 100.36 | 99.93 | 99.10 | 97.89 | 96.06 | 98.97 | 100.49 | 102.20 | 90.65 |
| OF [%] | 100.00 | 100.00 | 33.06 | 77.22 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.44 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.25 | 0.32 | 67.95 | 26.49 | 0.27 | 0.25 | 0.27 | 0.25 | 0.27 | 0.25 | 0.25 | 0.15 | 8.16 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 61425.89 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.25 % |
| Cumulative Energy Availability Factor (EAF) | : 92.7 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.34 % |
| Cumulative Unit Capability Factor (UCF) | : 92.75 % | Cumulative Planned Unavailability Factor (PUF) | : 6.91 % |
| Cumulative Load Factor (LF) | : 86.65 % | Cumulative Externally cause unavailability (XUF) | : 0.04 % |
| Cumulative Operating Factor (OF) | : 89.59 % | | |

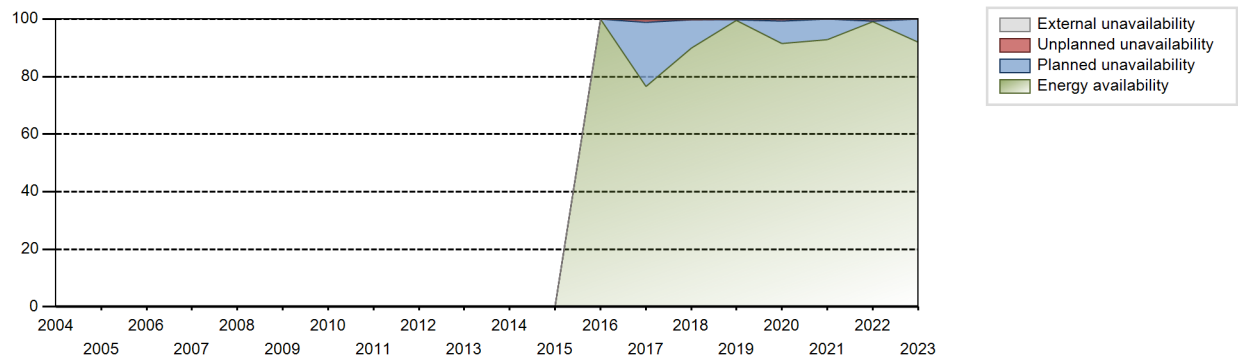
Electricity Production (net) [GWh]



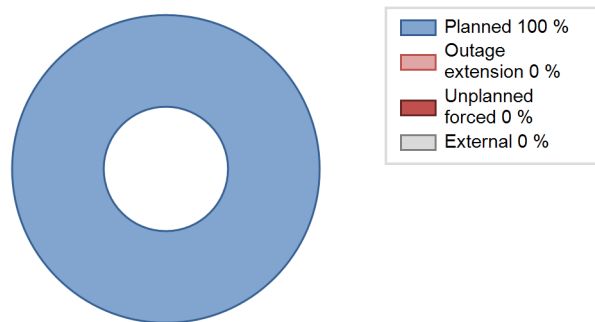
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 7141.83 | 7761 | 1000 | 99.97 | 99.97 | 81.30 | 88.35 | 0.00 | 0.00 | 0.03 | 0.01 |
| 2017 | 5212.98 | 5794 | 1000 | 76.66 | 76.82 | 59.51 | 66.14 | 0.00 | 0.91 | 22.27 | 0.16 |
| 2018 | 7425.87 | 7622 | 1000 | 90.01 | 90.19 | 84.77 | 87.01 | 0.01 | 0.01 | 9.80 | 0.18 |
| 2019 | 8540.31 | 8736 | 1000 | 99.62 | 99.62 | 97.49 | 99.73 | 0.36 | 0.36 | 0.02 | 0.00 |
| 2020 | 7919.20 | 8140 | 1000 | 91.43 | 91.43 | 90.15 | 92.67 | 0.72 | 0.66 | 7.91 | 0.00 |
| 2021 | 8168.79 | 8179 | 1000 | 92.90 | 92.90 | 93.25 | 93.37 | 0.00 | 0.00 | 7.09 | 0.00 |
| 2022 | 8414.60 | 8499 | 1000 | 99.18 | 99.18 | 96.06 | 97.02 | 0.81 | 0.81 | 0.01 | 0.00 |
| 2023 | 7940.89 | 8098 | 1000 | 91.84 | 91.84 | 90.65 | 92.44 | 0.00 | 0.00 | 8.16 | 0.00 |

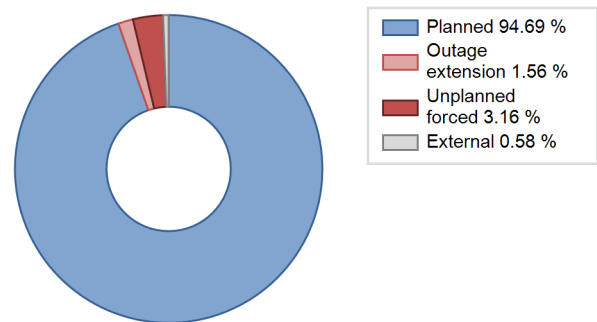
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 21 | |
| C. Inspection, maintenance or repair combined with refuelling | 659 | | | 573 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 319 |
| Subtotal | 659 | | | 573 | 21 | 319 |
| Total | | 659 | | | 913 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|-----------------------------|------------|--|-------------------------------------|----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 14. Safety Systems | | | | 10 |
| 15. Reactor Cooling Systems | | | | 8 |
| 31. Turbine and auxiliaries | | | | 3 |
| 34. Miscellaneous Systems | | | | 24 |
| Total | | | | 45 |

2023 Operating Experience

CN-39

FANGCHENGGANG-2

CHINA

Status at end of year : **Operational**
 Operator : GFNPC (Guangxi Fangchenggang Nuclear Power Company, Ltd.)
 Owner : GFNPC (Guangxi Fangchenggang Nuclear Power Company, Ltd.)
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)



Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1086 MWe
 Reference unit power (net) : 1000 MWe

Key Dates

Construction Date : 2010-12-23
 Grid Date : 2016-07-15
 Commercial Date : 2016-10-01
 Age at end of year : 7 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.43
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 44.6
 Average discharge burnup [MWd/t] : NA
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.6
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

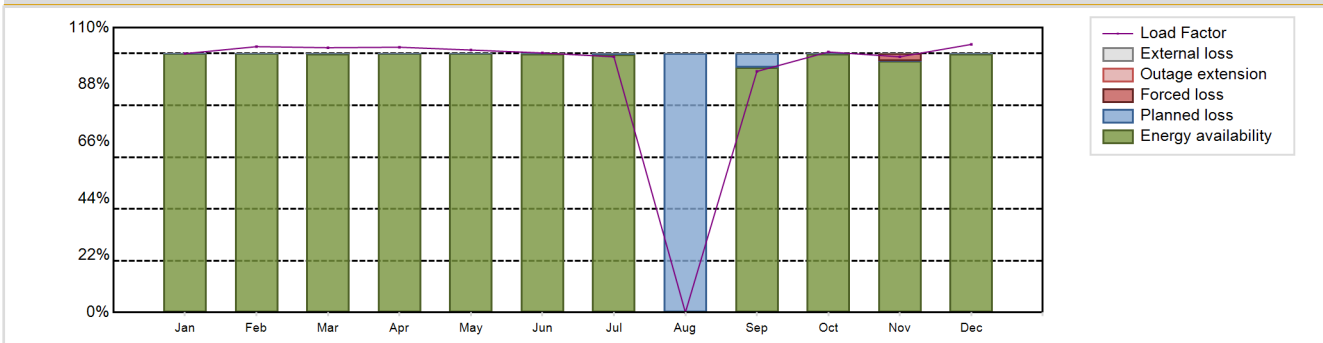
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8044.34 GW(e).h
 Energy Availability Factor (EAF) : 90.78 %
 Unit Capability Factor (UCF) : 90.78 %
 Load Factor (LF) : 91.83 %
 Operating Factor (OF) : 91.53 %
 Forced Loss Rate (FLR) : 0.26 %
 Unplanned Capability Loss Factor (UCL) : 0.23 %
 Planned Unavailability Factor (PUF) : 8.99 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 742 hours

Annual Summary

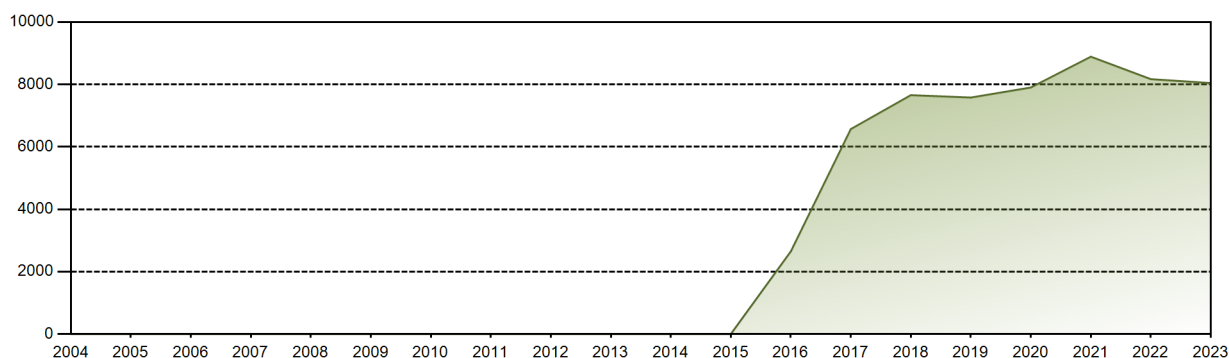


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|---------|
| GW(e)-h | 744.00 | 690.02 | 760.86 | 737.76 | 754.22 | 721.77 | 734.75 | 0.30 | 670.46 | 748.58 | 711.17 | 770.45 | 8044.34 |
| EAF [%] | 100.00 | 100.00 | 99.98 | 100.00 | 100.00 | 99.90 | 99.56 | 0.08 | 94.55 | 99.98 | 97.16 | 99.98 | 90.78 |
| UCF [%] | 100.00 | 100.00 | 99.98 | 100.00 | 100.00 | 99.90 | 99.56 | 0.08 | 94.55 | 99.98 | 97.16 | 99.98 | 90.78 |
| LF [%] | 100.00 | 102.68 | 102.27 | 102.47 | 101.37 | 100.25 | 98.76 | 0.04 | 93.12 | 100.62 | 98.77 | 103.56 | 91.83 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 0.27 | 100.00 | 100.00 | 100.00 | 100.00 | 91.53 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.84 | 0.00 | 0.26 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.84 | 0.00 | 0.23 |
| PUF [%] | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.10 | 0.44 | 99.92 | 5.45 | 0.02 | 0.00 | 0.02 | 8.99 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 57359.29 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.24 % |
| Cumulative Energy Availability Factor (EAF) | : 92.83 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.23 % |
| Cumulative Unit Capability Factor (UCF) | : 92.87 % | Cumulative Planned Unavailability Factor (PUF) | : 6.9 % |
| Cumulative Load Factor (LF) | : 89.41 % | Cumulative Externally cause unavailability (XUF) | : 0.04 % |
| Cumulative Operating Factor (OF) | : 89.74 % | | |

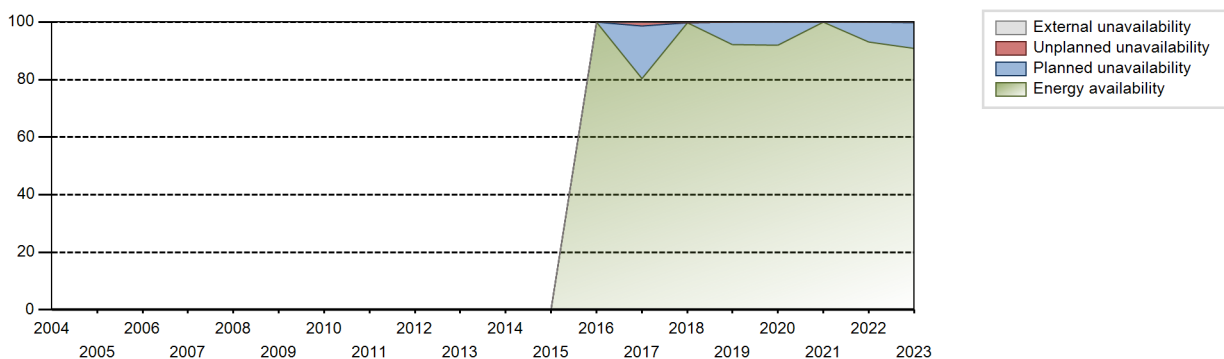
Electricity Production (net) [GWh]



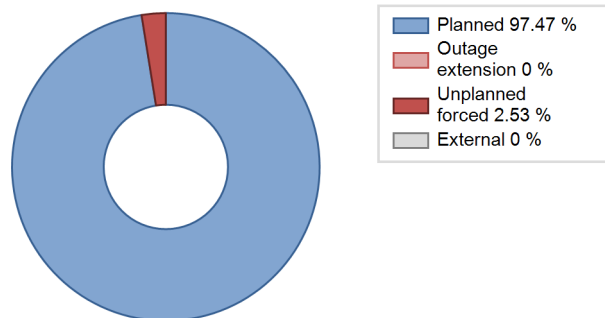
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|--------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 2648.30 | 3297 | 1000 | 100.00 | 100.00 | 91.13 | 88.22 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 6569.07 | 6827 | 1000 | 80.27 | 80.38 | 74.99 | 77.93 | 1.63 | 1.33 | 18.29 | 0.12 |
| 2018 | 7655.73 | 7816 | 1000 | 99.81 | 99.98 | 87.39 | 89.22 | 0.01 | 0.01 | 0.01 | 0.18 |
| 2019 | 7579.32 | 7625 | 1000 | 92.14 | 92.14 | 86.52 | 87.04 | 0.08 | 0.08 | 7.78 | 0.00 |
| 2020 | 7901.00 | 7911 | 1000 | 91.98 | 91.98 | 89.95 | 90.06 | 0.00 | 0.00 | 8.02 | 0.00 |
| 2021 | 8888.26 | 8760 | 1000 | 99.99 | 99.99 | 101.46 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2022 | 8168.69 | 8129 | 1000 | 93.04 | 93.04 | 93.25 | 92.80 | 0.00 | 0.00 | 6.96 | 0.00 |
| 2023 | 8044.34 | 8018 | 1000 | 90.78 | 90.78 | 91.83 | 91.53 | 0.26 | 0.23 | 8.99 | 0.00 |

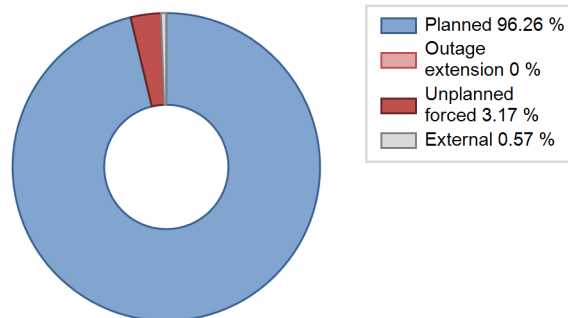
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 17 | |
| C. Inspection, maintenance or repair combined with refuelling | 742 | | | 573 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 309 |
| Subtotal | 742 | | | 573 | 17 | 309 |
| Total | | 742 | | | 899 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|-----------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 31. Turbine and auxiliaries | | | | 16 |
| 34. Miscellaneous Systems | | | | 100 |
| Total | | | | 116 |

2023 Operating Experience

CN-55

FANGCHENGGANG-3

CHINA

Status at end of year : **Operational**
 Operator : GFNPC (Guangxi Fangchenggang Nuclear Power Company, Ltd.)
 Owner : GFNPC (Guangxi Fangchenggang Nuclear Power Company, Ltd.)
 Reactor Supplier : CFHI (China First Heavy Industries)
 Turbine Supplier : SEG (Shanghai Electric Group)



Reactor Unit Details

Reactor type and model : PWR / HPR1000
 Thermal power : 3150 MWth
 Gross electrical power : 1180 MWe
 Reference unit power (net) : 1000 MWe

Key Dates

Construction Date : 2015-12-24
 Grid Date : 2023-01-10
 Commercial Date : 2023-03-25
 Age at end of year : 0 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.45
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 40.7
 Average discharge burnup [MWd/t] : 47400
 Active core diameter [m] : 3.23
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 17.95
 Number of control rod assemblies : 68
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 324.5
 Number of SG : 3
 Containment type : Double
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.45
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

Non-electrical applications

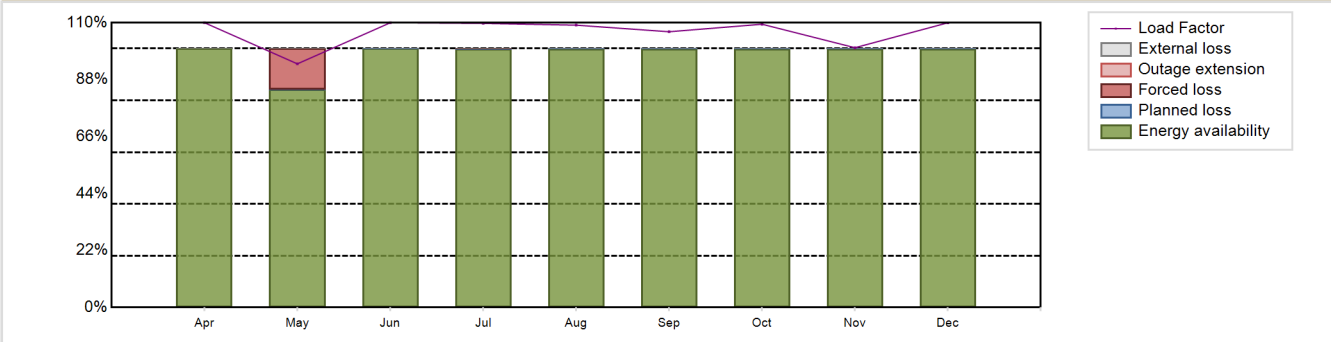
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7569.94 GW(e).h
 Energy Availability Factor (EAF) : 98.19 %
 Unit Capability Factor (UCF) : 98.19 %
 Load Factor (LF) : 106.57 %
 Operating Factor (OF) : 98.18 %

Forced Loss Rate (FLR) : 1.79 %
 Unplanned Capability Loss Factor (UCL) : 1.79 %
 Planned Unavailability Factor (PUF) : 0.02 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1903 hours

Annual Summary

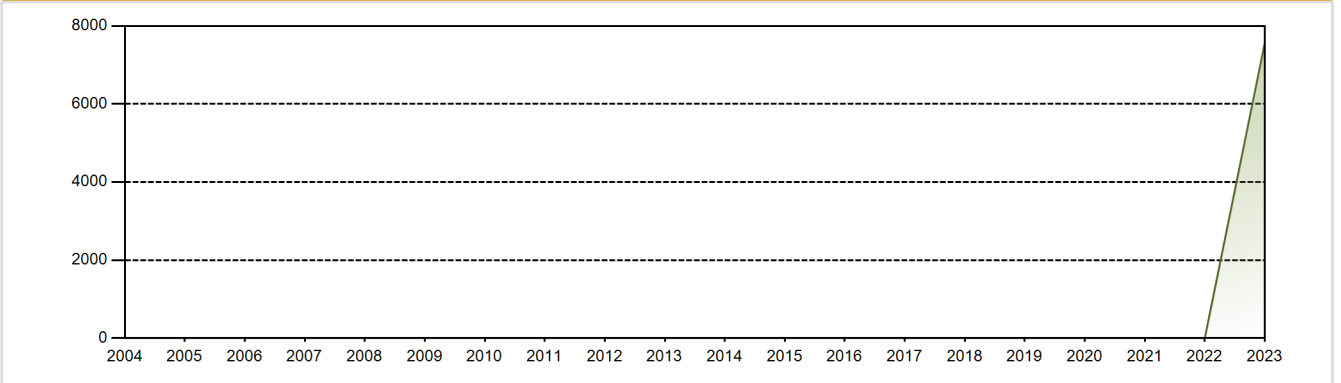


| | Mar | Jan | Feb | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-----|-----|-----|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | | | | 792.00 | 700.23 | 791.96 | 816.45 | 811.37 | 766.88 | 814.02 | 722.47 | 818.17 | 7033.55 |
| EAF [%] | | | | 100.00 | 84.12 | 99.99 | 99.95 | 99.98 | 99.96 | 99.97 | 99.97 | 99.97 | 98.19 |
| UCF [%] | | | | 100.00 | 84.12 | 99.99 | 99.95 | 99.98 | 99.96 | 99.97 | 99.97 | 99.97 | 98.19 |
| LF [%] | | | | 110.00 | 94.12 | 109.99 | 109.74 | 109.06 | 106.51 | 109.41 | 100.34 | 109.97 | 106.57 |
| OF [%] | | | | 100.00 | 83.87 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.18 |
| FLR [%] | | | | 0.00 | 15.87 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.79 |
| UCL [%] | | | | 0.00 | 15.86 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.79 |
| PUF [%] | | | | 0.00 | 0.02 | 0.01 | 0.02 | 0.02 | 0.04 | 0.03 | 0.03 | 0.03 | 0.02 |
| XUF [%] | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|-------------------|---|----------|
| Lifetime energy generation | : 7215.47 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.79 % |
| Cumulative Energy Availability Factor (EAF) | : 98.19 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.79 % |
| Cumulative Unit Capability Factor (UCF) | : 98.19 % | Cumulative Planned Unavailability Factor (PUF) | : 0.02 % |
| Cumulative Load Factor (LF) | : 106.57 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 98.18 % | | |

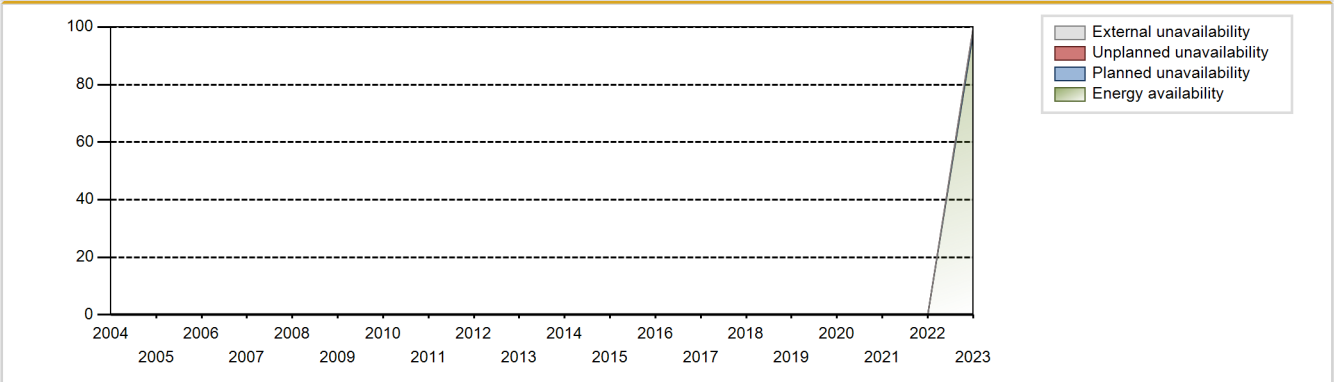
Electricity Production (net) [GWh]



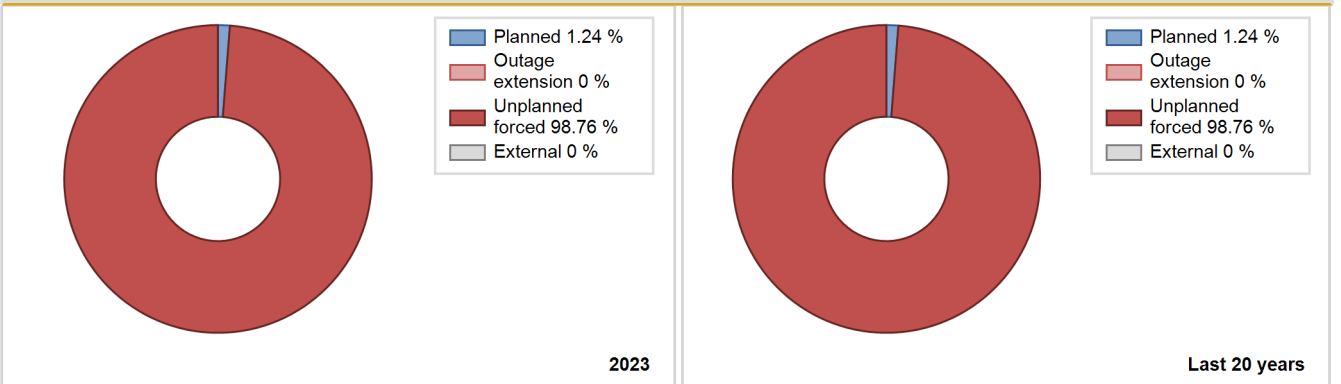
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|-------|------|------|------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2023 | 7569.94 | 6641 | 1000 | 98.19 | 98.19 | 106.57 | 98.18 | 1.79 | 1.79 | 0.02 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2023 to 2023 | | |
|------------------------------------|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 120 | | | 160 | |
| Subtotal | | 120 | | | 160 | |
| Total | | 120 | | | 160 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2023 to 2023 |
|-----------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 31. Turbine and auxiliaries | 120 | 120 |
| Total | 120 | 120 |

Highlights (2023)

1.CN55 was officially put into commercial operation on March 25, 2023,Unplanned shutdown and retreat once.2.At the request of grid system,CN55 deloaded for some holidays and weekends and other reasons.

2023 Operating Experience

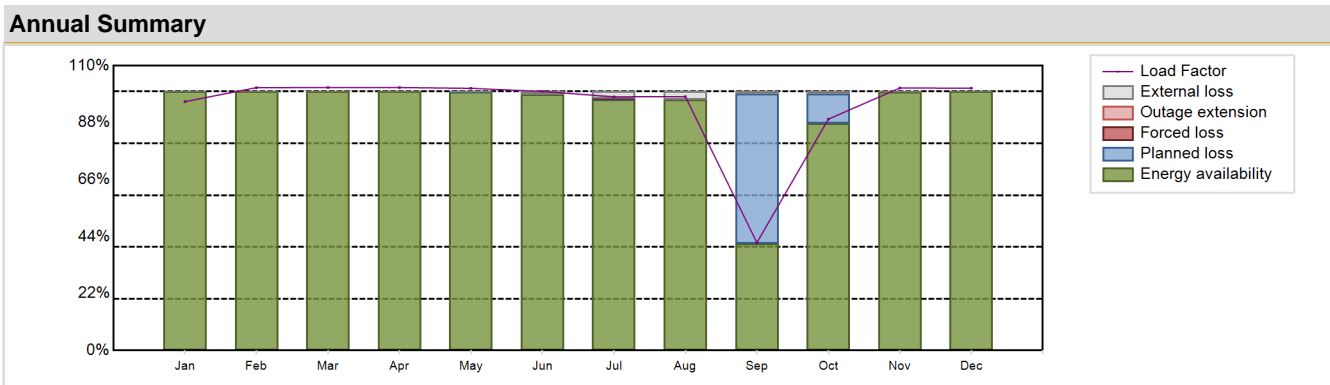
CN-24 **FANGJIASHAN-1** **CHINA**

Status at end of year : **Operational**
 Operator : CNNO (CNNC Nuclear Operation Management Company Limited)
 Owner : QNPC (QINSHAN NUCLEAR POWER COMPANY)
 Reactor Supplier : NPIC (Nuclear Power Institute of China)
 Turbine Supplier : DEC (Dongfang Electric Corporation)

| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / CPR-1000 | Construction Date | : 2008-12-26 |
| Thermal power | : 2905 MWth | Grid Date | : 2014-11-04 |
| Gross electrical power | : 1089 MWe | Commercial Date | : 2014-12-15 |
| Reference unit power (net) | : 1012 MWe | Age at end of year | : 9 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327.6 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.52 |
| Average fuel enrichment [% of U235] | : 2.4 | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : 2 |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 6.43 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : 24 |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.6 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 8364.58 GW(e).h | Forced Loss Rate (FLR) | : 0.03 % |
| Energy Availability Factor (EAF) | : 93.49 % | Unplanned Capability Loss Factor (UCL) | : 0.03 % |
| Unit Capability Factor (UCF) | : 94.26 % | Planned Unavailability Factor (PUF) | : 5.71 % |
| Load Factor (LF) | : 94.35 % | Externally cause unavailability (XUF) | : 0.77 % |
| Operating Factor (OF) | : 94.71 % | Total off-line time | : 463 hours |

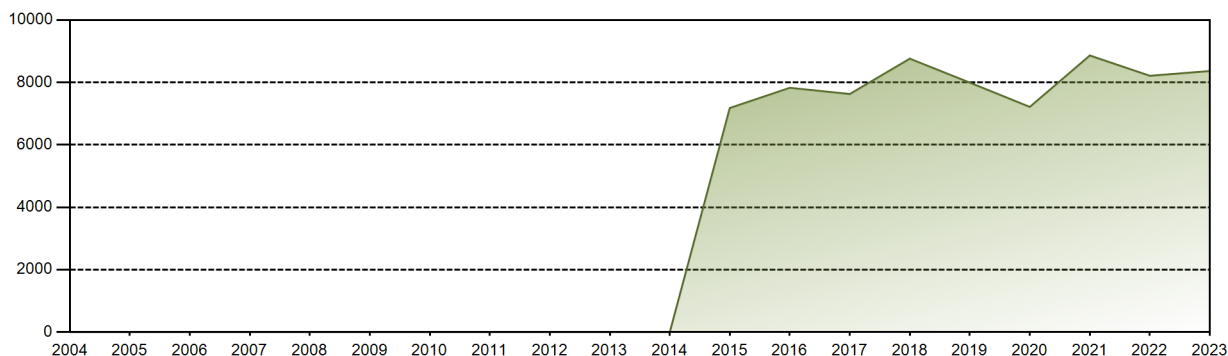


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 723.68 | 690.44 | 764.70 | 740.00 | 762.40 | 729.08 | 737.82 | 738.32 | 303.60 | 672.76 | 738.82 | 762.96 | 8364.58 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.75 | 98.79 | 96.95 | 96.99 | 41.24 | 87.82 | 99.90 | 100.00 | 93.49 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 | 100.00 | 99.64 | 100.00 | 42.25 | 88.64 | 100.00 | 100.00 | 94.26 |
| LF [%] | 96.12 | 101.53 | 101.56 | 101.56 | 101.26 | 100.06 | 97.99 | 98.06 | 41.67 | 89.35 | 101.40 | 101.33 | 94.35 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 42.92 | 93.01 | 100.00 | 100.00 | 94.71 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.02 | 0.00 | 57.75 | 11.36 | 0.00 | 0.00 | 5.71 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 1.21 | 2.70 | 3.01 | 1.01 | 0.83 | 0.10 | 0.00 | 0.77 |

Historical Summary

| | | | |
|---|-----------------|---|----------|
| Lifetime energy generation | : 72864 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.06 % |
| Cumulative Energy Availability Factor (EAF) | : 92.04 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.06 % |
| Cumulative Unit Capability Factor (UCF) | : 92.55 % | Cumulative Planned Unavailability Factor (PUF) | : 7.39 % |
| Cumulative Load Factor (LF) | : 89.41 % | Cumulative Externally cause unavailability (XUF) | : 0.51 % |
| Cumulative Operating Factor (OF) | : 90.52 % | | |

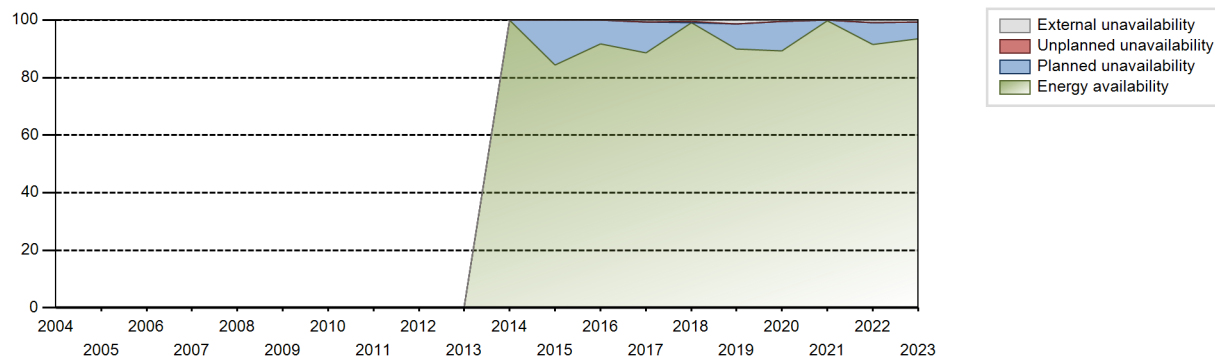
Electricity Production (net) [GWh]



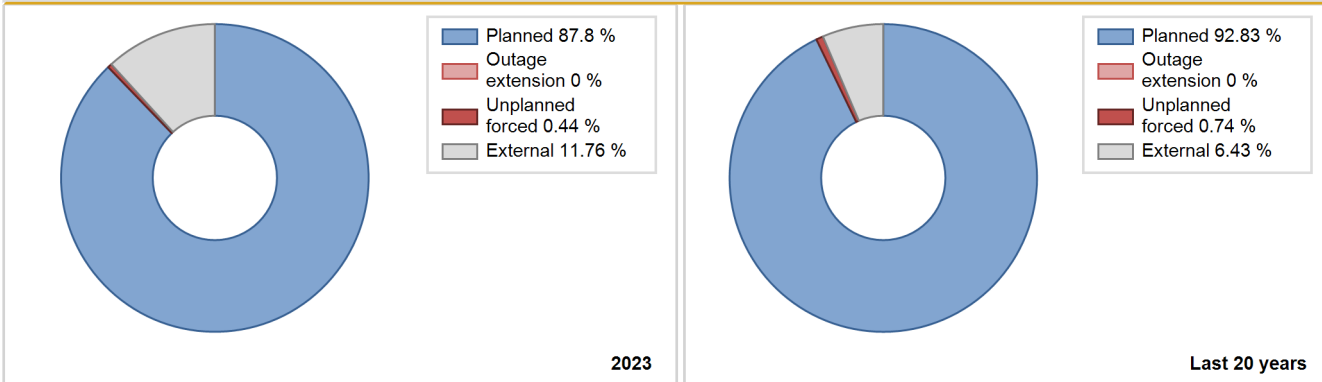
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2014 | 0.00 | 0 | 1000 | 100.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 7180.23 | 7289 | 1012 | 84.47 | 84.47 | 80.99 | 83.21 | 0.00 | 0.00 | 15.53 | 0.00 |
| 2016 | 7827.38 | 7910 | 1012 | 91.68 | 91.68 | 88.05 | 90.05 | 0.04 | 0.04 | 8.28 | 0.00 |
| 2017 | 7628.57 | 7676 | 1012 | 88.54 | 89.14 | 86.05 | 87.63 | 0.08 | 0.07 | 10.79 | 0.60 |
| 2018 | 8761.17 | 8732 | 1012 | 99.06 | 99.61 | 98.83 | 99.68 | 0.39 | 0.39 | 0.00 | 0.55 |
| 2019 | 7992.84 | 8048 | 1012 | 89.85 | 91.12 | 90.16 | 91.87 | 0.00 | 0.00 | 8.88 | 1.28 |
| 2020 | 7214.92 | 7218 | 1012 | 89.30 | 89.77 | 81.16 | 82.17 | 0.00 | 0.00 | 10.23 | 0.46 |
| 2021 | 8862.47 | 8760 | 1012 | 99.76 | 99.86 | 99.97 | 100.00 | 0.00 | 0.00 | 0.14 | 0.09 |
| 2022 | 8212.68 | 8150 | 1012 | 91.55 | 92.46 | 92.64 | 93.04 | 0.00 | 0.00 | 7.54 | 0.90 |
| 2023 | 8364.58 | 8297 | 1012 | 93.49 | 94.26 | 94.35 | 94.71 | 0.03 | 0.03 | 5.71 | 0.77 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2014 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| C. Inspection, maintenance or repair combined with refuelling | | | | 566 | | |
| D. Inspection, maintenance or repair without refuelling | 463 | | | 51 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 135 |
| L. Human factor related | | | | | 3 | |
| Subtotal | 463 | | | 617 | 3 | 135 |
| Total | | 463 | | | 755 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2014 to 2023 |
|---------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 34. Miscellaneous Systems | | 81 |
| Total | | 81 |

Highlights (2023)

The unit was shutdown for 107 refuelling outage from September 13 to October 3.

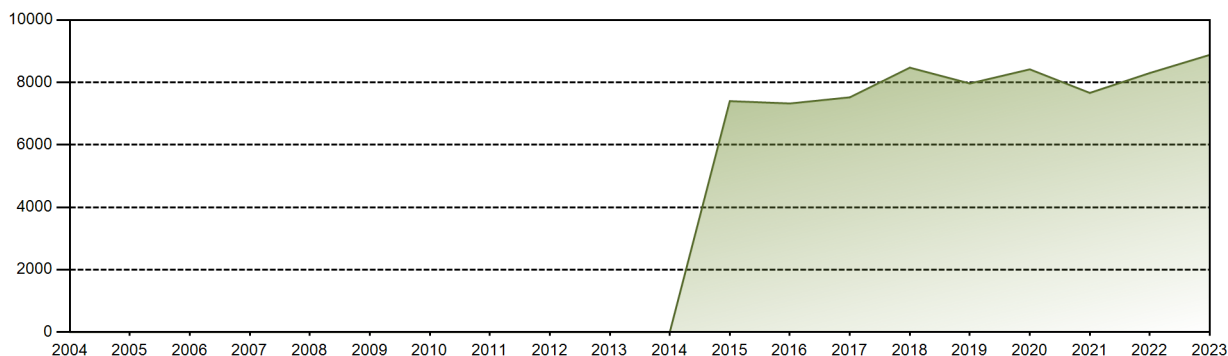
2023 Operating Experience

| CN-25 | | FANGJIASHAN-2 | | CHINA | | | | | | | | | |
|---|--|-----------------|--|--------|--------------------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : CNNO (CNNC Nuclear Operation Management Company Limited) | | | | | | | | | | | | |
| Owner | : QNPC (QINSHAN NUCLEAR POWER COMPANY) | | | | | | | | | | | | |
| Reactor Supplier | : NPIC (Nuclear Power Institute of China) | | | | | | | | | | | | |
| Turbine Supplier | : DEC (Dongfang Electric Corporation) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PWR / CPR-1000 | Construction Date | : | 2009-07-17 | | | | | | | | |
| Thermal power | : | 2905 MWth | Grid Date | : | 2015-01-12 | | | | | | | | |
| Gross electrical power | : | 1089 MWe | Commercial Date | : | 2015-02-12 | | | | | | | | |
| Reference unit power (net) | : | 1012 MWe | Age at end of year | : | 8 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | : | 15.5 | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Reactor outlet temperature [°C] | : | 327.6 | | | | | | | | |
| Fuel material | : | UO2 | Number of SG | : | 3 | | | | | | | | |
| Refuelling type | : | OFF-line | Containment type | : | Single | | | | | | | | |
| Moderator material | : | H2O | Containment design pressure [MPa] | : | 0.52 | | | | | | | | |
| Average fuel enrichment [% of U235] | : | 2.4 | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : | 12 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Part of the core refuelled [%] | : | 33.3 | Turbine speed [rpm] | : | 1500 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | 33000 | Number of LP cylinders per turbine | : | 2 | | | | | | | | |
| Active core diameter [m] | : | 3.04 | HP cylinder inlet steam pressure [MPa] | : | 6.43 | | | | | | | | |
| Active core height/length [m] | : | 3.66 | Output voltage [kV] | : | 24 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 157 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 18.6 | Number of main condensate pumps | : | 3 | | | | | | | | |
| Number of control rod assemblies | : | 61 | Number of FW pumps for full power operation | : | 2 | | | | | | | | |
| Number of external reactor coolant loops | : | 3 | Number of on-site safety related diesel generators | : | 3 | | | | | | | | |
| Coolant type | : | H2O | Non-electrical applications | | | | | | | | | | |
| | | | | : | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 8882.44 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 99.03 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 100 % | Planned Unavailability Factor (PUF) | : | 0 % | | | | | | | | |
| Load Factor (LF) | : | 100.2 % | Externally cause unavailability (XUF) | : | 0.97 % | | | | | | | | |
| Operating Factor (OF) | : | 100 % | Total off-line time | : | 0 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 734.52 | 692.78 | 767.78 | 742.06 | 762.44 | 727.92 | 739.30 | 737.98 | 715.84 | 756.26 | 739.68 | 765.88 | 8882.44 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.61 | 98.48 | 96.98 | 96.78 | 97.64 | 99.17 | 99.81 | 100.00 | 99.03 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| LF [%] | 97.56 | 101.87 | 101.97 | 101.84 | 101.26 | 99.90 | 98.19 | 98.01 | 98.24 | 100.44 | 101.52 | 101.72 | 100.20 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | 1.52 | 3.02 | 3.22 | 2.36 | 0.83 | 0.19 | 0.00 | 0.97 |

Historical Summary

| | | | |
|---|-----------------|---|----------|
| Lifetime energy generation | : 71805 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.24 % |
| Cumulative Energy Availability Factor (EAF) | : 92.28 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.23 % |
| Cumulative Unit Capability Factor (UCF) | : 92.87 % | Cumulative Planned Unavailability Factor (PUF) | : 6.9 % |
| Cumulative Load Factor (LF) | : 90.86 % | Cumulative Externally cause unavailability (XUF) | : 0.59 % |
| Cumulative Operating Factor (OF) | : 92.19 % | | |

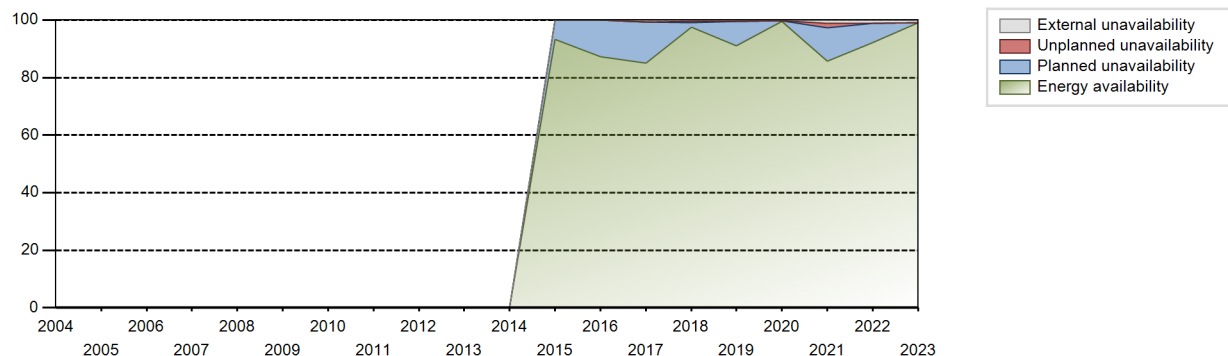
Electricity Production (net) [GWh]



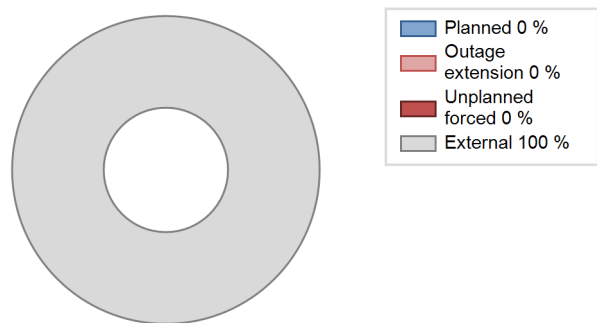
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2015 | 7400.55 | 7747 | 1012 | 93.22 | 93.22 | 89.98 | 92.90 | 0.02 | 0.02 | 6.76 | 0.00 |
| 2016 | 7324.84 | 7529 | 1012 | 87.29 | 87.29 | 82.40 | 85.71 | 0.00 | 0.00 | 12.71 | 0.00 |
| 2017 | 7521.75 | 7563 | 1012 | 84.95 | 85.72 | 84.85 | 86.34 | 0.00 | 0.00 | 14.28 | 0.77 |
| 2018 | 8472.42 | 8483 | 1012 | 97.62 | 98.08 | 95.57 | 96.84 | 0.48 | 0.47 | 1.45 | 0.46 |
| 2019 | 7965.85 | 7963 | 1012 | 90.97 | 91.45 | 89.86 | 90.90 | 0.00 | 0.00 | 8.55 | 0.48 |
| 2020 | 8418.73 | 8376 | 1012 | 99.62 | 99.93 | 94.71 | 95.36 | 0.04 | 0.04 | 0.03 | 0.31 |
| 2021 | 7663.47 | 7704 | 1012 | 85.78 | 86.96 | 86.45 | 87.95 | 1.70 | 1.50 | 11.54 | 1.18 |
| 2022 | 8301.13 | 8219 | 1012 | 92.15 | 93.24 | 93.64 | 93.82 | 0.00 | 0.00 | 6.76 | 1.09 |
| 2023 | 8882.44 | 8760 | 1012 | 99.03 | 100.00 | 100.20 | 100.00 | 0.00 | 0.00 | 0.00 | 0.97 |

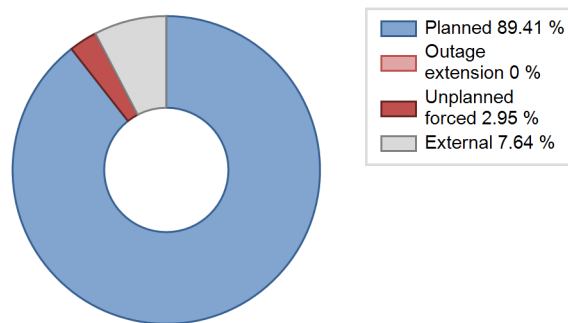
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2015 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 17 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 565 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 9 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 88 |
| Subtotal | | | | 574 | 17 | 88 |
| Total | | 0 | | | 679 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2015 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 31. Turbine and auxiliaries | | | | 3 |
| 32. Feedwater and Main Steam System | | | | 0 |
| 34. Miscellaneous Systems | | | | 42 |
| 41. Main Generator Systems | | | | 13 |
| Total | | | | 58 |

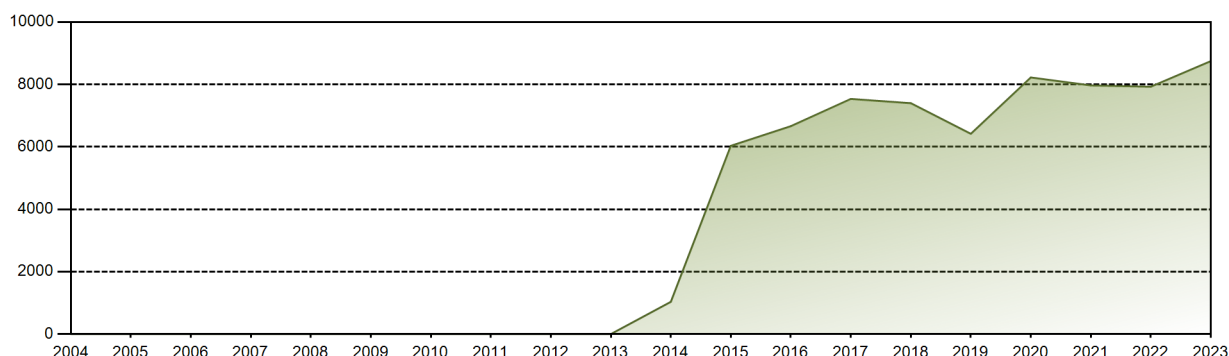
2023 Operating Experience

| CN-20 | | FUQING-1 | | CHINA | | | | | | | | | |
|---|--|-----------------|--|--------|--------------------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD) | | | | | | | | | | | | |
| Owner | : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD) | | | | | | | | | | | | |
| Reactor Supplier | : NPIC (Nuclear Power Institute of China) | | | | | | | | | | | | |
| Turbine Supplier | : DEC (Dongfang Electric Corporation) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PWR / CNP-1000 | Construction Date | : | 2008-11-21 | | | | | | | | |
| Thermal power | : | 2905 MWth | Grid Date | : | 2014-08-20 | | | | | | | | |
| Gross electrical power | : | 1089 MWe | Commercial Date | : | 2014-11-22 | | | | | | | | |
| Reference unit power (net) | : | 1000 MWe | Age at end of year | : | 9 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | : | 15.5 | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Reactor outlet temperature [°C] | : | 327.6 | | | | | | | | |
| Fuel material | : | UO2 | Number of SG | : | 3 | | | | | | | | |
| Refuelling type | : | OFF-line | Containment type | : | Single | | | | | | | | |
| Moderator material | : | H2O | Containment design pressure [MPa] | : | 0.52 | | | | | | | | |
| Average fuel enrichment [% of U235] | : | 2.4 | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : | 12 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Part of the core refuelled [%] | : | 33 | Turbine speed [rpm] | : | 1500 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | 33000 | Number of LP cylinders per turbine | : | 2 | | | | | | | | |
| Active core diameter [m] | : | 3.04 | HP cylinder inlet steam pressure [MPa] | : | 6.43 | | | | | | | | |
| Active core height/length [m] | : | 3.66 | Output voltage [kV] | : | 24 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 157 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 18.6 | Number of main condensate pumps | : | 3 | | | | | | | | |
| Number of control rod assemblies | : | 61 | Number of FW pumps for full power operation | : | 2 | | | | | | | | |
| Number of external reactor coolant loops | : | 3 | Number of on-site safety related diesel generators | : | 4 | | | | | | | | |
| Coolant type | : | H2O | Non-electrical applications | | | | | | | | | | |
| | | | | : | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 8746.94 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 99.59 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 100 % | Planned Unavailability Factor (PUF) | : | 0 % | | | | | | | | |
| Load Factor (LF) | : | 99.85 % | Externally cause unavailability (XUF) | : | 0.41 % | | | | | | | | |
| Operating Factor (OF) | : | 100 % | Total off-line time | : | 0 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 748.45 | 675.85 | 748.24 | 723.87 | 744.43 | 712.07 | 733.86 | 733.94 | 713.39 | 742.24 | 722.39 | 748.21 | 8746.94 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.90 | 98.64 | 98.65 | 99.08 | 99.78 | 100.00 | 100.00 | 99.59 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| LF [%] | 100.60 | 100.57 | 100.57 | 100.54 | 100.06 | 98.90 | 98.64 | 98.65 | 99.08 | 99.76 | 100.33 | 100.57 | 99.85 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.10 | 1.36 | 1.35 | 0.92 | 0.22 | 0.00 | 0.00 | 0.41 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 67943.45 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.2 % |
| Cumulative Energy Availability Factor (EAF) | : 91.08 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.44 % |
| Cumulative Unit Capability Factor (UCF) | : 91.38 % | Cumulative Planned Unavailability Factor (PUF) | : 8.19 % |
| Cumulative Load Factor (LF) | : 85.04 % | Cumulative Externally cause unavailability (XUF) | : 0.29 % |
| Cumulative Operating Factor (OF) | : 89.29 % | | |

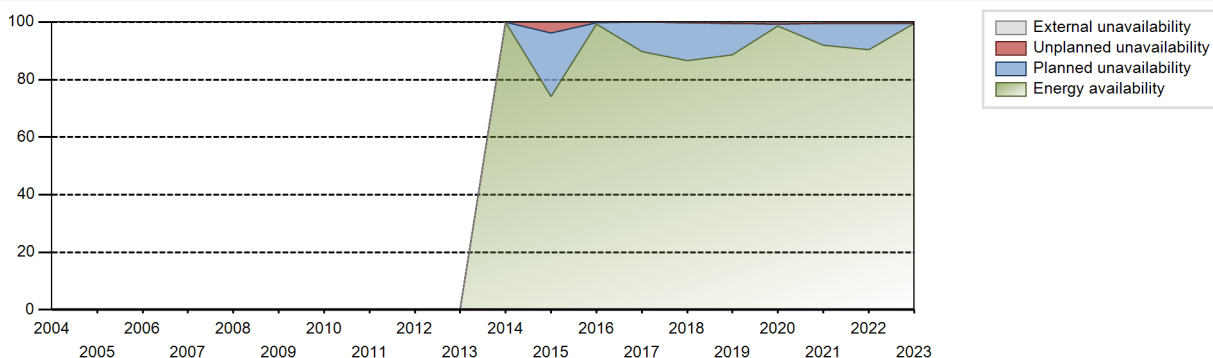
Electricity Production (net) [GWh]



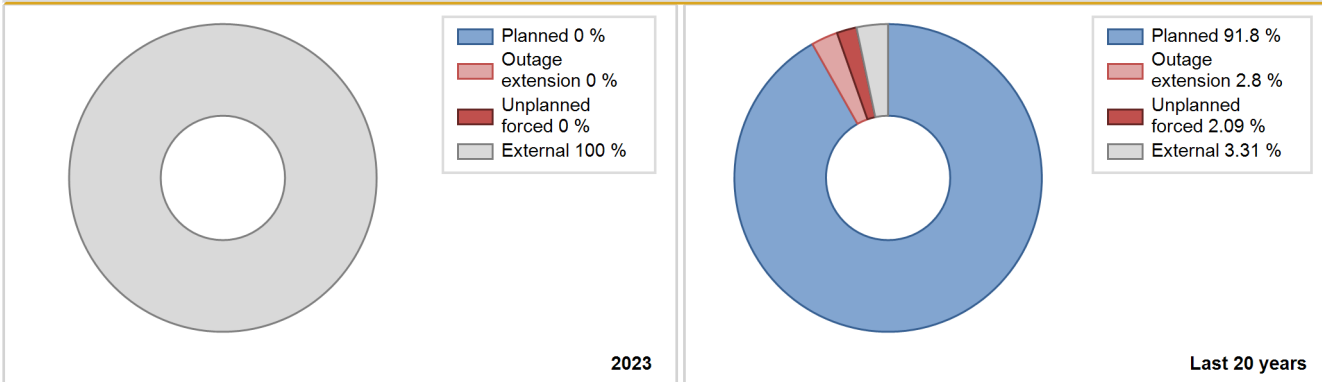
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2014 | 1033.07 | 949 | 1000 | 100.00 | 100.00 | 109.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 6032.38 | 6514 | 1000 | 74.11 | 74.11 | 68.86 | 74.36 | 1.98 | 3.77 | 22.12 | 0.00 |
| 2016 | 6662.04 | 7511 | 1000 | 99.31 | 99.31 | 75.84 | 85.51 | 0.20 | 0.20 | 0.50 | 0.00 |
| 2017 | 7535.41 | 7930 | 1000 | 89.81 | 89.81 | 86.02 | 90.53 | 0.00 | 0.00 | 10.19 | 0.00 |
| 2018 | 7398.98 | 7702 | 1000 | 86.59 | 86.78 | 84.46 | 87.92 | 0.00 | 0.00 | 13.22 | 0.19 |
| 2019 | 6417.64 | 7072 | 1000 | 88.64 | 89.03 | 73.26 | 80.73 | 0.00 | 0.00 | 10.97 | 0.39 |
| 2020 | 8222.85 | 8706 | 1000 | 98.58 | 99.30 | 93.61 | 99.11 | 0.01 | 0.01 | 0.70 | 0.72 |
| 2021 | 7967.88 | 8166 | 1000 | 91.98 | 92.54 | 90.96 | 93.22 | 0.00 | 0.00 | 7.46 | 0.56 |
| 2022 | 7927.14 | 8001 | 1000 | 90.32 | 90.73 | 90.49 | 91.34 | 0.00 | 0.00 | 9.27 | 0.40 |
| 2023 | 8746.94 | 8760 | 1000 | 99.59 | 100.00 | 99.85 | 100.00 | 0.00 | 0.00 | 0.00 | 0.41 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2014 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 36 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 672 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 238 |
| Subtotal | | | | 672 | 36 | 238 |
| Total | | 0 | | | 946 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2014 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 7 |
| 16. Steam generation systems | | | | 7 |
| 34. Miscellaneous Systems | | | | 9 |
| 42. Electrical Power Supply Systems | | | | 22 |
| Total | | | | 45 |

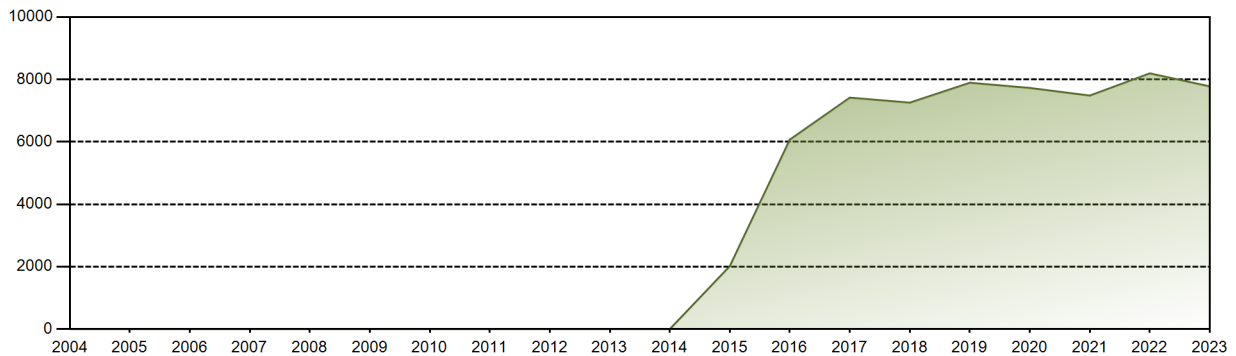
2023 Operating Experience

| CN-21 | | FUQING-2 | | CHINA | | | | | | | | | |
|---|--|-----------------|--|--------|--------------------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD) | | | | | | | | | | | | |
| Owner | : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD) | | | | | | | | | | | | |
| Reactor Supplier | : NPIC (Nuclear Power Institute of China) | | | | | | | | | | | | |
| Turbine Supplier | : DEC (Dongfang Electric Corporation) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PWR / CNP-1000 | Construction Date | : | 2009-06-17 | | | | | | | | |
| Thermal power | : | 2905 MWth | Grid Date | : | 2015-08-06 | | | | | | | | |
| Gross electrical power | : | 1089 MWe | Commercial Date | : | 2015-10-16 | | | | | | | | |
| Reference unit power (net) | : | 1000 MWe | Age at end of year | : | 8 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | | | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Reactor outlet temperature [°C] | : | 327.6 | | | | | | | | |
| Fuel material | : | UO2 | Number of SG | : | 3 | | | | | | | | |
| Refuelling type | : | OFF-line | Containment type | : | Single | | | | | | | | |
| Moderator material | : | H2O | Containment design pressure [MPa] | : | 0.52 | | | | | | | | |
| Average fuel enrichment [% of U235] | : | 2.4 | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : | 12 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Part of the core refuelled [%] | : | 33 | Turbine speed [rpm] | : | 1500 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | 33000 | Number of LP cylinders per turbine | : | 2 | | | | | | | | |
| Active core diameter [m] | : | 3.04 | HP cylinder inlet steam pressure [MPa] | : | 6.43 | | | | | | | | |
| Active core height/length [m] | : | 3.66 | Output voltage [kV] | : | 24 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 157 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 18.6 | Number of main condensate pumps | : | 3 | | | | | | | | |
| Number of control rod assemblies | : | 61 | Number of FW pumps for full power operation | : | 2 | | | | | | | | |
| Number of external reactor coolant loops | : | 3 | Number of on-site safety related diesel generators | : | 4 | | | | | | | | |
| Coolant type | : | H2O | Non-electrical applications | | | | | | | | | | |
| | | | | : | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 7775.95 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 92.19 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 92.93 % | Planned Unavailability Factor (PUF) | : | 7.07 % | | | | | | | | |
| Load Factor (LF) | : | 88.77 % | Externally cause unavailability (XUF) | : | 0.73 % | | | | | | | | |
| Operating Factor (OF) | : | 90.1 % | Total off-line time | : | 867 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 438.83 | 665.34 | 747.53 | 723.53 | 476.80 | 357.11 | 728.22 | 735.91 | 688.69 | 742.81 | 723.08 | 748.10 | 7775.95 |
| EAF [%] | 100.00 | 98.60 | 100.00 | 100.00 | 63.93 | 49.60 | 97.88 | 98.91 | 97.62 | 99.72 | 100.00 | 100.00 | 92.19 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 64.90 | 50.20 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.93 |
| LF [%] | 58.98 | 99.01 | 100.47 | 100.49 | 64.09 | 49.60 | 97.88 | 98.91 | 95.65 | 99.84 | 100.43 | 100.55 | 88.77 |
| OF [%] | 66.94 | 100.00 | 100.00 | 100.00 | 60.48 | 54.58 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.10 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 35.10 | 49.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.07 |
| XUF [%] | 0.00 | 1.40 | 0.00 | 0.00 | 0.97 | 0.60 | 2.12 | 1.09 | 2.38 | 0.28 | 0.00 | 0.00 | 0.73 |

Historical Summary

| | | | |
|---|-------------------|---|----------|
| Lifetime energy generation | : 61825.3 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.84 % |
| Cumulative Energy Availability Factor (EAF) | : 90.48 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.77 % |
| Cumulative Unit Capability Factor (UCF) | : 90.87 % | Cumulative Planned Unavailability Factor (PUF) | : 8.35 % |
| Cumulative Load Factor (LF) | : 85.35 % | Cumulative Externally cause unavailability (XUF) | : 0.4 % |
| Cumulative Operating Factor (OF) | : 90.27 % | | |

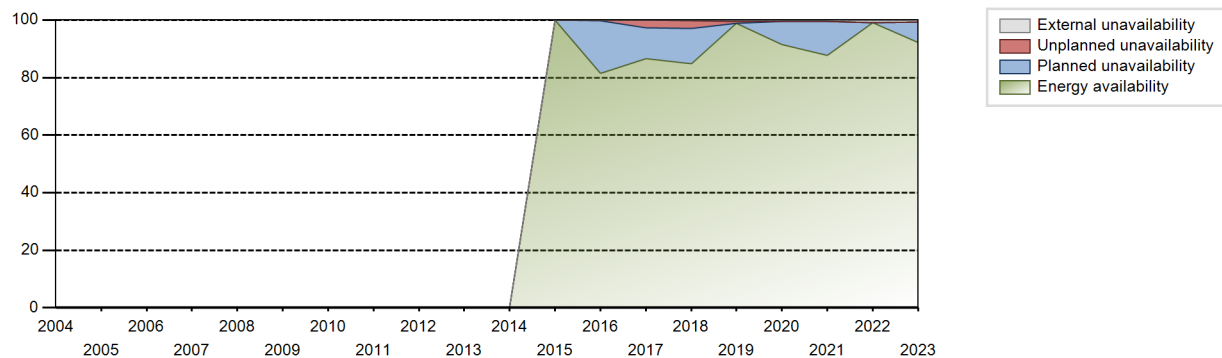
Electricity Production (net) [GWh]



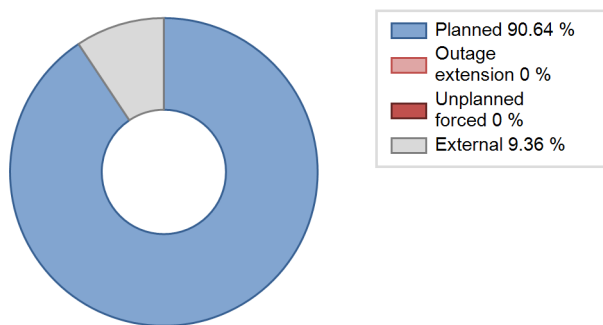
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2015 | 2017.22 | 3487 | 1000 | 100.00 | 100.00 | 87.75 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 6070.84 | 6807 | 1000 | 81.46 | 81.46 | 69.11 | 77.49 | 0.34 | 0.27 | 18.26 | 0.00 |
| 2017 | 7416.83 | 7659 | 1000 | 86.58 | 86.58 | 84.67 | 87.43 | 3.03 | 2.71 | 10.71 | 0.00 |
| 2018 | 7255.87 | 7587 | 1000 | 84.82 | 84.97 | 82.83 | 86.61 | 3.06 | 2.68 | 12.34 | 0.16 |
| 2019 | 7893.35 | 8685 | 1000 | 98.89 | 99.35 | 90.11 | 99.14 | 0.65 | 0.65 | 0.00 | 0.46 |
| 2020 | 7726.34 | 8137 | 1000 | 91.54 | 92.02 | 87.96 | 92.63 | 0.00 | 0.00 | 7.98 | 0.49 |
| 2021 | 7482.49 | 7781 | 1000 | 87.73 | 88.17 | 85.42 | 88.82 | 0.00 | 0.00 | 11.83 | 0.43 |
| 2022 | 8194.52 | 8610 | 1000 | 99.05 | 100.00 | 93.54 | 98.29 | 0.00 | 0.00 | 0.00 | 0.95 |
| 2023 | 7775.95 | 7893 | 1000 | 92.19 | 92.93 | 88.77 | 90.10 | 0.00 | 0.00 | 7.07 | 0.73 |

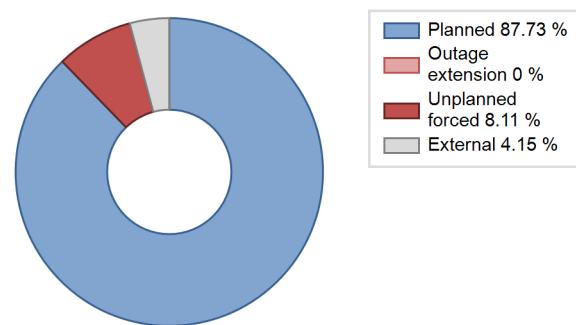
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2015 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 59 | |
| C. Inspection, maintenance or repair combined with refuelling | 583 | | | 681 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 298 | | | 117 |
| Subtotal | 583 | | 298 | 681 | 59 | 117 |
| Total | | 881 | | | 857 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2015 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 32. Feedwater and Main Steam System | | 1 |
| 33. Circulating Water System | | 46 |
| 34. Miscellaneous Systems | | 18 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 7 |
| Total | | 74 |

2023 Operating Experience

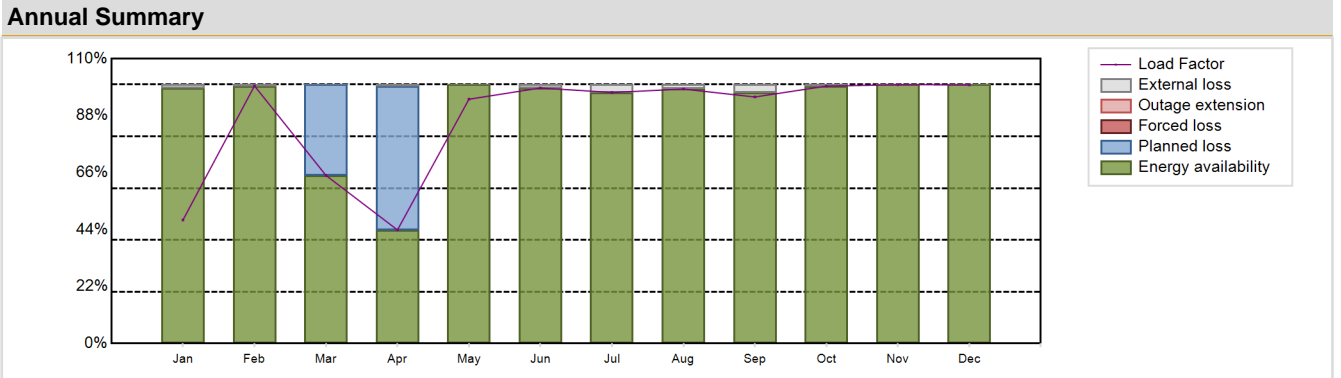
| | | |
|--------------|-----------------|--------------|
| CN-42 | FUQING-3 | CHINA |
|--------------|-----------------|--------------|

Status at end of year : **Operational**
 Operator : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD)
 Owner : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD)
 Reactor Supplier : NPIC (Nuclear Power Institute of China)
 Turbine Supplier : DEC (Dongfang Electric Corporation)

| Reactor Unit Details | Key Dates |
|---|--------------------------------|
| Reactor type and model : PWR / CNP-1000 | Construction Date : 2010-12-31 |
| Thermal power : 2905 MWth | Grid Date : 2016-09-07 |
| Gross electrical power : 1089 MWe | Commercial Date : 2016-10-24 |
| Reference unit power (net) : 1000 MWe | Age at end of year : 7 years |

| Design Characteristics | | |
|--|--|---|
| Primary Systems | | Operating coolant pressure [MPa] : 15.5 |
| Reactor vessel centreline orientation : Vertical | | Reactor outlet temperature [°C] : 327.6 |
| Fuel material : UO2 | | Number of SG : 3 |
| Refuelling type : OFF-line | | Containment type : Single |
| Moderator material : H2O | | Containment design pressure [MPa] : 0.52 |
| Average fuel enrichment [% of U235] : 2.4 | | Secondary systems |
| Refuelling frequency [month] : 12 | | Number of turbine-generators per unit/reactor : 1 |
| Part of the core refuelled [%] : 33 | | Turbine speed [rpm] : 1500 |
| Average discharge burnup [MWd/t] : 33000 | | Number of LP cylinders per turbine : 2 |
| Active core diameter [m] : 3.04 | | HP cylinder inlet steam pressure [MPa] : 6.43 |
| Active core height/length [m] : 3.66 | | Output voltage [kV] : 24 |
| Number of fissile fuel assemblies/bundles : 157 | | Primary means of condenser cooling : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] : 18.6 | | Number of main condensate pumps : 3 |
| Number of control rod assemblies : 61 | | Number of FW pumps for full power operation : 2 |
| Number of external reactor coolant loops : 3 | | Number of on-site safety related diesel generators : 4 |
| Coolant type : H2O | | Non-electrical applications : none |

| Annual Production Results (2023) | | |
|--|--|--|
| Net Energy Production : 7576.01 GW(e).h | Forced Loss Rate (FLR) : 0 % | |
| Energy Availability Factor (EAF) : 91.42 % | Unplanned Capability Loss Factor (UCL) : 0 % | |
| Unit Capability Factor (UCF) : 92.46 % | Planned Unavailability Factor (PUF) : 7.54 % | |
| Load Factor (LF) : 86.48 % | Externally cause unavailability (XUF) : 1.04 % | |
| Operating Factor (OF) : 88.95 % | Total off-line time : 968 hours | |

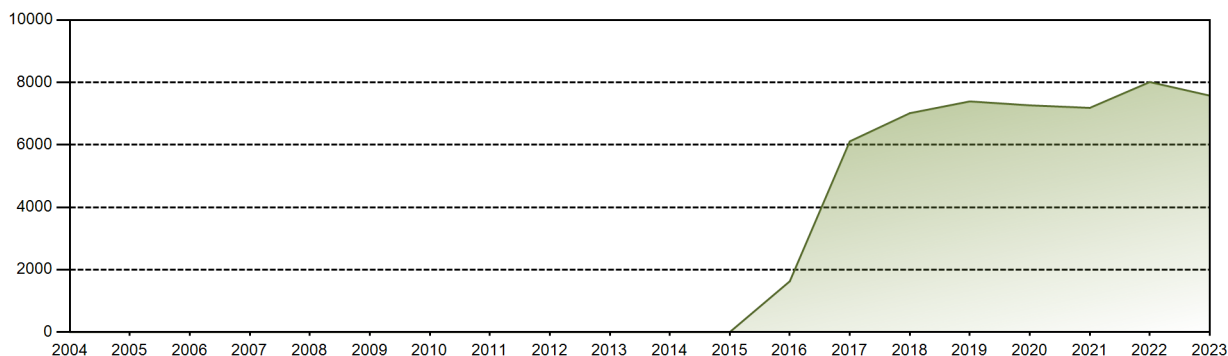


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 355.08 | 668.70 | 483.03 | 315.86 | 701.97 | 710.63 | 721.34 | 731.16 | 685.54 | 739.70 | 719.70 | 743.30 | 7576.01 |
| EAF [%] | 98.66 | 99.36 | 64.89 | 43.82 | 100.00 | 98.68 | 96.93 | 98.26 | 96.89 | 99.48 | 100.00 | 100.00 | 91.42 |
| UCF [%] | 100.00 | 100.00 | 64.89 | 44.56 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.46 |
| LF [%] | 47.73 | 99.51 | 64.92 | 43.87 | 94.35 | 98.70 | 96.95 | 98.27 | 95.21 | 99.42 | 99.96 | 99.91 | 86.48 |
| OF [%] | 54.03 | 100.00 | 65.59 | 48.61 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.95 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 35.11 | 55.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.54 |
| XUF [%] | 1.34 | 0.64 | 0.00 | 0.73 | 0.00 | 1.32 | 3.07 | 1.74 | 3.11 | 0.52 | 0.00 | 0.00 | 1.04 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 50714.92 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.11 % |
| Cumulative Energy Availability Factor (EAF) | : 91.09 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.1 % |
| Cumulative Unit Capability Factor (UCF) | : 91.57 % | Cumulative Planned Unavailability Factor (PUF) | : 8.33 % |
| Cumulative Load Factor (LF) | : 82.79 % | Cumulative Externally cause unavailability (XUF) | : 0.48 % |
| Cumulative Operating Factor (OF) | : 87.95 % | | |

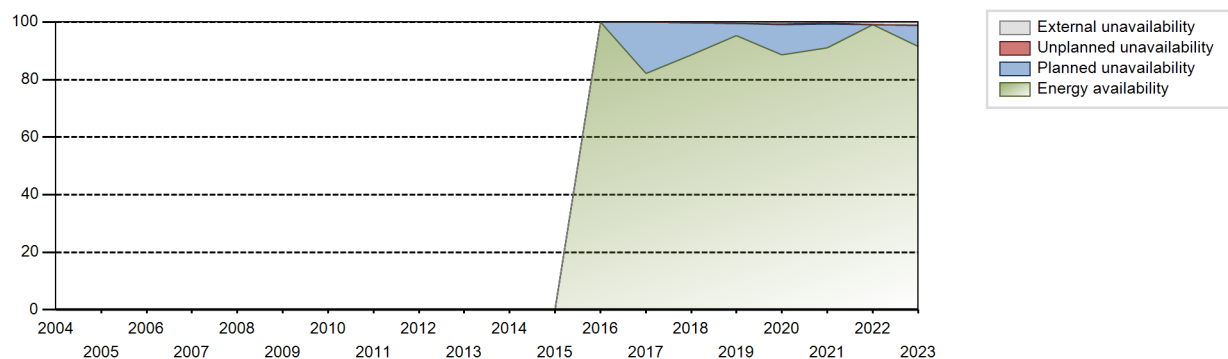
Electricity Production (net) [GWh]



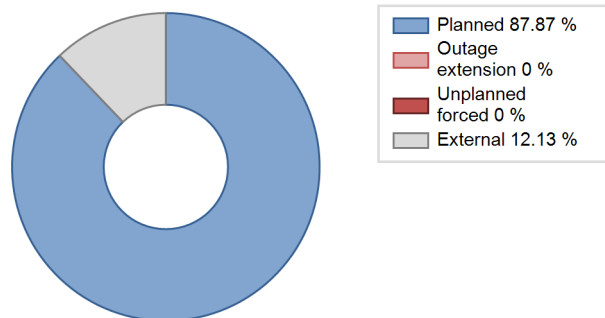
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|--------|--------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 1628.31 | 1648 | 1000 | 100.00 | 100.00 | 98.60 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 6110.93 | 6592 | 1000 | 82.12 | 82.12 | 69.76 | 75.25 | 0.00 | 0.00 | 17.88 | 0.00 |
| 2018 | 7013.40 | 7357 | 1000 | 88.67 | 88.88 | 80.06 | 83.98 | 0.00 | 0.00 | 11.12 | 0.21 |
| 2019 | 7390.94 | 8107 | 1000 | 95.23 | 95.78 | 84.37 | 92.55 | 0.00 | 0.00 | 4.22 | 0.55 |
| 2020 | 7265.42 | 7724 | 1000 | 88.61 | 89.24 | 82.71 | 87.93 | 0.22 | 0.20 | 10.56 | 0.63 |
| 2021 | 7184.22 | 7835 | 1000 | 90.97 | 91.13 | 82.01 | 89.44 | 0.55 | 0.51 | 8.36 | 0.17 |
| 2022 | 8011.27 | 8369 | 1000 | 99.16 | 100.00 | 91.45 | 95.54 | 0.00 | 0.00 | 0.00 | 0.84 |
| 2023 | 7576.01 | 7792 | 1000 | 91.42 | 92.46 | 86.48 | 88.95 | 0.00 | 0.00 | 7.54 | 1.04 |

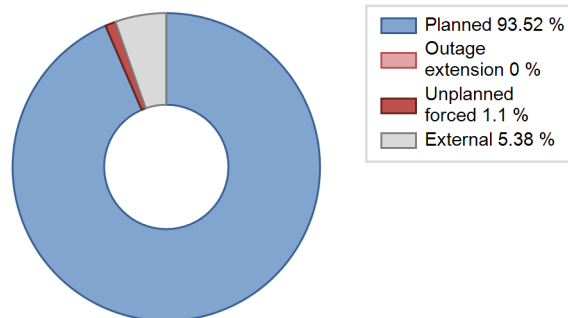
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 6 | |
| C. Inspection, maintenance or repair combined with refuelling | 626 | | | 683 | | |
| H. Nuclear regulatory requirements | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 351 | | | 367 |
| Subtotal | 626 | | 351 | 683 | 6 | 368 |
| Total | 977 | | | 1057 | | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2016 to 2023 |
|---------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 34. Miscellaneous Systems | | 115 |
| Total | | 115 |

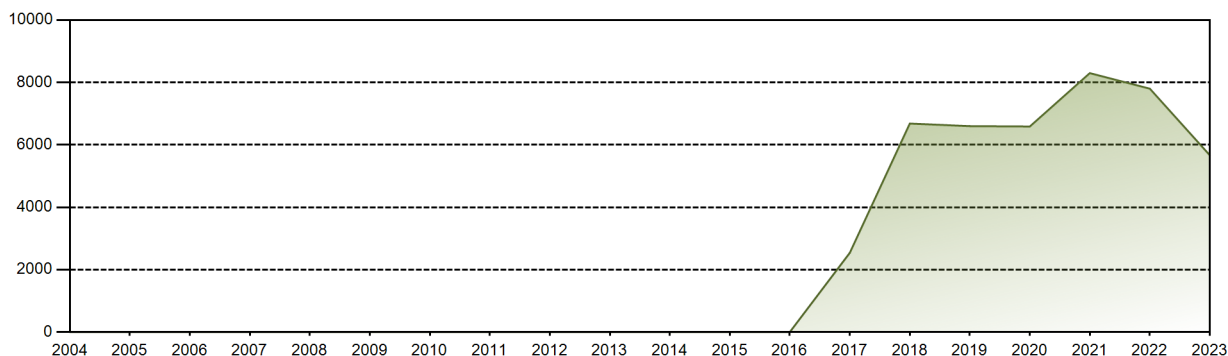
2023 Operating Experience

| CN-43 | | FUQING-4 | | CHINA | | | | | | | | | |
|---|--|-----------------|--|--------|--------------------|--------|--------|--------|--------|-------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD) | | | | | | | | | | | | |
| Owner | : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD) | | | | | | | | | | | | |
| Reactor Supplier | : NPIC (Nuclear Power Institute of China) | | | | | | | | | | | | |
| Turbine Supplier | : DEC (Dongfang Electric Corporation) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PWR / CNP-1000 | Construction Date | : | 2012-11-17 | | | | | | | | |
| Thermal power | : | 2905 MWth | Grid Date | : | 2017-07-29 | | | | | | | | |
| Gross electrical power | : | 1089 MWe | Commercial Date | : | 2017-09-17 | | | | | | | | |
| Reference unit power (net) | : | 1000 MWe | Age at end of year | : | 6 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | | | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Reactor outlet temperature [°C] | : | 327.6 | | | | | | | | |
| Fuel material | : | UO2 | Number of SG | : | 3 | | | | | | | | |
| Refuelling type | : | OFF-line | Containment type | : | Single | | | | | | | | |
| Moderator material | : | H2O | Containment design pressure [MPa] | : | 0.52 | | | | | | | | |
| Average fuel enrichment [% of U235] | : | 2.4 | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : | 12 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Part of the core refuelled [%] | : | 33 | Turbine speed [rpm] | : | 1500 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | 33000 | Number of LP cylinders per turbine | : | 2 | | | | | | | | |
| Active core diameter [m] | : | 3.04 | HP cylinder inlet steam pressure [MPa] | : | 6.43 | | | | | | | | |
| Active core height/length [m] | : | 3.66 | Output voltage [kV] | : | 24 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 157 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 18.6 | Number of main condensate pumps | : | 3 | | | | | | | | |
| Number of control rod assemblies | : | 61 | Number of FW pumps for full power operation | : | 2 | | | | | | | | |
| Number of external reactor coolant loops | : | 3 | Number of on-site safety related diesel generators | : | 4 | | | | | | | | |
| Coolant type | : | H2O | Non-electrical applications | | | | | | | | | | |
| | | | | : | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 5665.02 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 66.78 % | Unplanned Capability Loss Factor (UCL) | : | 0.05 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 67.26 % | Planned Unavailability Factor (PUF) | : | 32.68 % | | | | | | | | |
| Load Factor (LF) | : | 64.67 % | Externally cause unavailability (XUF) | : | 0.48 % | | | | | | | | |
| Operating Factor (OF) | : | 65.4 % | Total off-line time | : | 3031 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 745.11 | 674.02 | 745.86 | 720.73 | 742.65 | 710.37 | 729.65 | 378.79 | 217.84 | 0.00 | 0.00 | 0.00 | 5665.02 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.68 | 98.06 | 50.92 | 43.25 | 12.90 | 0.00 | 0.00 | 66.78 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 51.99 | 44.64 | 12.90 | 0.00 | 0.00 | 67.26 |
| LF [%] | 100.15 | 100.30 | 100.25 | 100.10 | 99.82 | 98.66 | 98.07 | 50.91 | 30.26 | 0.00 | 0.00 | 0.00 | 64.67 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 52.69 | 34.58 | 0.00 | 0.00 | 0.00 | 65.40 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.64 | 0.00 | 0.00 | 0.00 | 0.05 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 48.01 | 54.72 | 87.10 | 100.00 | 100.00 | 32.68 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.32 | 1.94 | 1.07 | 1.39 | 0.00 | 0.00 | 0.00 | 0.48 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 44172.36 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.14 % |
| Cumulative Energy Availability Factor (EAF) | : 86.62 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.13 % |
| Cumulative Unit Capability Factor (UCF) | : 87.03 % | Cumulative Planned Unavailability Factor (PUF) | : 12.84 % |
| Cumulative Load Factor (LF) | : 80.01 % | Cumulative Externally cause unavailability (XUF) | : 0.41 % |
| Cumulative Operating Factor (OF) | : 82.69 % | | |

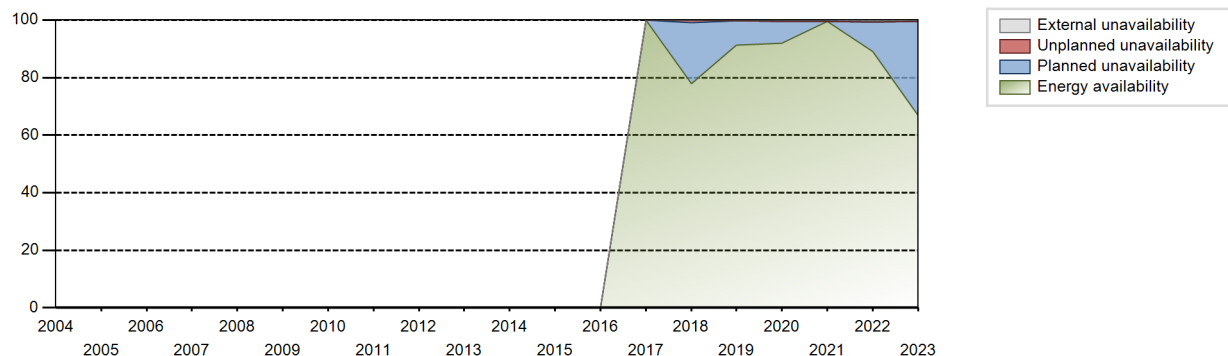
Electricity Production (net) [GWh]



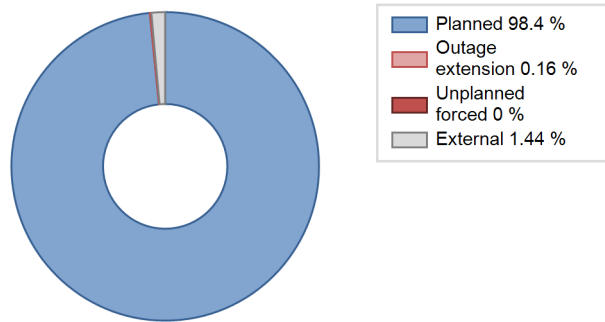
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|--------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2017 | 2540.07 | 2544 | 1000 | 100.00 | 100.00 | 100.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 6682.09 | 6890 | 1000 | 77.79 | 77.91 | 76.28 | 78.65 | 0.98 | 0.77 | 21.32 | 0.12 |
| 2019 | 6599.78 | 7215 | 1000 | 91.31 | 91.68 | 75.34 | 82.36 | 0.00 | 0.00 | 8.32 | 0.36 |
| 2020 | 6587.82 | 6953 | 1000 | 92.01 | 92.47 | 75.00 | 79.16 | 0.00 | 0.00 | 7.53 | 0.45 |
| 2021 | 8297.78 | 8407 | 1000 | 99.44 | 100.00 | 94.72 | 95.97 | 0.00 | 0.00 | 0.00 | 0.56 |
| 2022 | 7799.96 | 7904 | 1000 | 88.99 | 89.60 | 89.04 | 90.23 | 0.00 | 0.00 | 10.40 | 0.61 |
| 2023 | 5665.02 | 5729 | 1000 | 66.78 | 67.26 | 64.67 | 65.40 | 0.00 | 0.05 | 32.68 | 0.48 |

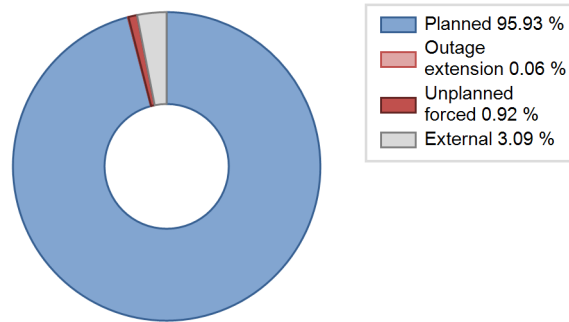
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2017 to 2023 | | |
|--|-------------|-----------|------------|-------------------------------------|-----------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 9 | |
| C. Inspection, maintenance or repair combined with refuelling | 725 | | | 778 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 194 | | | 443 |
| Z. Other | 2112 | | | 352 | | |
| Subtotal | 2837 | | 194 | 1130 | 9 | 443 |
| Total | 3031 | | | 1582 | | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2017 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 32. Feedwater and Main Steam System | | 9 |
| 34. Miscellaneous Systems | | 265 |
| Total | | 274 |

2023 Operating Experience

CN-51

FUQING-5

CHINA

Status at end of year : **Operational**
 Operator : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD)
 Owner : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD)
 Reactor Supplier : NPIC (Nuclear Power Institute of China)
 Turbine Supplier : DEC (Dongfang Electric Corporation)

Reactor Unit Details

Reactor type and model : PWR / HPR1000
 Thermal power : 3050 MWth
 Gross electrical power : 1161 MWe
 Reference unit power (net) : 1075 MWe

Key Dates

Construction Date : 2015-05-07
 Grid Date : 2020-11-27
 Commercial Date : 2021-01-30
 Age at end of year : 3 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.45
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 40
 Average discharge burnup [MWd/t] : 47000
 Active core diameter [m] : 3.328
 Active core height/length [m] : 3.567
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 18.12
 Number of control rod assemblies : 69
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.9
 Number of SG : 3
 Containment type : Double
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : NA
 Output voltage [kV] : 27
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

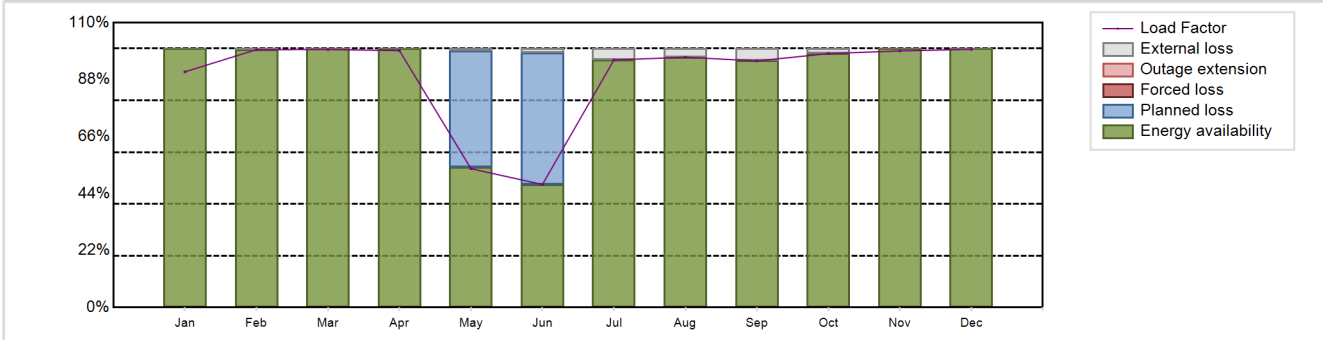
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8433.14 GW(e).h
 Energy Availability Factor (EAF) : 90.56 %
 Unit Capability Factor (UCF) : 92 %
 Load Factor (LF) : 89.55 %
 Operating Factor (OF) : 92.4 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 8 %
 Externally cause unavailability (XUF) : 1.45 %
 Total off-line time : 666 hours

Annual Summary

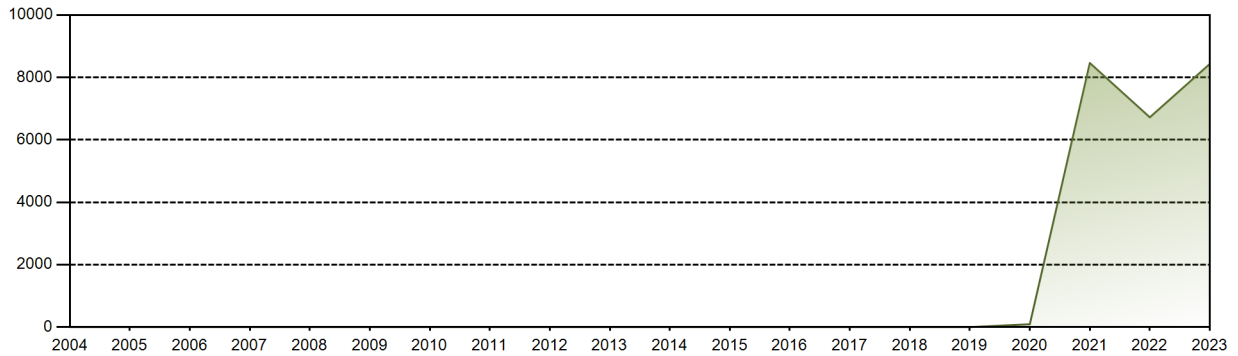


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 728.19 | 719.45 | 797.04 | 767.94 | 428.87 | 367.82 | 764.63 | 773.23 | 737.09 | 784.33 | 766.93 | 797.62 | 8433.14 |
| EAF [%] | 100.00 | 99.59 | 100.00 | 100.00 | 54.17 | 47.54 | 95.57 | 96.68 | 95.29 | 98.08 | 100.00 | 100.00 | 90.56 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 55.02 | 49.15 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.00 |
| LF [%] | 91.05 | 99.59 | 99.66 | 99.22 | 53.62 | 47.52 | 95.60 | 96.68 | 95.23 | 98.07 | 99.09 | 99.73 | 89.55 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 55.91 | 53.06 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.40 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 44.98 | 50.85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.00 |
| XUF [%] | 0.00 | 0.41 | 0.00 | 0.00 | 0.85 | 1.62 | 4.43 | 3.32 | 4.71 | 1.92 | 0.00 | 0.00 | 1.45 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 23708.58 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.7 % |
| Cumulative Energy Availability Factor (EAF) | : 85.47 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.59 % |
| Cumulative Unit Capability Factor (UCF) | : 86.56 % | Cumulative Planned Unavailability Factor (PUF) | : 8.85 % |
| Cumulative Load Factor (LF) | : 83.13 % | Cumulative Externally cause unavailability (XUF) | : 1.09 % |
| Cumulative Operating Factor (OF) | : 85.2 % | | |

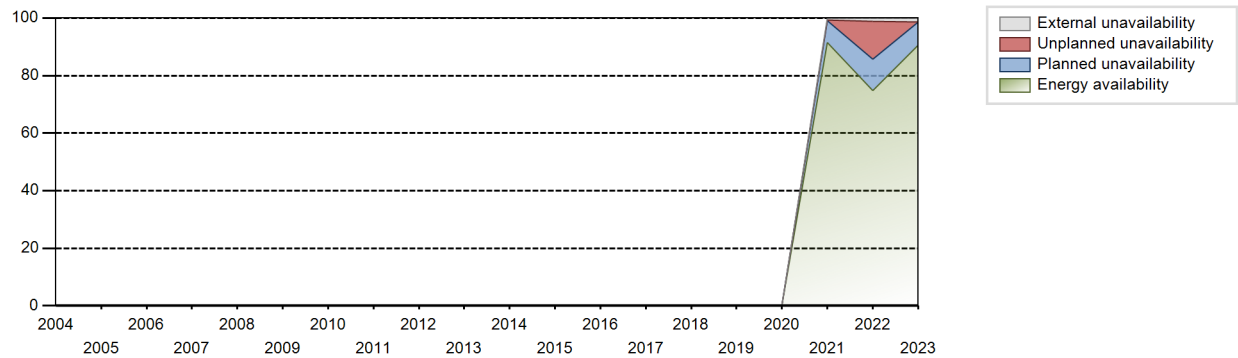
Electricity Production (net) [GWh]



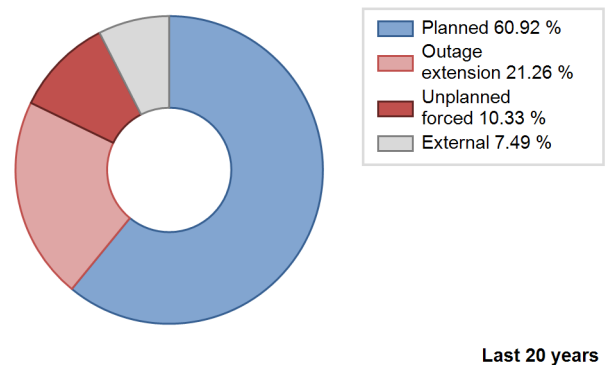
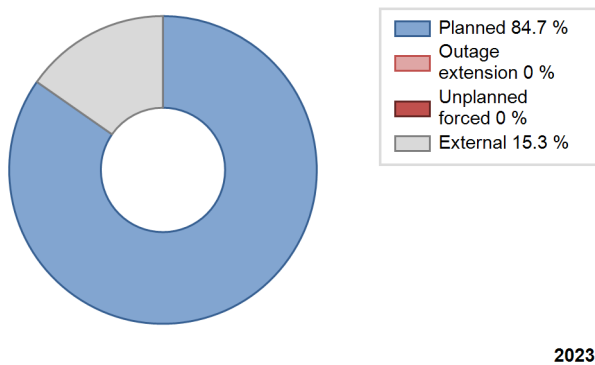
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|-------|-------|------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2021 | 8461.95 | 7965 | 1075 | 91.50 | 92.11 | 88.97 | 90.08 | 0.22 | 0.20 | 7.68 | 0.61 |
| 2022 | 6721.77 | 6441 | 1075 | 74.86 | 76.03 | 71.38 | 73.53 | 5.23 | 13.20 | 10.78 | 1.17 |
| 2023 | 8433.14 | 8094 | 1075 | 90.56 | 92.00 | 89.55 | 92.40 | 0.00 | 0.00 | 8.00 | 1.45 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2021 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 115 | |
| C. Inspection, maintenance or repair combined with refuelling | 666 | | | 763 | | |
| E. Testing of plant systems or components | | | | 181 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 131 |
| L. Human factor related | | | | | 11 | |
| Z. Other | | | | | 270 | |
| Subtotal | 666 | | | 944 | 396 | 131 |
| Total | | 666 | | | 1471 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2021 to 2023 | |
|---------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 34. Miscellaneous Systems | | | | 486 |
| Total | | | | 486 |

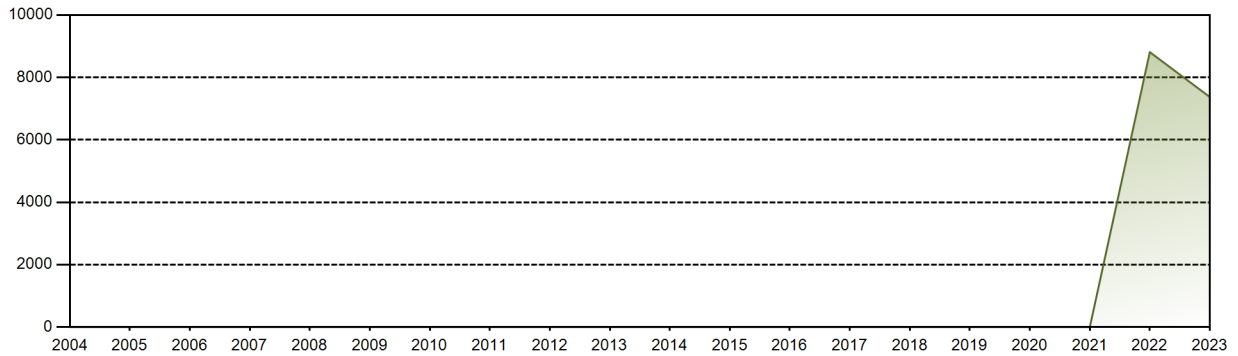
2023 Operating Experience

| CN-52 | | FUQING-6 | | CHINA | | | | | | | | | |
|---|--|-----------------|--|--------|--------------------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD) | | | | | | | | | | | | |
| Owner | : FQNP (CNNC Fujian Fuqing Nuclear Power Co., LTD) | | | | | | | | | | | | |
| Reactor Supplier | : NPIC (Nuclear Power Institute of China) | | | | | | | | | | | | |
| Turbine Supplier | : DEC (Dongfang Electric Corporation) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PWR / HPR1000 | Construction Date | : | 2015-12-22 | | | | | | | | |
| Thermal power | : | 3060 MWth | Grid Date | : | 2022-01-01 | | | | | | | | |
| Gross electrical power | : | 1150 MWe | Commercial Date | : | 2022-03-25 | | | | | | | | |
| Reference unit power (net) | : | 1075 MWe | Age at end of year | : | 1 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | | | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Reactor outlet temperature [°C] | : | 328.5 | | | | | | | | |
| Fuel material | : | UO2 | Number of SG | : | 3 | | | | | | | | |
| Refuelling type | : | OFF-line | Containment type | : | Single | | | | | | | | |
| Moderator material | : | H2O | Containment design pressure [MPa] | : | 0.52 | | | | | | | | |
| Average fuel enrichment [% of U235] | : | 2.4 | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : | 18 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Part of the core refuelled [%] | : | 33.3 | Turbine speed [rpm] | : | 1500 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | 46410 | Number of LP cylinders per turbine | : | 2 | | | | | | | | |
| Active core diameter [m] | : | 3.228 | HP cylinder inlet steam pressure [MPa] | : | 6.5 | | | | | | | | |
| Active core height/length [m] | : | 3.66 | Output voltage [kV] | : | 24 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 177 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 17.38 | Number of main condensate pumps | : | 3 | | | | | | | | |
| Number of control rod assemblies | : | 61 | Number of FW pumps for full power operation | : | 2 | | | | | | | | |
| Number of external reactor coolant loops | : | 3 | Number of on-site safety related diesel generators | : | 2 | | | | | | | | |
| Coolant type | : | H2O | Non-electrical applications | | | | | | | | | | |
| | | | | : | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 7371.42 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 79.29 % | Unplanned Capability Loss Factor (UCL) | : | 1.02 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 81 % | Planned Unavailability Factor (PUF) | : | 17.97 % | | | | | | | | |
| Load Factor (LF) | : | 78.28 % | Externally cause unavailability (XUF) | : | 1.72 % | | | | | | | | |
| Operating Factor (OF) | : | 81.16 % | Total off-line time | : | 1650 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 489.28 | 0.00 | 10.02 | 758.32 | 756.98 | 745.78 | 763.85 | 771.52 | 735.45 | 781.79 | 763.75 | 794.67 | 7371.42 |
| EAF [%] | 64.52 | 0.00 | 1.74 | 98.48 | 100.00 | 96.68 | 95.46 | 96.46 | 95.02 | 97.75 | 100.00 | 100.00 | 79.29 |
| UCF [%] | 64.52 | 0.00 | 2.99 | 99.12 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 81.00 |
| LF [%] | 61.18 | 0.00 | 1.25 | 97.97 | 94.65 | 96.35 | 95.51 | 96.46 | 95.02 | 97.75 | 98.68 | 99.36 | 78.28 |
| OF [%] | 64.52 | 0.00 | 4.03 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 81.16 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 11.22 | 0.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.02 |
| PUF [%] | 35.48 | 100.00 | 85.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 17.97 |
| XUF [%] | 0.00 | 0.00 | 1.25 | 0.64 | 0.00 | 3.32 | 4.54 | 3.54 | 4.98 | 2.25 | 0.00 | 0.00 | 1.72 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 14027.91 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0 % |
| Cumulative Energy Availability Factor (EAF) | : 86.11 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.58 % |
| Cumulative Unit Capability Factor (UCF) | : 87.77 % | Cumulative Planned Unavailability Factor (PUF) | : 11.64 % |
| Cumulative Load Factor (LF) | : 84.06 % | Cumulative Externally cause unavailability (XUF) | : 1.67 % |
| Cumulative Operating Factor (OF) | : 87.23 % | | |

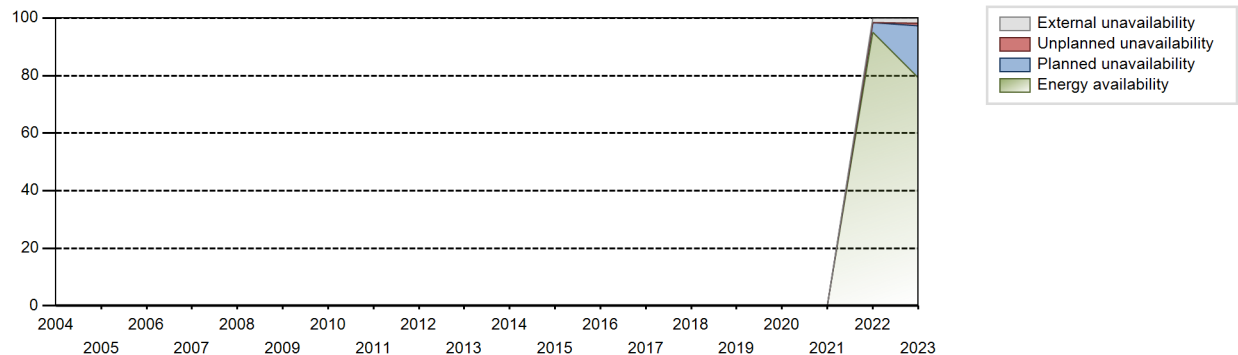
Electricity Production (net) [GWh]



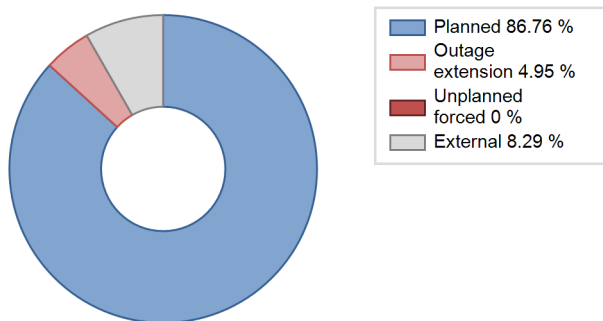
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2022 | 8810.67 | 8449 | 1075 | 95.16 | 96.76 | 91.74 | 95.29 | 0.00 | 0.00 | 3.24 | 1.60 |
| 2023 | 7371.42 | 7110 | 1075 | 79.29 | 81.00 | 78.28 | 81.16 | 0.00 | 1.02 | 17.97 | 1.72 |

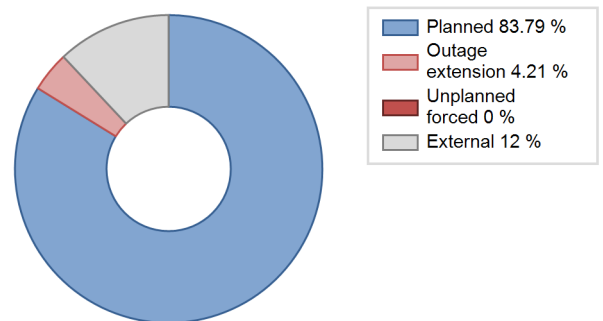
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2022 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| C. Inspection, maintenance or repair combined with refuelling | 1560 | | | 891 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 61 |
| Z. Other | | 90 | | 117 | 51 | |
| Subtotal | 1560 | 90 | | 1008 | 51 | 61 |
| Total | | 1650 | | | 1120 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2022 to 2023 | |
|---------------------------|------------|-----------|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 34. Miscellaneous Systems | | 90 | | 98 |
| Total | | 90 | | 98 |

2023 Operating Experience

CN-30

HAIYANG-1

CHINA

Status at end of year : **Operational**
 Operator : SDNPC (Shandong Nuclear Power Company, Ltd.)
 Owner : CPIG (China Power Investment Group)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)

Reactor Unit Details

Reactor type and model : PWR / AP-1000
 Thermal power : 3415 MWth
 Gross electrical power : 1250 MWe
 Reference unit power (net) : 1170 MWe

Key Dates

Construction Date : 2009-09-24
 Grid Date : 2018-08-17
 Commercial Date : 2018-10-22
 Age at end of year : 5 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.7239
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 40.76
 Average discharge burnup [MWd/t] : 50000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 4.2672
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.76
 Number of control rod assemblies : 69
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.513
 Reactor outlet temperature [°C] : 321.11
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.407

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.38
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : -

Non-electrical applications

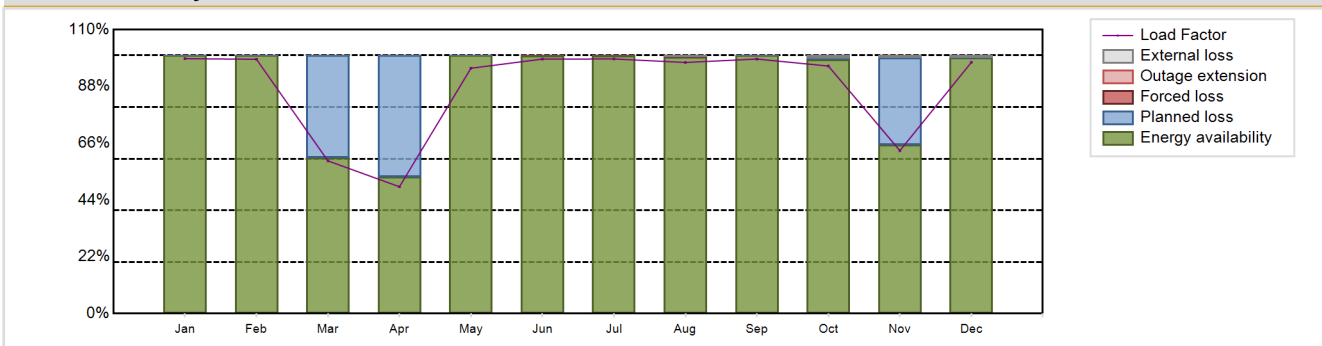
: DH

Annual Production Results (2023)

Net Energy Production : 8971.59 GW(e).h
 Energy Availability Factor (EAF) : 89.65 %
 Unit Capability Factor (UCF) : 89.95 %
 Load Factor (LF) : 87.53 %
 Operating Factor (OF) : 89.98 %
 Equivalent non-electrical energy generated (NEG) : 565.8 GW(e).h

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 10.04 %
 Externally cause unavailability (XUF) : 0.31 %
 Total off-line time : 878 hours

Annual Summary

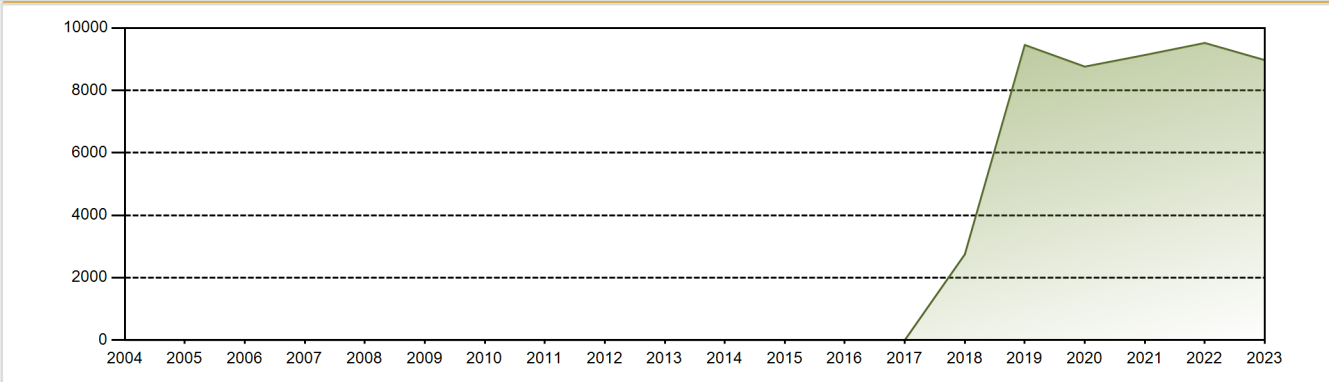


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 859.77 | 774.59 | 515.10 | 414.07 | 827.43 | 830.63 | 858.67 | 846.87 | 830.69 | 834.74 | 531.83 | 847.21 | 8971.59 |
| EAF [%] | 100.00 | 100.00 | 60.42 | 53.02 | 100.00 | 99.99 | 99.99 | 99.31 | 100.00 | 98.40 | 65.31 | 99.03 | 89.65 |
| UCF [%] | 100.00 | 100.00 | 60.42 | 53.02 | 100.00 | 99.99 | 99.99 | 100.00 | 100.00 | 99.60 | 66.11 | 100.00 | 89.95 |
| LF [%] | 98.77 | 98.52 | 59.17 | 49.15 | 95.05 | 98.60 | 98.64 | 97.29 | 98.61 | 95.89 | 63.13 | 97.33 | 87.53 |
| OF [%] | 100.00 | 100.00 | 62.10 | 51.94 | 96.51 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 68.89 | 100.00 | 89.98 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 39.58 | 46.98 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.40 | 33.89 | 0.00 | 10.04 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.69 | 0.00 | 1.19 | 0.80 | 0.96 | 0.31 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 48591.31 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.78 % |
| Cumulative Energy Availability Factor (EAF) | : 91.71 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.73 % |
| Cumulative Unit Capability Factor (UCF) | : 92.65 % | Cumulative Planned Unavailability Factor (PUF) | : 6.62 % |
| Cumulative Load Factor (LF) | : 89.56 % | Cumulative Externally cause unavailability (XUF) | : 0.93 % |
| Cumulative Operating Factor (OF) | : 91.94 % | | |

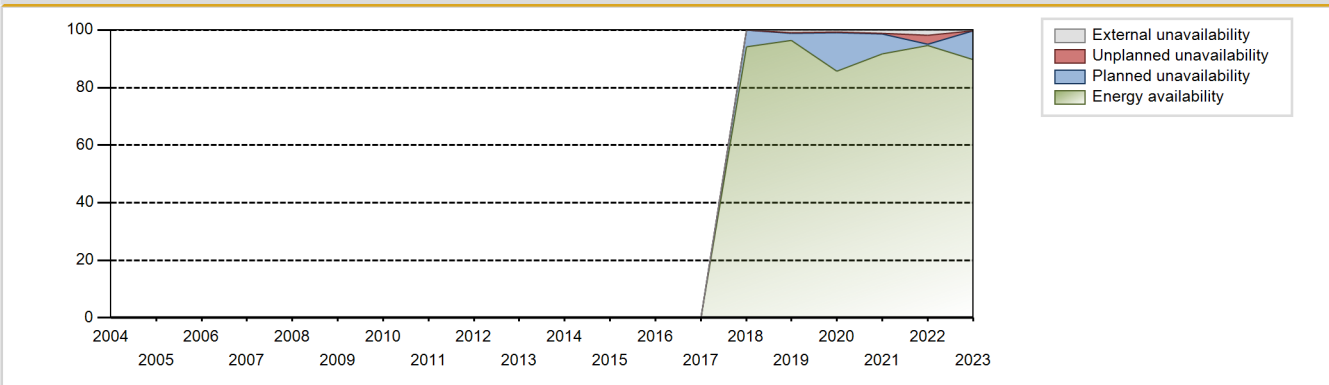
Electricity Production (net) [GWh]



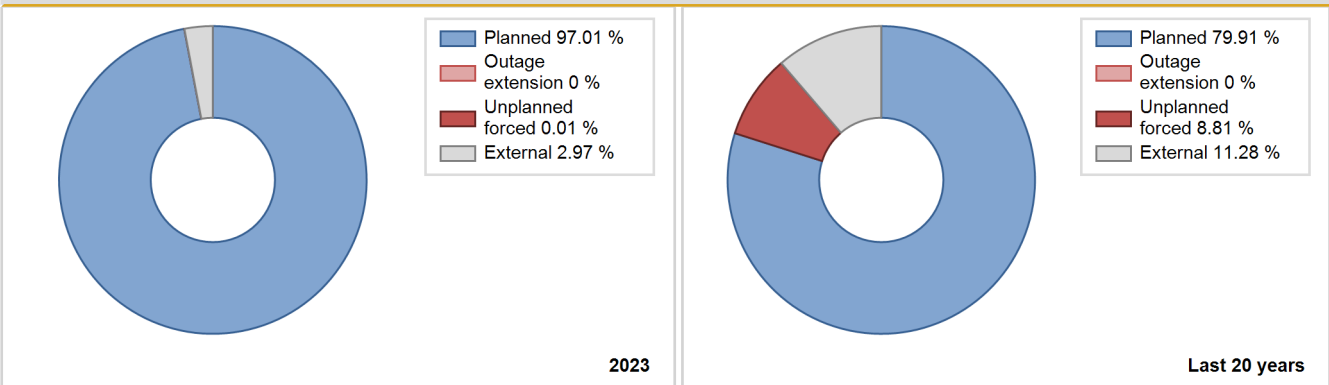
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2018 | 2746.03 | 2870 | 1170 | 94.20 | 94.20 | 93.91 | 95.29 | 0.00 | 0.00 | 5.80 | 0.00 |
| 2019 | 9456.75 | 8221 | 1170 | 96.46 | 97.39 | 92.27 | 93.85 | 0.16 | 0.16 | 2.45 | 0.93 |
| 2020 | 8762.30 | 7701 | 1170 | 85.68 | 86.31 | 85.26 | 87.67 | 0.31 | 0.27 | 13.42 | 0.63 |
| 2021 | 9133.85 | 8030 | 1170 | 91.78 | 92.90 | 89.12 | 91.67 | 0.30 | 0.28 | 6.82 | 1.12 |
| 2022 | 9520.82 | 8409 | 1170 | 94.61 | 96.45 | 92.89 | 95.99 | 3.08 | 3.06 | 0.49 | 1.83 |
| 2023 | 8971.59 | 7882 | 1170 | 89.65 | 89.95 | 87.53 | 89.98 | 0.00 | 0.00 | 10.04 | 0.31 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2018 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 48 | |
| C. Inspection, maintenance or repair combined with refuelling | 633 | | | 436 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 123 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | 247 | | | 48 | | |
| I. Grid capacity limitation | | | 48 | | | 56 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 64 |
| L. Human factor related | | | | | 1 | |
| Subtotal | 880 | | 48 | 607 | 49 | 120 |
| Total | | 928 | | | 776 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2018 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 34. Miscellaneous Systems | | 48 | | 53 |
| 41. Main Generator Systems | | | | 1 |
| 42. Electrical Power Supply Systems | | | | 46 |
| Total | | 48 | | 100 |

2023 Operating Experience

CN-31
HAIYANG-2
CHINA

Status at end of year : **Operational**
 Operator : SDNPC (Shandong Nuclear Power Company, Ltd.)
 Owner : CPIG (China Power Investment Group)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)

Reactor Unit Details

Reactor type and model : PWR / AP-1000
 Thermal power : 3415 MWth
 Gross electrical power : 1250 MWe
 Reference unit power (net) : 1170 MWe

Key Dates

Construction Date : 2010-06-20
 Grid Date : 2018-10-13
 Commercial Date : 2019-01-09
 Age at end of year : 5 years

Design Characteristics
Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.7239
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 40.76
 Average discharge burnup [MWd/t] : 50000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 4.2672
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.76
 Number of control rod assemblies : 69
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.513
 Reactor outlet temperature [°C] : 321.11
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.407

Secondary systems

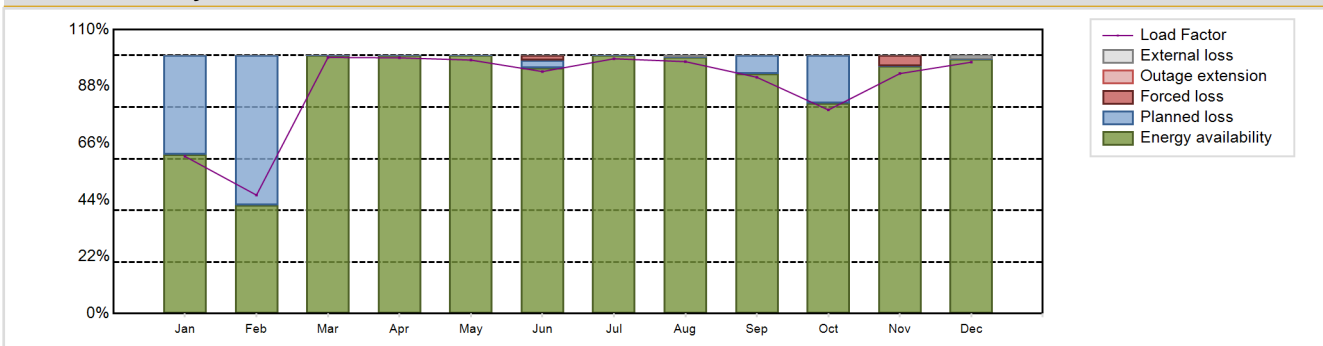
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.38
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : -

Non-electrical applications : DH

Annual Production Results (2023)

Net Energy Production : 9032.01 GW(e).h
 Energy Availability Factor (EAF) : 89.23 %
 Unit Capability Factor (UCF) : 89.39 %
 Load Factor (LF) : 88.12 %
 Operating Factor (OF) : 90.18 %
 Equivalent non-electrical energy generated (NEG) : 161.7 GW(e).h

Forced Loss Rate (FLR) : 0.53 %
 Unplanned Capability Loss Factor (UCL) : 0.48 %
 Planned Unavailability Factor (PUF) : 10.13 %
 Externally cause unavailability (XUF) : 0.16 %
 Total off-line time : 860 hours

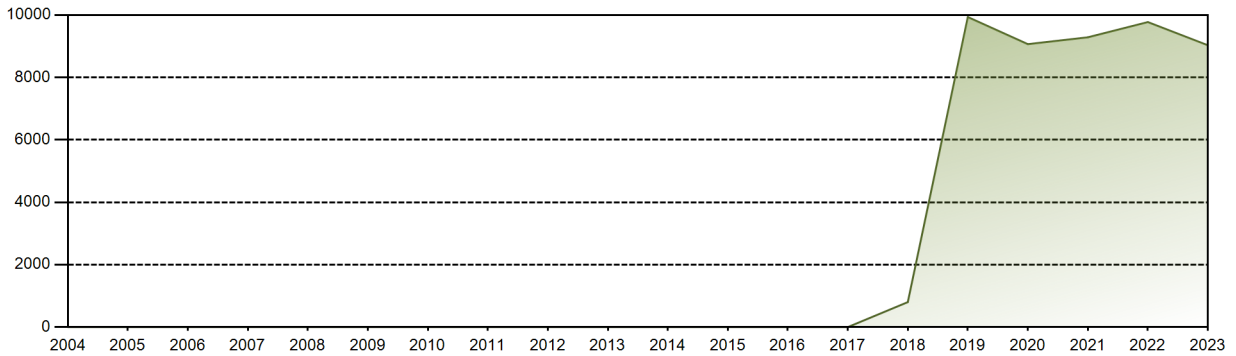
Annual Summary


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 530.20 | 360.95 | 863.61 | 834.69 | 854.94 | 789.78 | 859.30 | 849.64 | 771.12 | 686.75 | 783.24 | 847.79 | 9032.01 |
| EAF [%] | 61.54 | 42.04 | 100.00 | 100.00 | 100.00 | 95.08 | 100.00 | 99.42 | 92.89 | 81.45 | 95.97 | 98.67 | 89.23 |
| UCF [%] | 61.54 | 42.04 | 100.00 | 100.00 | 100.00 | 95.08 | 100.00 | 99.99 | 92.89 | 81.45 | 95.97 | 100.00 | 89.39 |
| LF [%] | 60.91 | 45.91 | 99.21 | 99.08 | 98.21 | 93.75 | 98.72 | 97.61 | 91.54 | 78.89 | 92.98 | 97.39 | 88.12 |
| OF [%] | 62.37 | 44.49 | 100.00 | 100.00 | 100.00 | 96.39 | 100.00 | 100.00 | 96.11 | 81.18 | 98.19 | 100.00 | 90.18 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.86 | 0.00 | 0.00 | 0.00 | 0.00 | 4.03 | 0.00 | 0.53 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.81 | 0.00 | 0.00 | 0.00 | 0.00 | 4.03 | 0.00 | 0.48 |
| PUF [%] | 38.46 | 57.96 | 0.00 | 0.00 | 0.00 | 3.11 | 0.00 | 0.01 | 7.11 | 18.55 | 0.00 | 0.00 | 10.13 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.58 | 0.00 | 0.00 | 0.00 | 1.33 | 0.16 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 47894.25 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.64 % |
| Cumulative Energy Availability Factor (EAF) | : 93.29 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.61 % |
| Cumulative Unit Capability Factor (UCF) | : 93.99 % | Cumulative Planned Unavailability Factor (PUF) | : 5.4 % |
| Cumulative Load Factor (LF) | : 91.85 % | Cumulative Externally cause unavailability (XUF) | : 0.7 % |
| Cumulative Operating Factor (OF) | : 94.13 % | | |

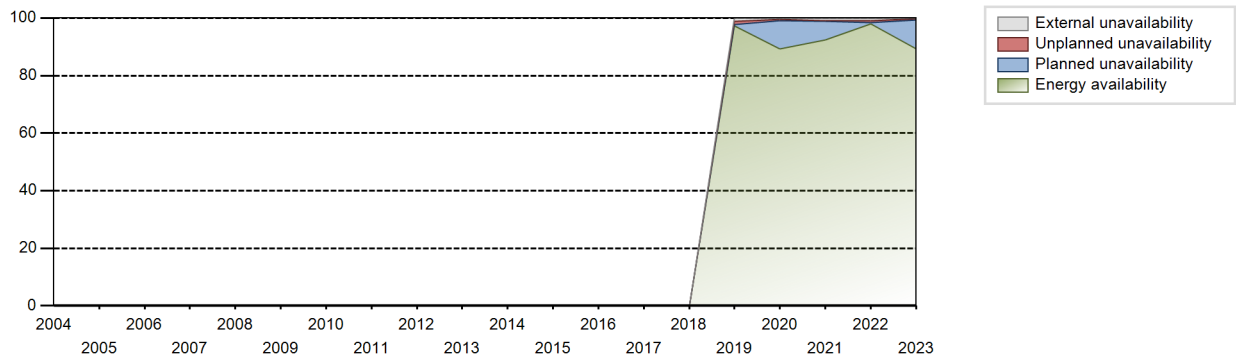
Electricity Production (net) [GWh]



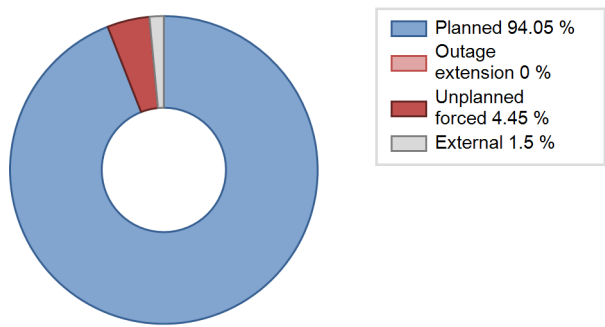
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2019 | 9935.22 | 8711 | 1170 | 97.38 | 98.43 | 96.94 | 99.44 | 1.25 | 1.25 | 0.32 | 1.05 |
| 2020 | 9066.38 | 7983 | 1170 | 89.33 | 89.91 | 88.22 | 90.88 | 0.44 | 0.40 | 9.69 | 0.58 |
| 2021 | 9286.00 | 8139 | 1170 | 92.49 | 93.32 | 90.60 | 92.91 | 0.33 | 0.31 | 6.38 | 0.83 |
| 2022 | 9773.92 | 8519 | 1170 | 98.04 | 98.92 | 95.36 | 97.25 | 0.61 | 0.61 | 0.47 | 0.88 |
| 2023 | 9032.01 | 7900 | 1170 | 89.23 | 89.39 | 88.12 | 90.18 | 0.53 | 0.48 | 10.13 | 0.16 |

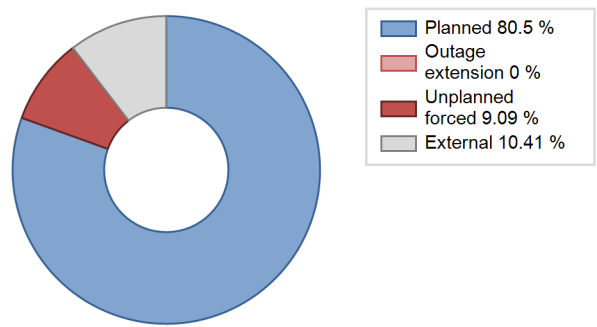
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2019 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 40 | | | 33 | |
| C. Inspection, maintenance or repair combined with refuelling | 678 | | | 387 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 92 | | |
| E. Testing of plant systems or components | | | | 19 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | 211 | | | 42 | | |
| I. Grid capacity limitation | | | | | | 51 |
| L. Human factor related | | | | | 66 | |
| Subtotal | 889 | 40 | | 540 | 99 | 51 |
| Total | | 929 | | | 690 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2019 to 2023 | |
|-------------------------------------|------------|-----------|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 7 |
| 15. Reactor Cooling Systems | | 40 | | 19 |
| 31. Turbine and auxiliaries | | | | 2 |
| 32. Feedwater and Main Steam System | | | | 65 |
| 34. Miscellaneous Systems | | | | 49 |
| Total | | 40 | | 142 |

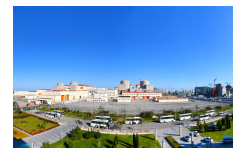
2023 Operating Experience

CN-16

HONGYANHE-1

CHINA

Status at end of year : **Operational**
 Operator : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Owner : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / CPR-1000 | Construction Date | : 2007-08-18 |
| Thermal power | : 2905 MWth | Grid Date | : 2013-02-17 |
| Gross electrical power | : 1119 MWe | Commercial Date | : 2013-06-06 |
| Reference unit power (net) | : 1061 MWe | Age at end of year | : 10 years |

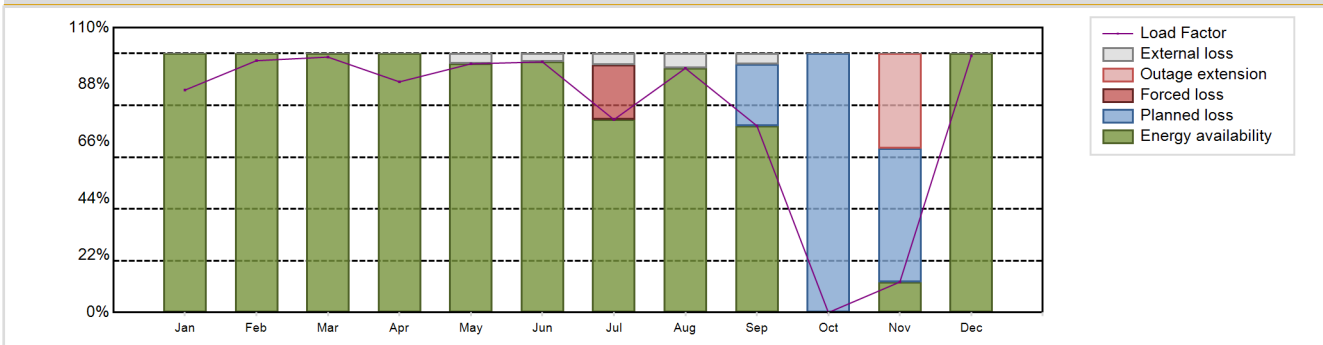
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.5 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 327.6 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 2.43 | Containment design pressure [MPa] | : 0.52 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : NA | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 6.11 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : 24 |
| Fuel linear heat generation rate [kW/m] | : 18.6 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 61 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 3 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 7084.46 GW(e).h | Forced Loss Rate (FLR) | : 2.19 % |
| Energy Availability Factor (EAF) | : 78.71 % | Unplanned Capability Loss Factor (UCL) | : 4.83 % |
| Unit Capability Factor (UCF) | : 80.5 % | Planned Unavailability Factor (PUF) | : 14.67 % |
| Load Factor (LF) | : 76.22 % | Externally cause unavailability (XUF) | : 1.79 % |
| Operating Factor (OF) | : 80.72 % | Total off-line time | : 1689 hours |

Annual Summary

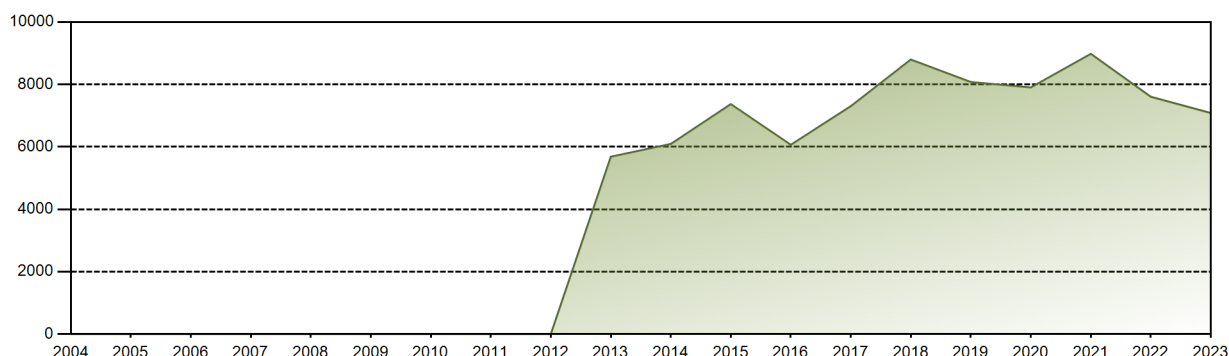


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|---------|
| GW(e)-h | 678.10 | 693.49 | 778.69 | 680.51 | 758.10 | 739.32 | 588.08 | 744.47 | 550.88 | 0.00 | 90.00 | 782.81 | 7084.46 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 96.04 | 96.78 | 74.50 | 94.31 | 72.11 | 0.00 | 11.78 | 100.00 | 78.71 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 78.73 | 100.00 | 76.33 | 0.00 | 11.78 | 100.00 | 80.50 |
| LF [%] | 85.90 | 97.27 | 98.65 | 89.08 | 96.04 | 96.78 | 74.50 | 94.31 | 72.11 | 0.00 | 11.78 | 99.17 | 76.22 |
| OF [%] | 100.00 | 100.00 | 100.00 | 96.94 | 100.00 | 100.00 | 79.30 | 100.00 | 76.67 | 0.00 | 16.53 | 100.00 | 80.72 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.19 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.27 | 0.00 | 0.00 | 0.00 | 36.73 | 0.00 | 4.83 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 23.67 | 100.00 | 51.49 | 0.00 | 14.67 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 3.96 | 3.22 | 4.23 | 5.69 | 4.22 | 0.00 | 0.00 | 0.00 | 1.79 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 81059.92 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.21 % |
| Cumulative Energy Availability Factor (EAF) | : 88.1 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.4 % |
| Cumulative Unit Capability Factor (UCF) | : 89.28 % | Cumulative Planned Unavailability Factor (PUF) | : 9.32 % |
| Cumulative Load Factor (LF) | : 82.14 % | Cumulative Externally cause unavailability (XUF) | : 1.18 % |
| Cumulative Operating Factor (OF) | : 88.16 % | | |

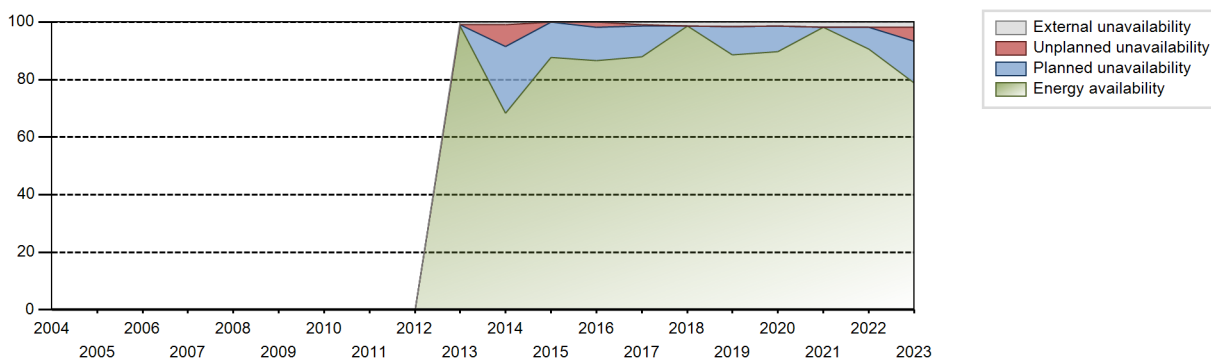
Electricity Production (net) [GWh]



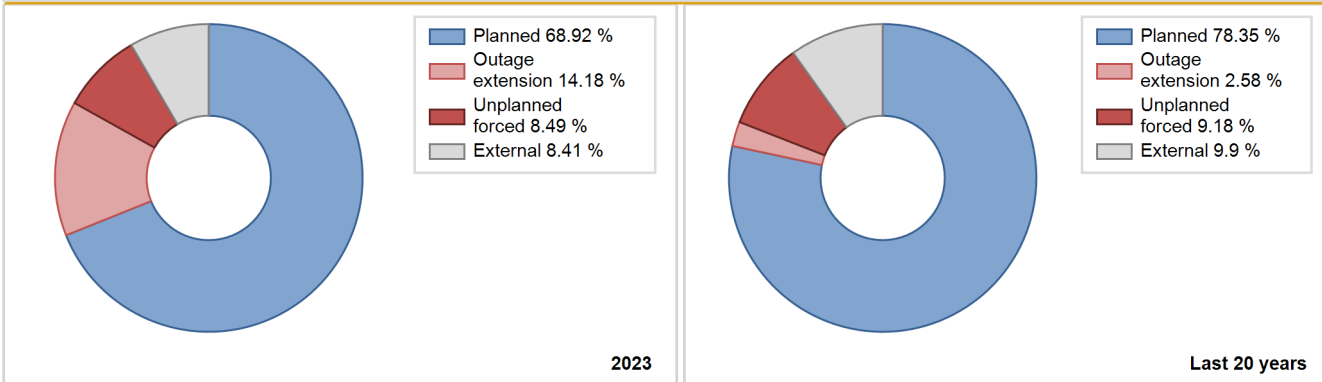
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2013 | 5683.38 | 7632 | 1061 | 98.62 | 99.55 | 102.41 | 100.00 | 0.01 | 0.01 | 0.44 | 0.94 |
| 2014 | 6093.20 | 6218 | 1061 | 68.38 | 69.32 | 65.56 | 70.98 | 9.71 | 7.65 | 23.03 | 0.95 |
| 2015 | 7369.75 | 7756 | 1061 | 87.80 | 87.80 | 79.29 | 88.54 | 0.01 | 0.01 | 12.19 | 0.00 |
| 2016 | 6066.04 | 6694 | 1061 | 86.62 | 86.62 | 65.09 | 76.21 | 2.14 | 1.93 | 11.45 | 0.00 |
| 2017 | 7304.12 | 7720 | 1061 | 87.92 | 88.92 | 78.59 | 88.13 | 0.43 | 0.38 | 10.69 | 1.01 |
| 2018 | 8797.86 | 8760 | 1061 | 98.55 | 99.98 | 94.66 | 100.00 | 0.00 | 0.00 | 0.01 | 1.43 |
| 2019 | 8077.71 | 7954 | 1061 | 88.51 | 90.20 | 86.91 | 90.80 | 0.00 | 0.00 | 9.80 | 1.68 |
| 2020 | 7903.95 | 8033 | 1061 | 89.65 | 91.10 | 84.81 | 91.45 | 0.00 | 0.00 | 8.90 | 1.44 |
| 2021 | 8980.89 | 8760 | 1061 | 98.15 | 100.00 | 96.63 | 100.00 | 0.00 | 0.00 | 0.00 | 1.85 |
| 2022 | 7605.00 | 7696 | 1061 | 90.56 | 92.32 | 81.82 | 87.85 | 0.00 | 0.00 | 7.68 | 1.76 |
| 2023 | 7084.46 | 7071 | 1061 | 78.71 | 80.50 | 76.22 | 80.72 | 2.19 | 4.83 | 14.67 | 1.79 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2013 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 428 | | | 101 | |
| C. Inspection, maintenance or repair combined with refuelling | 1248 | | | 772 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 22 | | | 166 |
| Subtotal | 1248 | 428 | 22 | 772 | 101 | 166 |
| Total | | 1698 | | | 1039 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2013 to 2023 | |
|-------------------------------------|------------|------------|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 286 | | 65 |
| 31. Turbine and auxiliaries | | | | 0 |
| 33. Circulating Water System | | 163 | | 27 |
| 41. Main Generator Systems | | | | 45 |
| 42. Electrical Power Supply Systems | | | | 1 |
| Total | | 449 | | 138 |

Highlights (2023)

At the request of the sate grid,the power was reduced separately for some pe of time

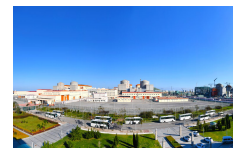
2023 Operating Experience

CN-17

HONGYANHE-2

CHINA

Status at end of year : **Operational**
 Operator : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Owner : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)



Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1119 MWe
 Reference unit power (net) : 1061 MWe

Key Dates

Construction Date : 2008-03-28
 Grid Date : 2013-11-23
 Commercial Date : 2014-05-13
 Age at end of year : 10 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.43
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : NA
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.6
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : NA
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

Non-electrical applications

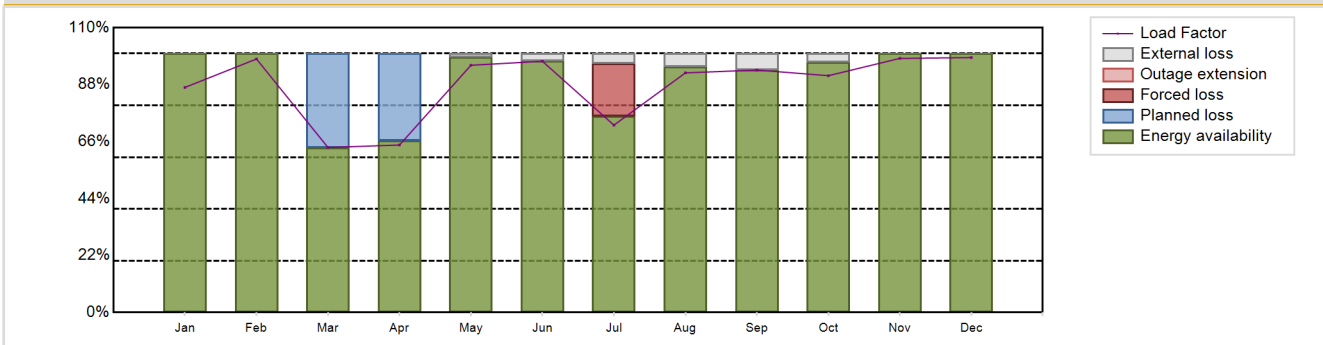
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8143.39 GW(e).h
 Energy Availability Factor (EAF) : 90.5 %
 Unit Capability Factor (UCF) : 92.44 %
 Load Factor (LF) : 87.62 %
 Operating Factor (OF) : 92.92 %

Forced Loss Rate (FLR) : 1.82 %
 Unplanned Capability Loss Factor (UCL) : 1.71 %
 Planned Unavailability Factor (PUF) : 5.84 %
 Externally cause unavailability (XUF) : 1.95 %
 Total off-line time : 620 hours

Annual Summary

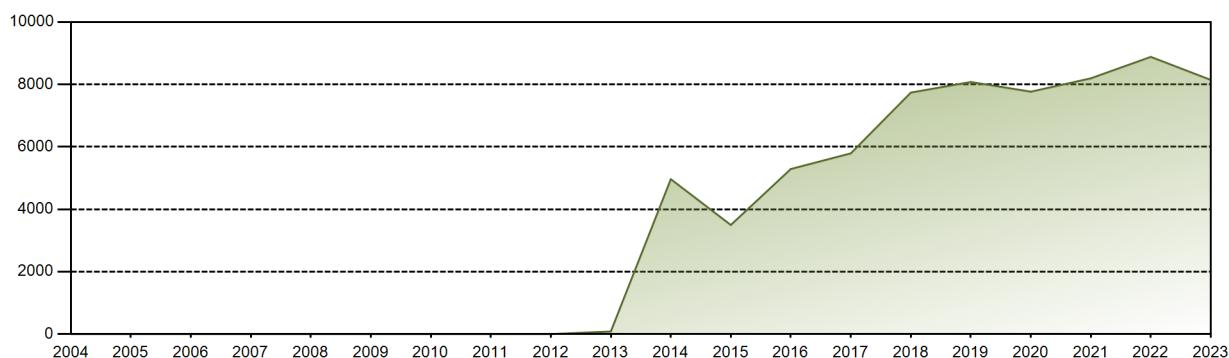


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 686.38 | 698.15 | 503.19 | 494.17 | 753.82 | 741.26 | 571.31 | 730.60 | 715.38 | 722.06 | 749.83 | 777.25 | 8143.39 |
| EAF [%] | 100.00 | 100.00 | 63.74 | 66.35 | 98.69 | 97.03 | 75.90 | 94.78 | 93.65 | 96.55 | 100.00 | 100.00 | 90.50 |
| UCF [%] | 100.00 | 100.00 | 63.74 | 66.35 | 100.00 | 100.00 | 79.85 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.44 |
| LF [%] | 86.95 | 97.92 | 63.74 | 64.69 | 95.49 | 97.03 | 72.37 | 92.55 | 93.65 | 91.47 | 98.16 | 98.46 | 87.62 |
| OF [%] | 100.00 | 100.00 | 64.52 | 70.97 | 100.00 | 100.00 | 80.24 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.92 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.82 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.71 |
| PUF [%] | 0.00 | 0.00 | 36.26 | 33.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.84 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.31 | 2.97 | 3.95 | 5.22 | 6.35 | 3.45 | 0.00 | 0.00 | 1.95 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 68421.51 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.8 % |
| Cumulative Energy Availability Factor (EAF) | : 87.75 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.97 % |
| Cumulative Unit Capability Factor (UCF) | : 89.09 % | Cumulative Planned Unavailability Factor (PUF) | : 9.94 % |
| Cumulative Load Factor (LF) | : 75.49 % | Cumulative Externally cause unavailability (XUF) | : 1.34 % |
| Cumulative Operating Factor (OF) | : 81.56 % | | |

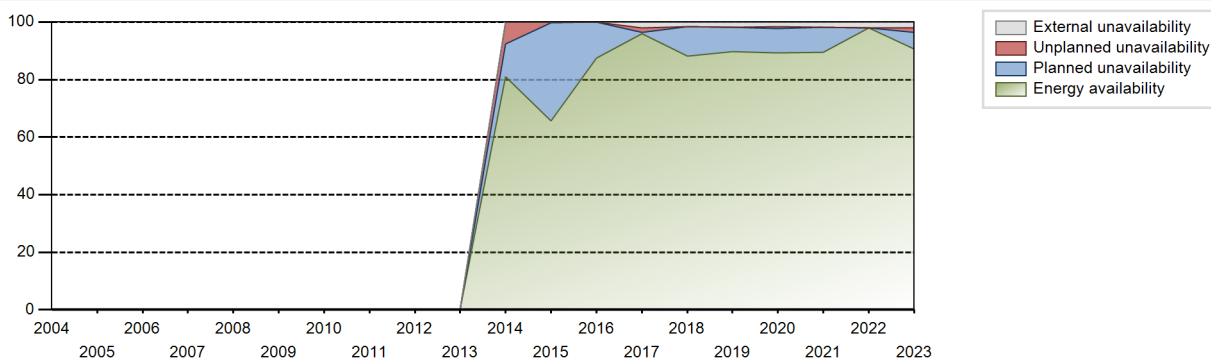
Electricity Production (net) [GWh]



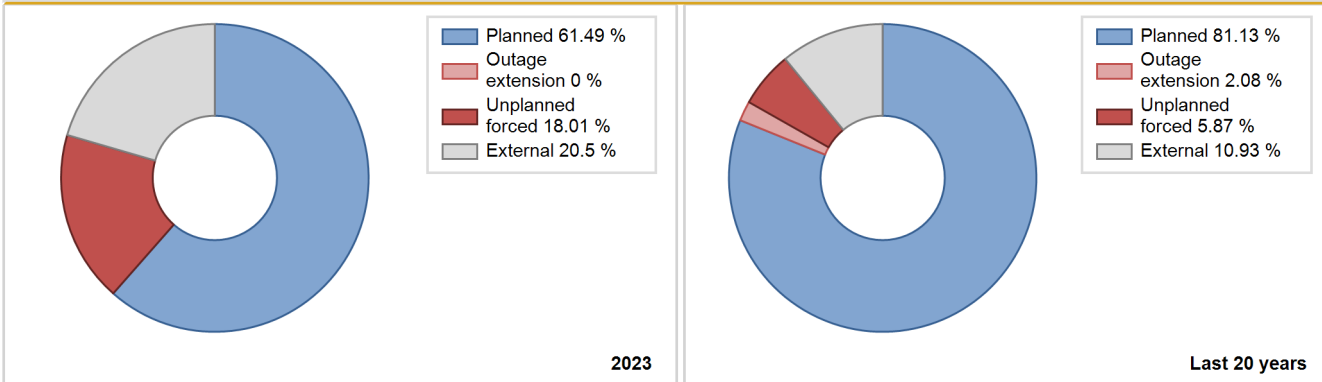
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2014 | 4963.31 | 5053 | 1061 | 81.06 | 81.06 | 72.46 | 79.81 | 8.62 | 7.64 | 11.29 | 0.00 |
| 2015 | 3496.01 | 3925 | 1061 | 65.63 | 65.63 | 37.61 | 44.81 | 0.16 | 0.34 | 34.03 | 0.00 |
| 2016 | 5288.78 | 5542 | 1061 | 87.53 | 87.53 | 56.75 | 63.09 | 0.01 | 0.01 | 12.47 | 0.00 |
| 2017 | 5790.37 | 6250 | 1061 | 95.98 | 98.08 | 62.30 | 71.35 | 0.00 | 1.53 | 0.40 | 2.10 |
| 2018 | 7737.78 | 7723 | 1061 | 88.18 | 89.80 | 83.25 | 88.16 | 0.00 | 0.00 | 10.20 | 1.63 |
| 2019 | 8077.34 | 8056 | 1061 | 89.72 | 91.62 | 86.91 | 91.96 | 0.00 | 0.00 | 8.38 | 1.89 |
| 2020 | 7767.35 | 8018 | 1061 | 89.29 | 90.88 | 83.34 | 91.28 | 0.00 | 0.70 | 8.42 | 1.59 |
| 2021 | 8195.34 | 8027 | 1061 | 89.41 | 91.17 | 88.18 | 91.63 | 0.00 | 0.00 | 8.83 | 1.76 |
| 2022 | 8882.06 | 8760 | 1061 | 97.96 | 100.00 | 95.56 | 100.00 | 0.00 | 0.00 | 0.00 | 2.04 |
| 2023 | 8143.39 | 8140 | 1061 | 90.50 | 92.44 | 87.62 | 92.92 | 1.82 | 1.71 | 5.84 | 1.95 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2014 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 155 | | | 82 | |
| C. Inspection, maintenance or repair combined with refuelling | 473 | | | 834 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 690 |
| Subtotal | 473 | 155 | | 834 | 82 | 690 |
| Total | | 628 | | | 1606 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2014 to 2023 | |
|------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 6 |
| 15. Reactor Cooling Systems | | | | 13 |
| 31. Turbine and auxiliaries | | | | 18 |
| 33. Circulating Water System | | | 155 | 42 |
| Total | | | 155 | 79 |

Highlights (2023)

At the request of the state grid, the power was reduced separately for some part of time

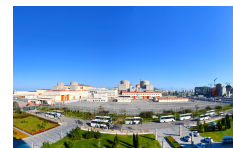
2023 Operating Experience

CN-26

HONGYANHE-3

CHINA

Status at end of year : **Operational**
 Operator : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Owner : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)



Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1119 MWe
 Reference unit power (net) : 1061 MWe

Key Dates

Construction Date : 2009-03-07
 Grid Date : 2015-03-23
 Commercial Date : 2015-08-16
 Age at end of year : 8 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.43
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : -
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.6
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.11
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

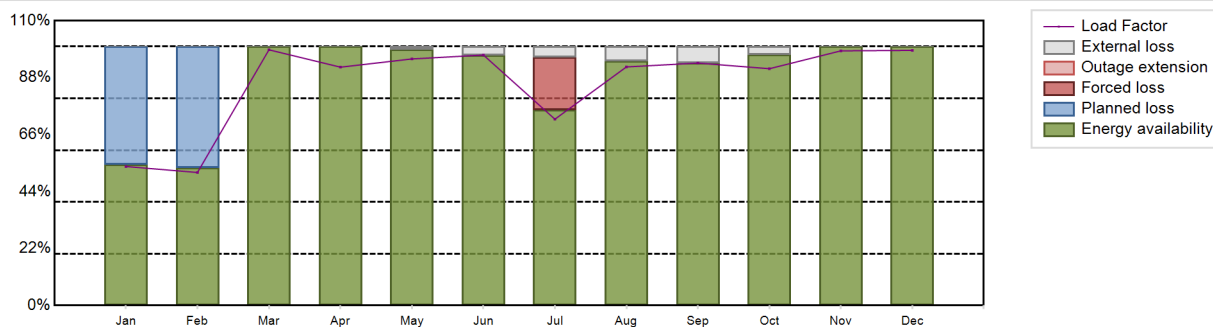
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8025.66 GW(e).h
 Energy Availability Factor (EAF) : 88.82 %
 Unit Capability Factor (UCF) : 90.82 %
 Load Factor (LF) : 86.35 %
 Operating Factor (OF) : 91.28 %
 Forced Loss Rate (FLR) : 1.85 %
 Unplanned Capability Loss Factor (UCL) : 1.71 %
 Planned Unavailability Factor (PUF) : 7.46 %
 Externally cause unavailability (XUF) : 2 %
 Total off-line time : 764 hours

Annual Summary

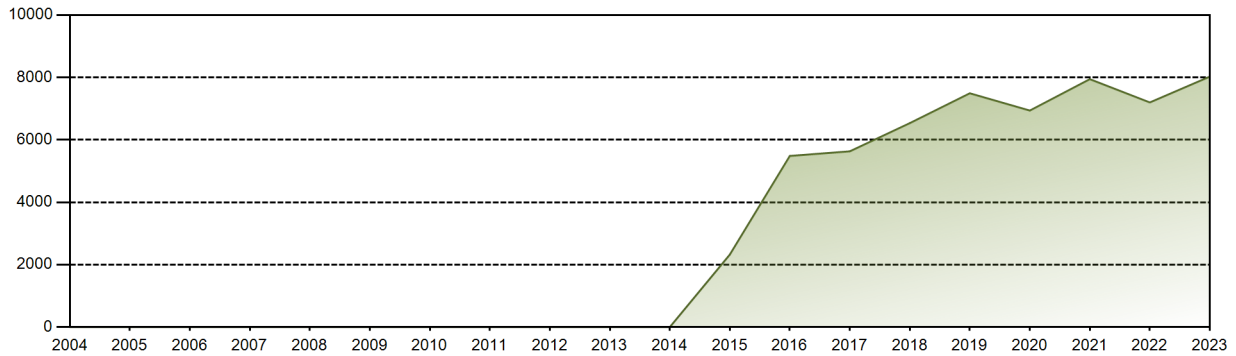


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 423.81 | 366.40 | 779.64 | 703.25 | 751.70 | 738.98 | 568.05 | 727.36 | 715.31 | 721.95 | 751.37 | 777.84 | 8025.66 |
| EAF [%] | 54.48 | 53.09 | 100.00 | 100.00 | 98.76 | 96.74 | 75.64 | 94.43 | 93.64 | 96.76 | 100.00 | 100.00 | 88.82 |
| UCF [%] | 54.48 | 53.09 | 100.00 | 100.00 | 100.00 | 100.00 | 79.84 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.82 |
| LF [%] | 53.69 | 51.39 | 98.77 | 92.06 | 95.23 | 96.74 | 71.96 | 92.14 | 93.64 | 91.46 | 98.36 | 98.54 | 86.35 |
| OF [%] | 54.84 | 58.18 | 100.00 | 100.00 | 100.00 | 100.00 | 80.24 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.28 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.85 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.71 |
| PUF [%] | 45.52 | 46.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.46 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.24 | 3.26 | 4.20 | 5.57 | 6.36 | 3.24 | 0.00 | 0.00 | 2.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 57554.03 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.45 % |
| Cumulative Energy Availability Factor (EAF) | : 89.26 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.75 % |
| Cumulative Unit Capability Factor (UCF) | : 90.87 % | Cumulative Planned Unavailability Factor (PUF) | : 8.38 % |
| Cumulative Load Factor (LF) | : 73.01 % | Cumulative Externally cause unavailability (XUF) | : 1.61 % |
| Cumulative Operating Factor (OF) | : 78.81 % | | |

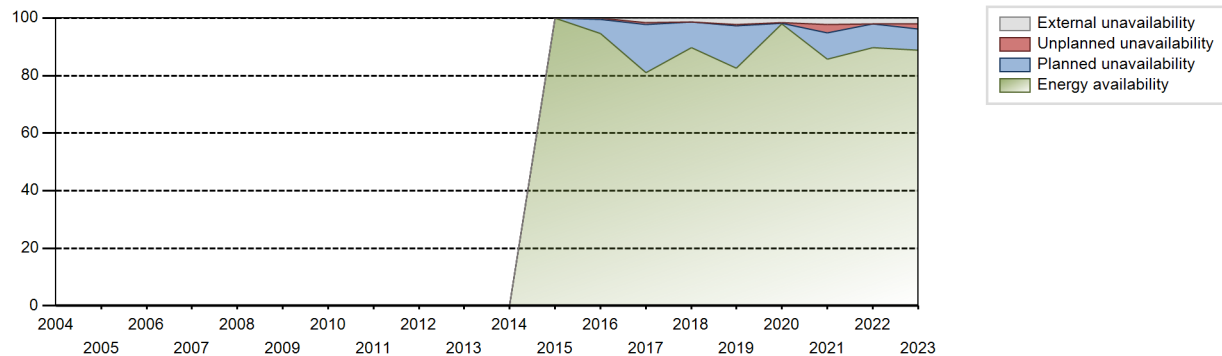
Electricity Production (net) [GWh]



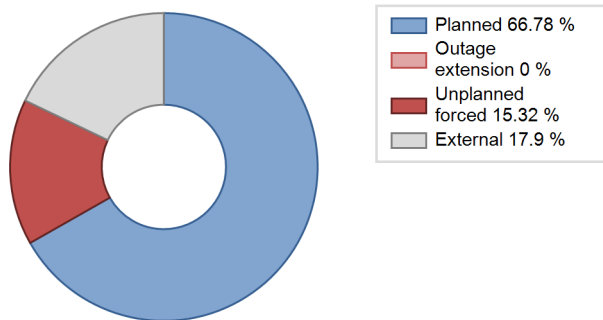
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2015 | 2322.53 | 2835 | 1061 | 99.98 | 99.98 | 43.20 | 47.98 | 0.01 | 0.01 | 0.01 | 0.00 |
| 2016 | 5483.99 | 5764 | 1061 | 94.69 | 94.69 | 58.84 | 65.62 | 0.55 | 0.52 | 4.79 | 0.00 |
| 2017 | 5631.50 | 5975 | 1061 | 80.94 | 82.61 | 60.59 | 68.21 | 0.67 | 0.56 | 16.83 | 1.67 |
| 2018 | 6535.98 | 6697 | 1061 | 89.74 | 91.17 | 70.32 | 76.45 | 0.00 | 0.00 | 8.82 | 1.44 |
| 2019 | 7491.34 | 7481 | 1061 | 82.68 | 84.95 | 80.60 | 85.40 | 0.60 | 0.51 | 14.53 | 2.27 |
| 2020 | 6938.56 | 7116 | 1061 | 98.05 | 99.73 | 74.45 | 81.01 | 0.09 | 0.09 | 0.18 | 1.69 |
| 2021 | 7943.87 | 7670 | 1061 | 85.80 | 88.06 | 85.47 | 87.56 | 0.00 | 2.84 | 9.10 | 2.26 |
| 2022 | 7198.11 | 7472 | 1061 | 89.71 | 91.81 | 77.45 | 85.30 | 0.00 | 0.00 | 8.19 | 2.10 |
| 2023 | 8025.66 | 7996 | 1061 | 88.82 | 90.82 | 86.35 | 91.28 | 1.85 | 1.71 | 7.46 | 2.00 |

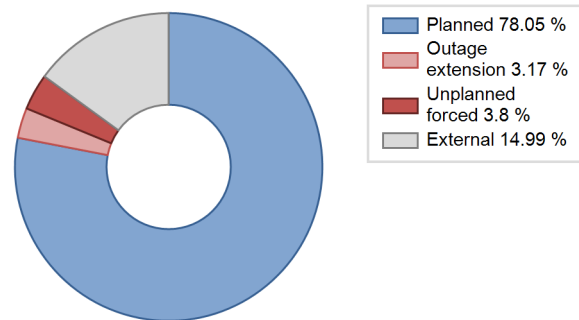
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2015 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 153 | | | 58 | |
| C. Inspection, maintenance or repair combined with refuelling | 617 | | | 706 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1094 |
| Subtotal | 617 | 153 | | 706 | 58 | 1094 |
| Total | | 770 | | | 1858 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2015 to 2023 | |
|------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 295 |
| 12. Reactor I&C Systems | | | | 5 |
| 33. Circulating Water System | | | 153 | 22 |
| Total | | | 153 | 322 |

Highlights (2023)

At the request of the state grid, the power was reduced separately for some pe of time

2023 Operating Experience

CN-27

HONGYANHE-4

CHINA

Status at end of year : **Operational**
 Operator : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Owner : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)



Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1119 MWe
 Reference unit power (net) : 1061 MWe

Key Dates

Construction Date : 2009-08-15
 Grid Date : 2016-04-01
 Commercial Date : 2016-06-08
 Age at end of year : 7 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.43
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : NA
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.6
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : NA
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

Non-electrical applications

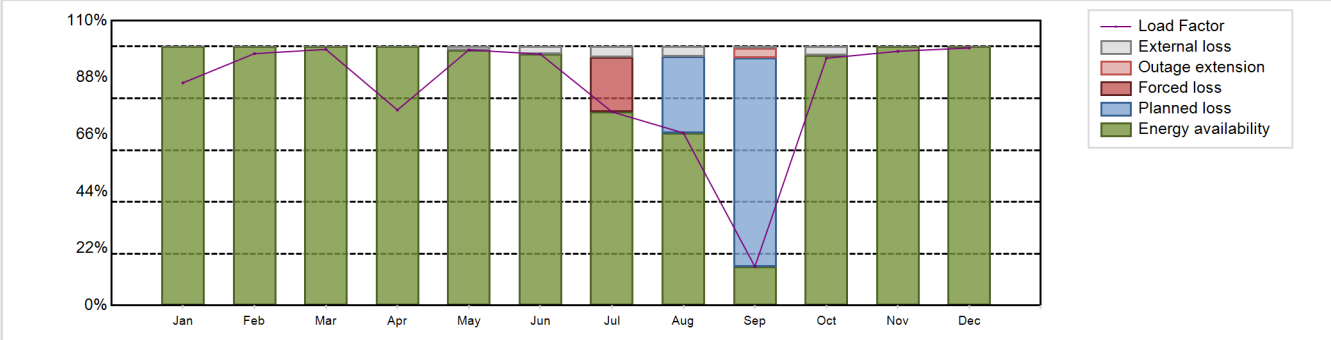
: none

Annual Production Results (2023)

Net Energy Production : 7771.55 GW(e).h
 Energy Availability Factor (EAF) : 87.41 %
 Unit Capability Factor (UCF) : 88.79 %
 Load Factor (LF) : 83.62 %
 Operating Factor (OF) : 87.39 %

Forced Loss Rate (FLR) : 1.97 %
 Unplanned Capability Loss Factor (UCL) : 2.08 %
 Planned Unavailability Factor (PUF) : 9.13 %
 Externally cause unavailability (XUF) : 1.38 %
 Total off-line time : 1105 hours

Annual Summary

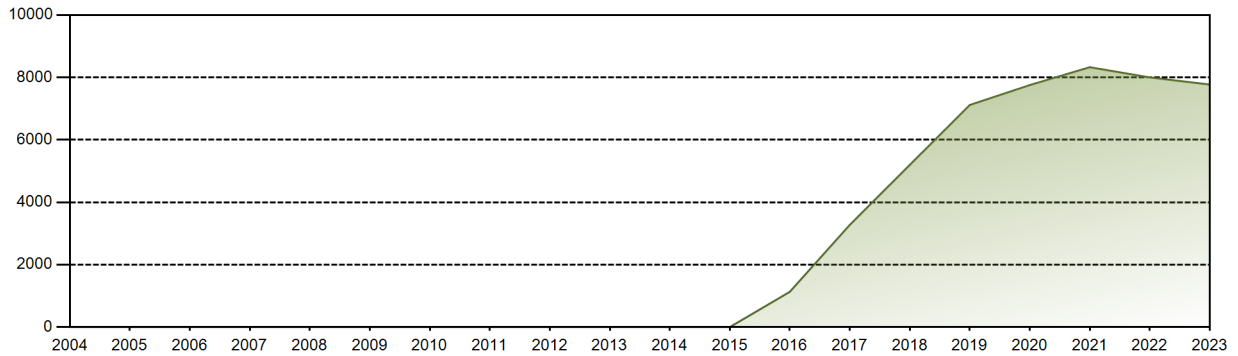


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 678.87 | 693.63 | 780.73 | 576.90 | 779.42 | 741.55 | 590.60 | 526.10 | 114.80 | 753.79 | 750.04 | 785.14 | 7771.55 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 98.74 | 97.07 | 74.82 | 66.65 | 15.03 | 96.58 | 100.00 | 100.00 | 87.41 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 78.99 | 70.58 | 15.69 | 100.00 | 100.00 | 100.00 | 88.79 |
| LF [%] | 86.00 | 97.28 | 98.90 | 75.52 | 98.74 | 97.07 | 74.82 | 66.65 | 15.03 | 95.49 | 98.18 | 99.46 | 83.62 |
| OF [%] | 100.00 | 100.00 | 100.00 | 77.64 | 100.00 | 100.00 | 79.84 | 70.97 | 19.72 | 100.00 | 100.00 | 100.00 | 87.39 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.97 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.01 | 0.00 | 3.57 | 0.00 | 0.00 | 0.00 | 2.08 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 29.42 | 80.74 | 0.00 | 0.00 | 0.00 | 9.13 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.26 | 2.93 | 4.17 | 3.94 | 0.66 | 3.42 | 0.00 | 0.00 | 1.38 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 49292.74 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.36 % |
| Cumulative Energy Availability Factor (EAF) | : 89.27 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.37 % |
| Cumulative Unit Capability Factor (UCF) | : 90.68 % | Cumulative Planned Unavailability Factor (PUF) | : 8.95 % |
| Cumulative Load Factor (LF) | : 69.18 % | Cumulative Externally cause unavailability (XUF) | : 1.41 % |
| Cumulative Operating Factor (OF) | : 74.2 % | | |

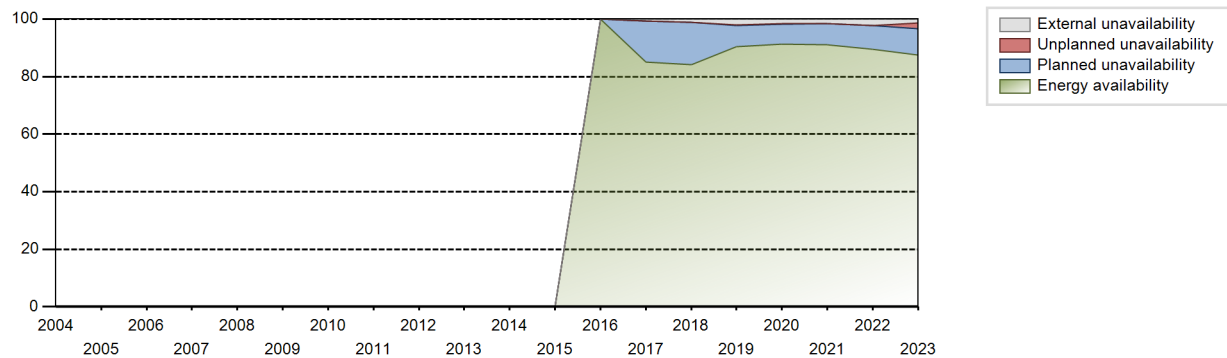
Electricity Production (net) [GWh]



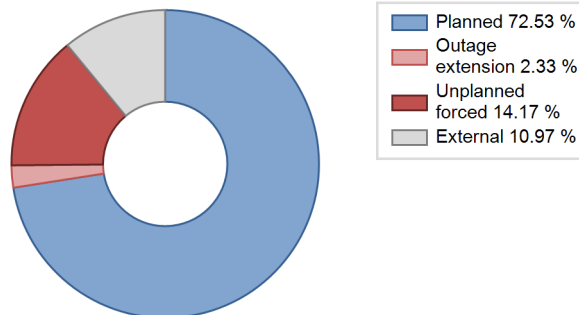
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 1130.44 | 1200 | 1000 | 99.99 | 99.99 | 22.01 | 23.36 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2017 | 3276.06 | 3638 | 1061 | 85.13 | 85.76 | 35.25 | 41.53 | 0.17 | 0.15 | 14.10 | 0.63 |
| 2018 | 5198.53 | 5361 | 1061 | 84.08 | 85.16 | 55.93 | 61.20 | 0.03 | 0.03 | 14.82 | 1.08 |
| 2019 | 7117.14 | 7035 | 1061 | 90.39 | 92.47 | 76.57 | 80.31 | 0.21 | 0.20 | 7.33 | 2.09 |
| 2020 | 7755.39 | 8183 | 1061 | 91.28 | 92.78 | 83.21 | 93.16 | 0.37 | 0.35 | 6.87 | 1.50 |
| 2021 | 8327.55 | 8177 | 1061 | 91.15 | 92.83 | 89.60 | 93.34 | 0.00 | 0.00 | 7.17 | 1.68 |
| 2022 | 8000.10 | 8076 | 1061 | 89.50 | 91.81 | 86.07 | 92.19 | 0.00 | 0.00 | 8.19 | 2.30 |
| 2023 | 7771.55 | 7655 | 1061 | 87.41 | 88.79 | 83.62 | 87.39 | 1.97 | 2.08 | 9.13 | 1.38 |

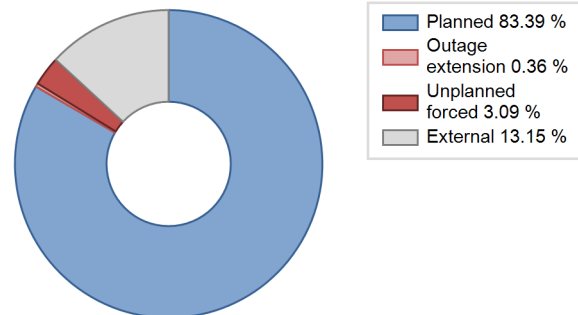
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 188 | | | 31 | |
| C. Inspection, maintenance or repair combined with refuelling | 768 | | | 754 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 161 | | | 1129 |
| Subtotal | 768 | 188 | 161 | 754 | 31 | 1129 |
| Total | | 1117 | | | 1914 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|-------------------------------------|------------|-----|-------------------------------------|----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 187 | | 24 |
| 32. Feedwater and Main Steam System | | | | 2 |
| 33. Circulating Water System | | 162 | | 25 |
| Total | | 349 | | 51 |

Highlights (2023)

At the request of the sate grid,the power was reduced separately for some pe of time

2023 Operating Experience

CN-49

HONGYANHE-5

CHINA

Status at end of year : **Operational**
 Operator : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Owner : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------|--------------------|--------------|
| Reactor type and model | : PWR / ACPR-1000 | Construction Date | : 2015-03-29 |
| Thermal power | : 2905 MWth | Grid Date | : 2021-06-25 |
| Gross electrical power | : 1119 MWe | Commercial Date | : 2021-07-31 |
| Reference unit power (net) | : 1061 MWe | Age at end of year | : 2 years |

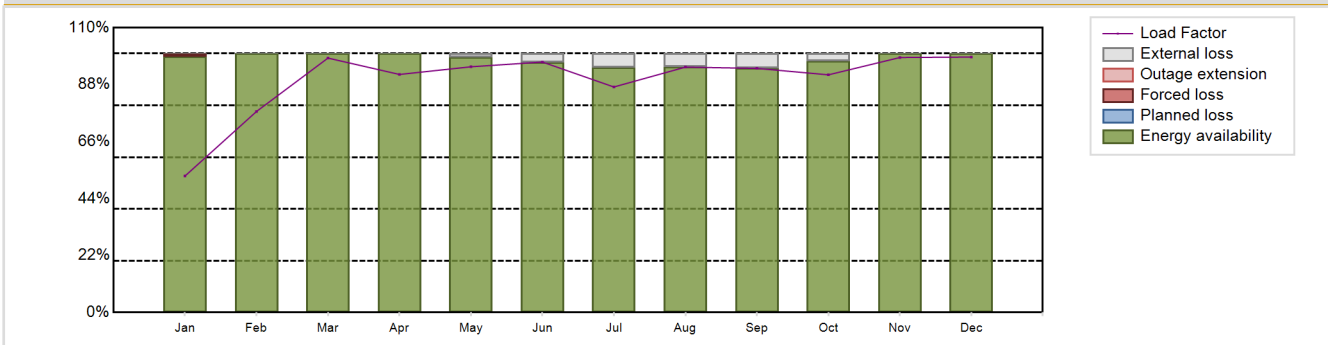
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|---|--|--------|
| Reactor vessel centreline orientation | : | Operating coolant pressure [MPa] | : |
| Fuel material | : | Reactor outlet temperature [°C] | : |
| Refuelling type | : | Number of SG | : |
| Moderator material | : | Containment type | : |
| Average fuel enrichment [% of U235] | : | Containment design pressure [MPa] | : |
| Refuelling frequency [month] | : | Secondary systems | |
| Part of the core refuelled [%] | : | Number of turbine-generators per unit/reactor | : |
| Average discharge burnup [MWd/t] | : | Turbine speed [rpm] | : |
| Active core diameter [m] | : | Number of LP cylinders per turbine | : |
| Active core height/length [m] | : | HP cylinder inlet steam pressure [MPa] | : |
| Number of fissile fuel assemblies/bundles | : | Output voltage [kV] | : |
| Fuel linear heat generation rate [kW/m] | : | Primary means of condenser cooling | : |
| Number of control rod assemblies | : | Number of main condensate pumps | : |
| Number of external reactor coolant loops | : | Number of FW pumps for full power operation | : |
| Coolant type | : | Number of on-site safety related diesel generators | : |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|------------------|--|-------------|
| Net Energy Production | : 8347.9 GW(e).h | Forced Loss Rate (FLR) | : 0.09 % |
| Energy Availability Factor (EAF) | : 97.91 % | Unplanned Capability Loss Factor (UCL) | : 0.09 % |
| Unit Capability Factor (UCF) | : 99.91 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 89.82 % | Externally cause unavailability (XUF) | : 2 % |
| Operating Factor (OF) | : 95.21 % | Total off-line time | : 420 hours |

Annual Summary

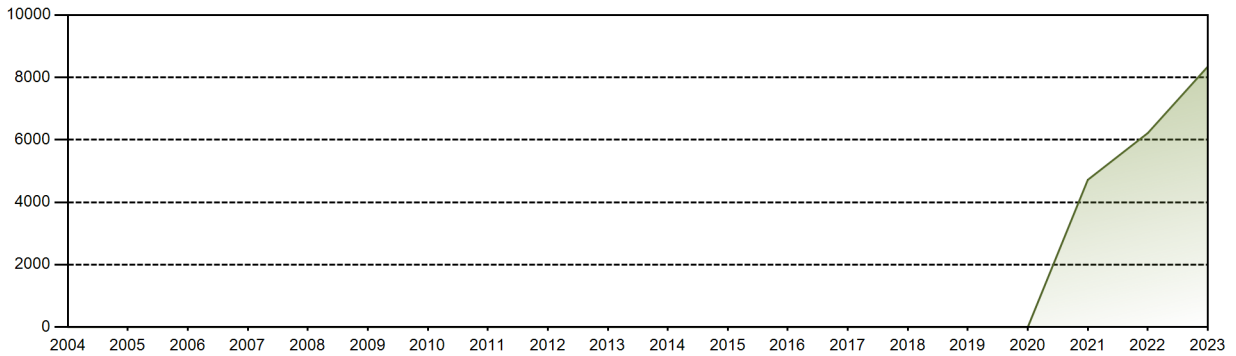


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 416.17 | 553.59 | 775.73 | 702.41 | 749.19 | 738.96 | 687.61 | 748.15 | 720.27 | 724.64 | 752.37 | 778.81 | 8347.90 |
| EAF [%] | 98.95 | 100.00 | 100.00 | 100.00 | 98.50 | 96.73 | 94.60 | 94.78 | 94.29 | 97.23 | 100.00 | 100.00 | 97.91 |
| UCF [%] | 98.95 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.91 |
| LF [%] | 52.72 | 77.64 | 98.27 | 91.95 | 94.91 | 96.73 | 87.11 | 94.78 | 94.29 | 91.80 | 98.49 | 98.66 | 89.82 |
| OF [%] | 59.68 | 82.14 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.21 |
| FLR [%] | 1.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 |
| UCL [%] | 1.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.50 | 3.27 | 5.40 | 5.22 | 5.71 | 2.77 | 0.00 | 0.00 | 2.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 18341.51 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.04 % |
| Cumulative Energy Availability Factor (EAF) | : 93.48 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.04 % |
| Cumulative Unit Capability Factor (UCF) | : 94.97 % | Cumulative Planned Unavailability Factor (PUF) | : 4.99 % |
| Cumulative Load Factor (LF) | : 81.57 % | Cumulative Externally cause unavailability (XUF) | : 1.49 % |
| Cumulative Operating Factor (OF) | : 87.31 % | | |

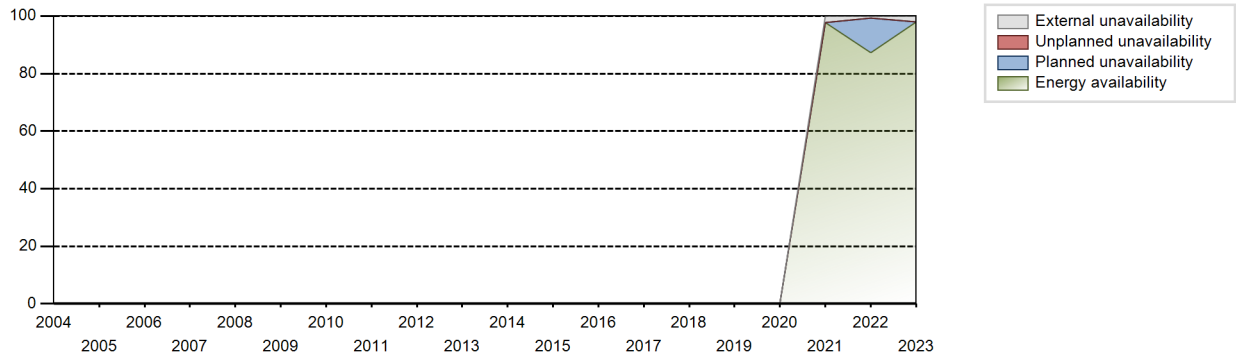
Electricity Production (net) [GWh]



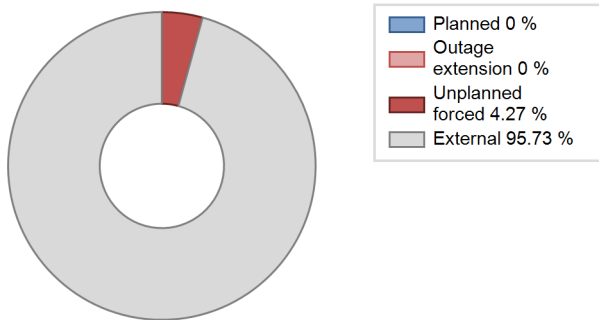
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|--------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2021 | 4718.48 | 4560 | 1061 | 97.74 | 100.00 | 96.93 | 100.00 | 0.00 | 0.00 | 0.00 | 2.26 |
| 2022 | 6217.30 | 6490 | 1061 | 87.26 | 87.92 | 66.89 | 74.09 | 0.00 | 0.00 | 12.08 | 0.66 |
| 2023 | 8347.90 | 8340 | 1061 | 97.91 | 99.91 | 89.82 | 95.21 | 0.09 | 0.09 | 0.00 | 2.00 |

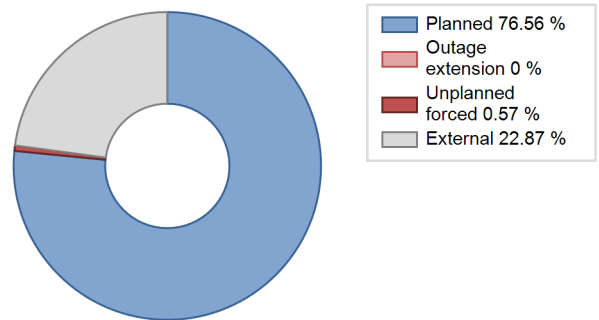
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2021 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| C. Inspection, maintenance or repair combined with refuelling | | | | 424 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 413 | | | 686 |
| L. Human factor related | | 8 | | | 3 | |
| Subtotal | | 8 | 413 | 424 | 3 | 686 |
| Total | | 421 | | | 1113 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2021 to 2023 | |
|-----------------------------|------------|------------|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 420 | | 645 |
| Total | | 420 | | 645 |

Highlights (2023)

At the request of the sate grid,the power was reduced separately for some pe of time

2023 Operating Experience

CN-50

HONGYANHE-6

CHINA

Status at end of year : **Operational**
 Operator : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Owner : LHNPC (Liaoning Hongyanhe Nuclear Power Co. Ltd. (LHNPC))
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)



Reactor Unit Details

Reactor type and model : PWR / ACPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1119 MWe
 Reference unit power (net) : 1061 MWe

Key Dates

Construction Date : 2015-07-24
 Grid Date : 2022-05-02
 Commercial Date : 2022-06-23
 Age at end of year : 1 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : -
 Fuel material : -
 Refuelling type : -
 Moderator material : -
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : -
 Active core diameter [m] : -
 Active core height/length [m] : -
 Number of fissile fuel assemblies/bundles : -
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : -
 Number of external reactor coolant loops : -
 Coolant type : -

Operating coolant pressure [MPa] : -
 Reactor outlet temperature [°C] : -
 Number of SG : -
 Containment type : -
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : -
 Turbine speed [rpm] : -
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : -
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

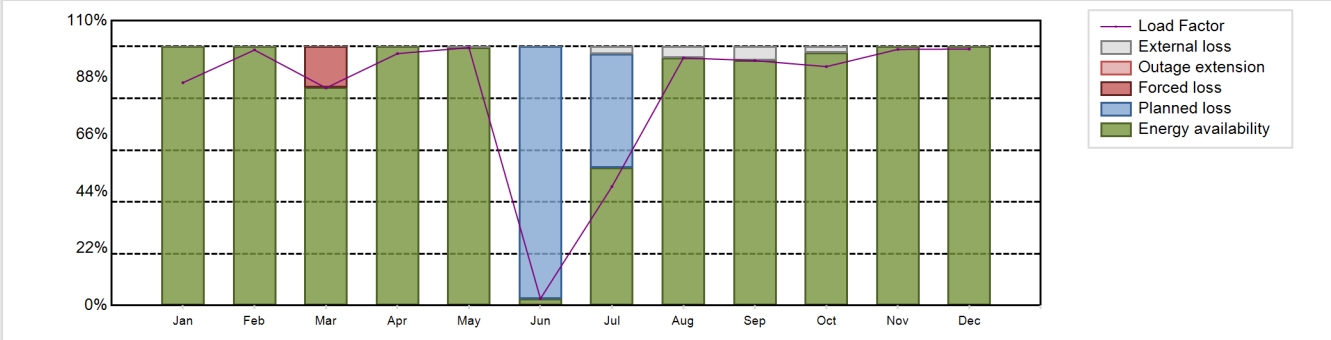
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7701.66 GW(e).h
 Energy Availability Factor (EAF) : 85.63 %
 Unit Capability Factor (UCF) : 86.93 %
 Load Factor (LF) : 82.86 %
 Operating Factor (OF) : 87.45 %

Forced Loss Rate (FLR) : 1.51 %
 Unplanned Capability Loss Factor (UCL) : 1.34 %
 Planned Unavailability Factor (PUF) : 11.74 %
 Externally cause unavailability (XUF) : 1.3 %
 Total off-line time : 1099 hours

Annual Summary

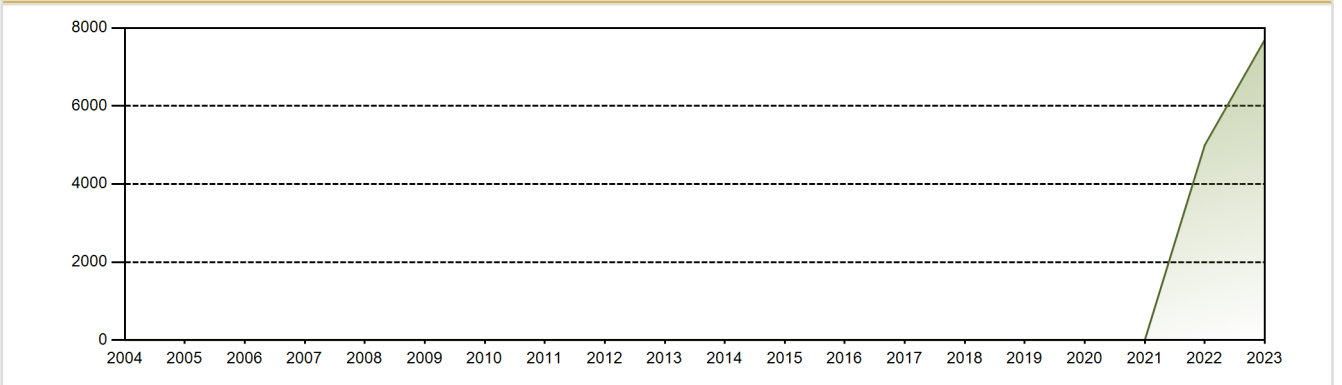


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 679.35 | 703.61 | 663.31 | 743.24 | 786.13 | 20.25 | 362.48 | 754.94 | 722.56 | 728.34 | 755.65 | 781.80 | 7701.66 |
| EAF [%] | 100.00 | 100.00 | 84.28 | 100.00 | 99.59 | 2.65 | 53.09 | 95.64 | 94.59 | 97.66 | 100.00 | 100.00 | 85.63 |
| UCF [%] | 100.00 | 100.00 | 84.28 | 100.00 | 100.00 | 2.65 | 56.02 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.93 |
| LF [%] | 86.06 | 98.68 | 84.03 | 97.29 | 99.59 | 2.65 | 45.92 | 95.64 | 94.59 | 92.27 | 98.92 | 99.04 | 82.86 |
| OF [%] | 100.00 | 100.00 | 85.22 | 100.00 | 100.00 | 3.06 | 60.89 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.45 |
| FLR [%] | 0.00 | 0.00 | 15.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.51 |
| UCL [%] | 0.00 | 0.00 | 15.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.34 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 97.35 | 43.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.74 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.41 | 0.00 | 2.93 | 4.36 | 5.41 | 2.34 | 0.00 | 0.00 | 1.30 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 11938.19 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.05 % |
| Cumulative Energy Availability Factor (EAF) | : 89.72 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.97 % |
| Cumulative Unit Capability Factor (UCF) | : 91.23 % | Cumulative Planned Unavailability Factor (PUF) | : 7.8 % |
| Cumulative Load Factor (LF) | : 82.52 % | Cumulative Externally cause unavailability (XUF) | : 1.5 % |
| Cumulative Operating Factor (OF) | : 87.8 % | | |

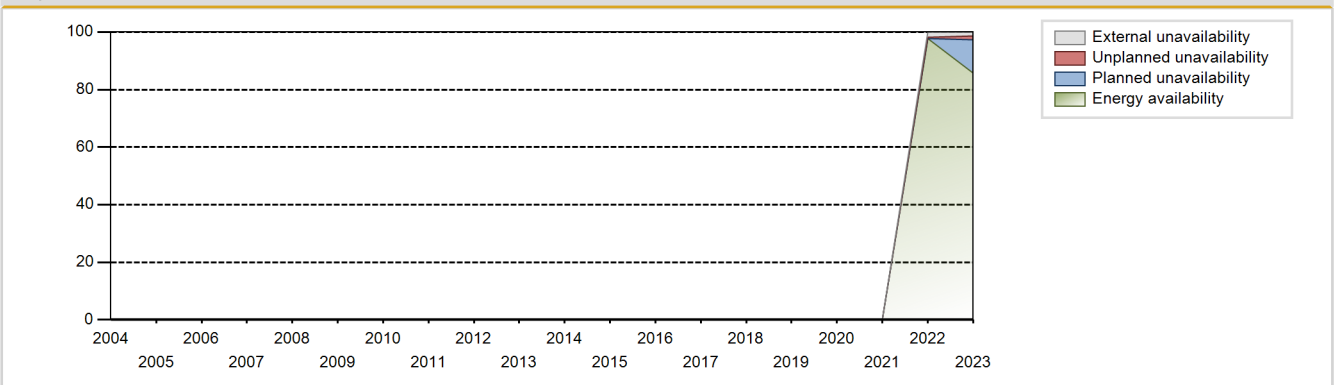
Electricity Production (net) [GWh]



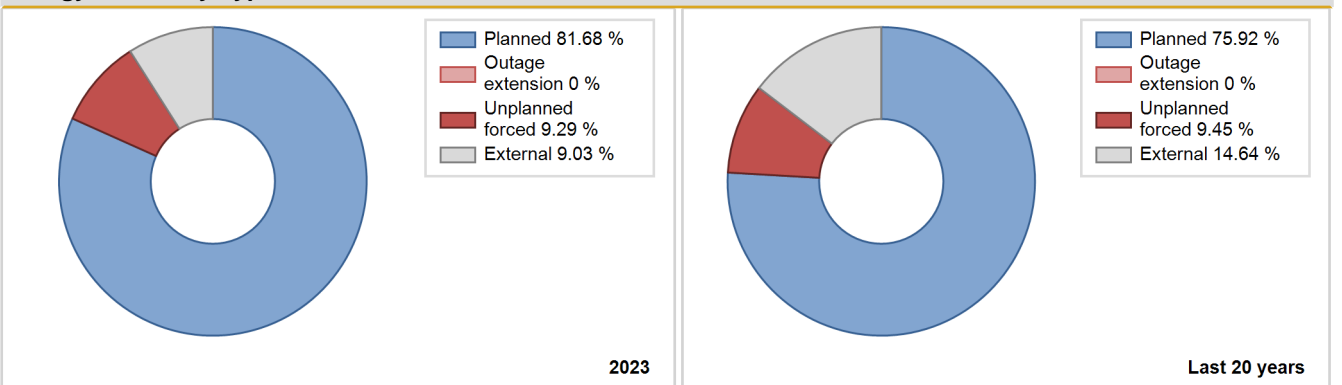
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2022 | 5000.45 | 5007 | 1061 | 97.84 | 99.75 | 81.83 | 88.50 | 0.25 | 0.25 | 0.00 | 1.91 |
| 2023 | 7701.66 | 7661 | 1061 | 85.63 | 86.93 | 82.86 | 87.45 | 1.51 | 1.34 | 11.74 | 1.30 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2022 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 123 | | | 85 | |
| C. Inspection, maintenance or repair combined with refuelling | 989 | | | 659 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 563 |
| Subtotal | 989 | 123 | | 659 | 85 | 563 |
| Total | | 1112 | | | 1307 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2022 to 2023 | |
|-------------------------------------|------------|-----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 507 |
| 32. Feedwater and Main Steam System | | 123 | | 76 |
| Total | | 123 | | 583 |

Highlights (2023)

At the request of the sate grid,the power was reduced separately for some pe of time

2023 Operating Experience

CN-6 **LING AO-1** **CHINA**

Status at end of year : **Operational**
 Operator : DNMC (Daya Bay Nuclear Power Operations and Management Co, Ltd.)
 Owner : LANPC (LINGAO NUCLEAR POWER COMPANY LTD.)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))

Reactor Unit Details

Reactor type and model : PWR / M310
 Thermal power : 2905 MWth
 Gross electrical power : 990 MWe
 Reference unit power (net) : 950 MWe

Key Dates

Construction Date : 1997-05-15
 Grid Date : 2002-02-26
 Commercial Date : 2002-05-28
 Age at end of year : 21 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.45
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 40
 Average discharge burnup [MWd/t] : 46000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.81
 Reactor outlet temperature [°C] : 327.6
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 26
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 2

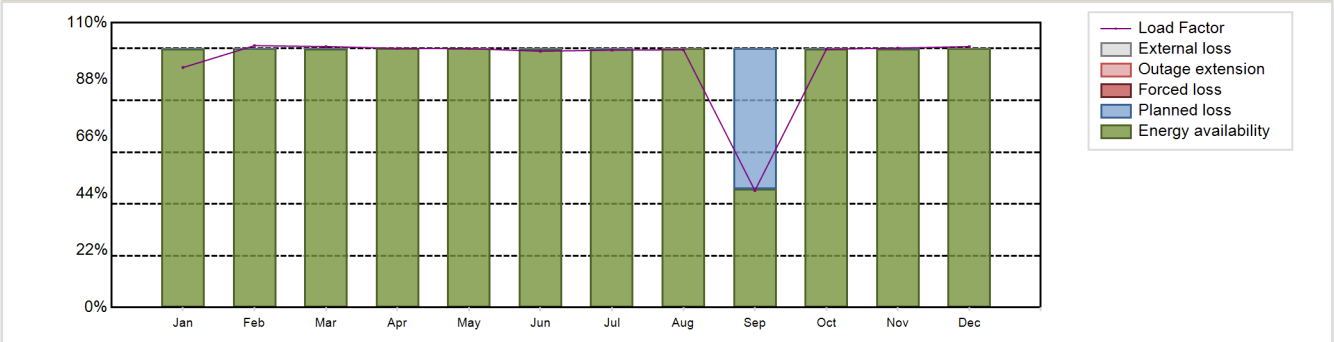
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 7899.06 GW(e).h
 Energy Availability Factor (EAF) : 95.53 %
 Unit Capability Factor (UCF) : 95.53 %
 Load Factor (LF) : 94.92 %
 Operating Factor (OF) : 96.21 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 4.47 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 332 hours

Annual Summary

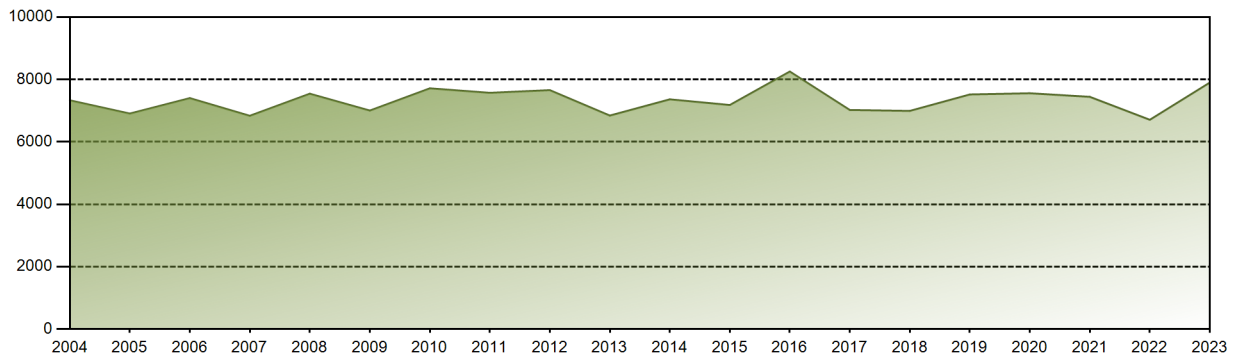


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 655.09 | 645.64 | 712.34 | 684.47 | 706.79 | 677.05 | 702.57 | 703.56 | 308.94 | 705.06 | 685.31 | 712.24 | 7899.06 |
| EAF [%] | 99.94 | 100.00 | 99.98 | 100.00 | 100.00 | 99.96 | 100.00 | 100.00 | 45.78 | 99.94 | 99.98 | 100.00 | 95.53 |
| UCF [%] | 99.94 | 100.00 | 99.98 | 100.00 | 100.00 | 99.96 | 100.00 | 100.00 | 45.78 | 99.94 | 99.98 | 100.00 | 95.53 |
| LF [%] | 92.68 | 101.13 | 100.78 | 100.07 | 100.00 | 98.98 | 99.40 | 99.54 | 45.17 | 99.75 | 100.19 | 100.77 | 94.92 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 53.89 | 100.00 | 100.00 | 100.00 | 96.21 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.06 | 0.00 | 0.02 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 54.22 | 0.06 | 0.02 | 0.00 | 4.47 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 158093.29 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.38 % |
| Cumulative Energy Availability Factor (EAF) | : 89.74 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.96 % |
| Cumulative Unit Capability Factor (UCF) | : 90.07 % | Cumulative Planned Unavailability Factor (PUF) | : 8.96 % |
| Cumulative Load Factor (LF) | : 88.23 % | Cumulative Externally cause unavailability (XUF) | : 0.33 % |
| Cumulative Operating Factor (OF) | : 90.55 % | | |

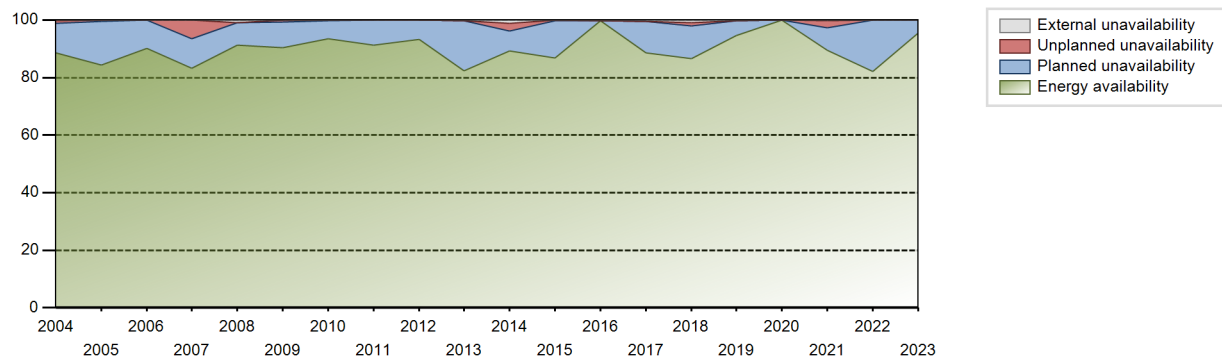
Electricity Production (net) [GWh]



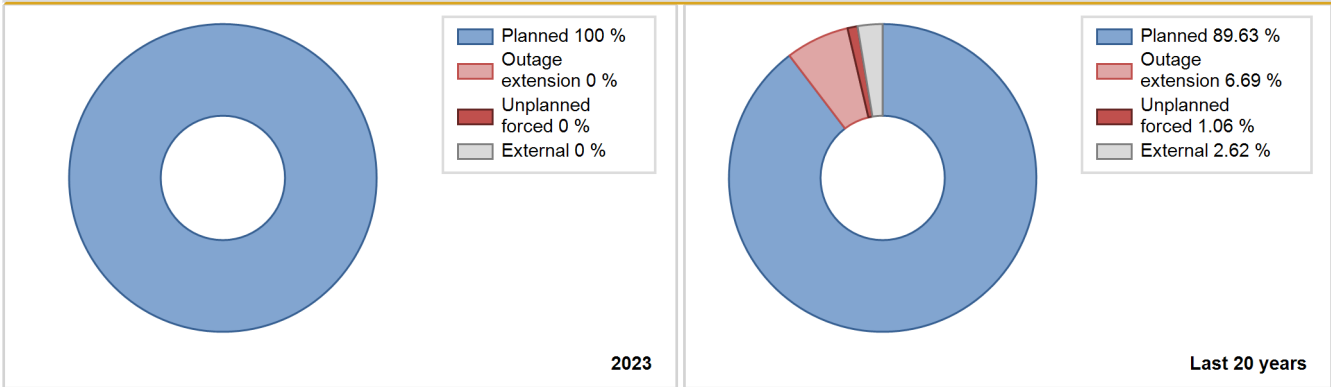
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance Metrics | | | | | | | |
|------|------------------|------------------------|------------------------------|---------------------|---------|--------|--------|---------|---------|---------|---------|
| | | | | EAF [%] | UCF [%] | LF [%] | OF [%] | FLR [%] | UCL [%] | PUF [%] | XUF [%] |
| 2002 | 4583.85 | 5184 | 938 | 95.06 | 95.06 | 93.54 | 99.51 | 0.00 | 0.00 | 4.94 | 0.00 |
| 2003 | 6375.05 | 7215 | 938 | 80.36 | 82.30 | 77.58 | 82.36 | 6.17 | 5.41 | 12.30 | 1.93 |
| 2004 | 7331.36 | 7884 | 938 | 88.69 | 88.95 | 88.98 | 89.75 | 0.51 | 0.91 | 10.13 | 0.26 |
| 2005 | 6906.43 | 7424 | 938 | 84.27 | 84.27 | 84.05 | 84.75 | 0.46 | 0.39 | 15.34 | 0.00 |
| 2006 | 7401.01 | 7964 | 938 | 90.12 | 90.12 | 90.07 | 90.91 | 0.01 | 0.01 | 9.87 | 0.00 |
| 2007 | 6835.04 | 7345 | 938 | 83.18 | 83.18 | 83.18 | 83.85 | 0.00 | 6.58 | 10.24 | 0.00 |
| 2008 | 7542.85 | 8163 | 938 | 91.20 | 92.11 | 91.55 | 92.93 | 0.09 | 0.08 | 7.81 | 0.91 |
| 2009 | 7002.52 | 7997 | 938 | 90.35 | 90.39 | 85.22 | 91.29 | 0.69 | 0.63 | 8.99 | 0.04 |
| 2010 | 7714.57 | 8288 | 938 | 93.60 | 93.66 | 93.89 | 94.61 | 0.18 | 0.17 | 6.18 | 0.05 |
| 2011 | 7571.37 | 8072 | 938 | 91.16 | 91.16 | 92.14 | 92.15 | 0.00 | 0.00 | 8.84 | 0.00 |
| 2012 | 7657.29 | 8286 | 938 | 93.35 | 93.47 | 92.94 | 94.33 | 0.01 | 0.01 | 6.52 | 0.12 |
| 2013 | 6841.69 | 7340 | 950 | 82.46 | 82.80 | 82.30 | 83.79 | 0.03 | 0.02 | 17.18 | 0.34 |
| 2014 | 7361.90 | 7899 | 950 | 89.37 | 90.44 | 88.46 | 90.17 | 0.03 | 2.71 | 6.86 | 1.06 |
| 2015 | 7180.10 | 7656 | 950 | 86.80 | 86.80 | 86.28 | 87.40 | 0.07 | 0.34 | 12.86 | 0.00 |
| 2016 | 8253.13 | 8784 | 950 | 99.66 | 99.98 | 98.90 | 100.00 | 0.01 | 0.01 | 0.02 | 0.31 |
| 2017 | 7020.49 | 7538 | 950 | 88.57 | 89.15 | 84.36 | 86.05 | 0.01 | 0.01 | 10.84 | 0.58 |
| 2018 | 6990.81 | 7667 | 950 | 86.52 | 87.40 | 84.00 | 87.52 | 0.28 | 1.27 | 11.33 | 0.88 |
| 2019 | 7518.48 | 8363 | 950 | 94.72 | 95.04 | 90.34 | 95.47 | 0.00 | 0.00 | 4.96 | 0.33 |
| 2020 | 7556.54 | 8784 | 950 | 99.99 | 99.99 | 90.55 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2021 | 7441.92 | 7896 | 950 | 89.39 | 89.67 | 89.42 | 90.14 | 0.00 | 2.32 | 8.01 | 0.28 |
| 2022 | 6706.96 | 7226 | 950 | 82.02 | 82.03 | 80.59 | 82.49 | 0.00 | 0.00 | 17.97 | 0.01 |
| 2023 | 7899.06 | 8428 | 950 | 95.53 | 95.53 | 94.92 | 96.21 | 0.00 | 0.00 | 4.47 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2002 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 71 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 731 | 11 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 18 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| Z. Other | 350 | | | 17 | | |
| Subtotal | 350 | | | 748 | 82 | 21 |
| Total | | 350 | | | 851 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2002 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 10 |
| 12. Reactor I&C Systems | | 1 |
| 15. Reactor Cooling Systems | | 27 |
| 16. Steam generation systems | | 2 |
| 31. Turbine and auxiliaries | | 2 |
| 42. Electrical Power Supply Systems | | 28 |
| Total | | 70 |

2023 Operating Experience

CN-7

LING AO-2

CHINA

Status at end of year : **Operational**
 Operator : DNMC (Daya Bay Nuclear Power Operations and Management Co, Ltd.)
 Owner : LANPC (LINGAO NUCLEAR POWER COMPANY LTD.)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))

Reactor Unit Details

Reactor type and model : PWR / M310
 Thermal power : 2905 MWth
 Gross electrical power : 990 MWe
 Reference unit power (net) : 950 MWe

Key Dates

Construction Date : 1997-11-28
 Grid Date : 2002-09-14
 Commercial Date : 2003-01-08
 Age at end of year : 21 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.45
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 40
 Average discharge burnup [MWd/t] : 46000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.81
 Reactor outlet temperature [°C] : 327.6
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 26
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 2

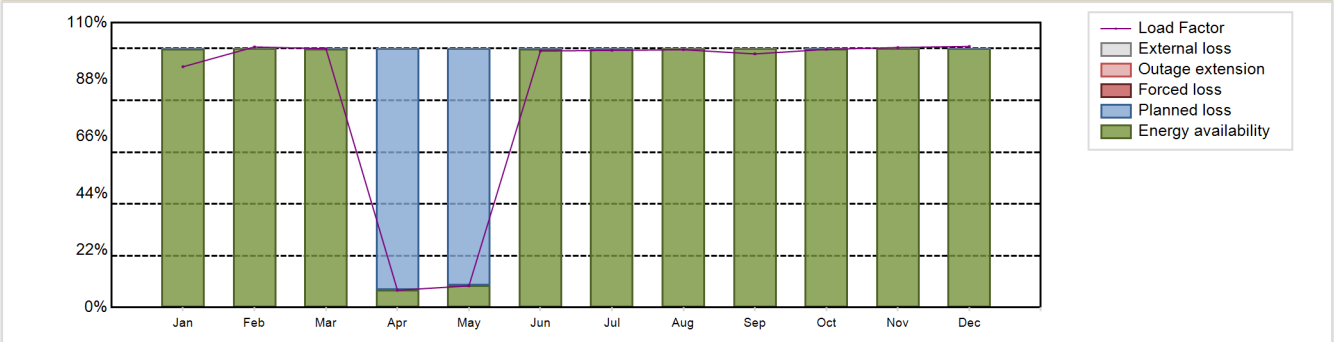
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 6968.32 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 84.56 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 84.56 % | Planned Unavailability Factor (PUF) | : 15.44 % |
| Load Factor (LF) | : 83.73 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 85.08 % | Total off-line time | : 1307 hours |

Annual Summary

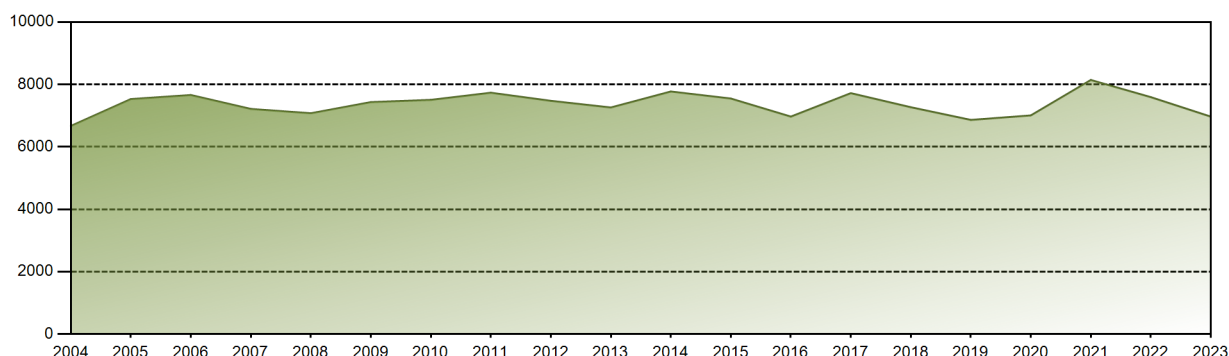


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 657.18 | 642.45 | 706.52 | 45.58 | 59.24 | 677.63 | 701.96 | 703.63 | 669.99 | 704.63 | 686.77 | 712.73 | 6968.32 |
| EAF [%] | 99.98 | 100.00 | 99.97 | 6.77 | 8.65 | 99.90 | 99.96 | 100.00 | 100.00 | 99.98 | 100.00 | 100.00 | 84.56 |
| UCF [%] | 99.98 | 100.00 | 99.97 | 6.77 | 8.65 | 99.90 | 99.96 | 100.00 | 100.00 | 99.98 | 100.00 | 100.00 | 84.56 |
| LF [%] | 92.98 | 100.63 | 99.96 | 6.66 | 8.38 | 99.07 | 99.32 | 99.55 | 97.95 | 99.69 | 100.41 | 100.84 | 83.73 |
| OF [%] | 100.00 | 100.00 | 100.00 | 7.22 | 14.11 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.08 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.02 | 0.00 | 0.03 | 93.23 | 91.35 | 0.10 | 0.04 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 15.44 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 154414.23 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.38 % |
| Cumulative Energy Availability Factor (EAF) | : 90.24 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.39 % |
| Cumulative Unit Capability Factor (UCF) | : 90.55 % | Cumulative Planned Unavailability Factor (PUF) | : 9.06 % |
| Cumulative Load Factor (LF) | : 88.8 % | Cumulative Externally cause unavailability (XUF) | : 0.31 % |
| Cumulative Operating Factor (OF) | : 90.59 % | | |

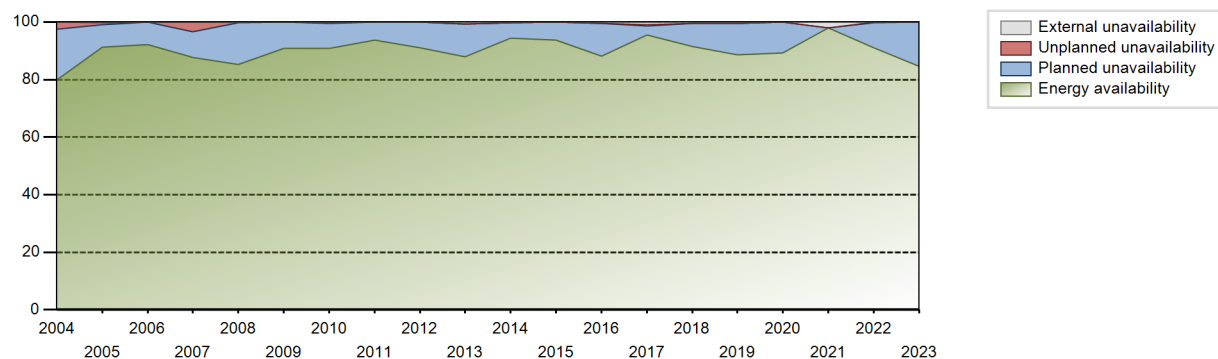
Electricity Production (net) [GWh]



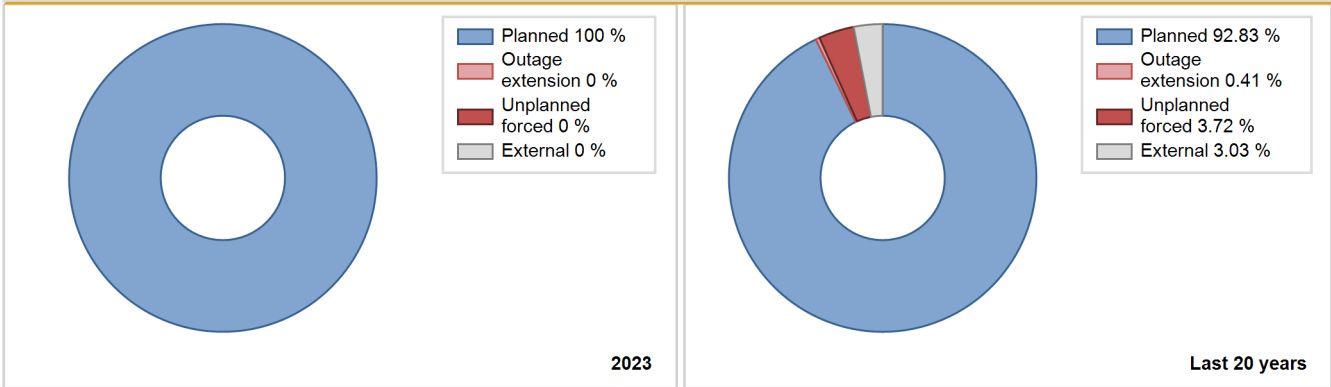
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2003 | 6934.88 | 7494 | 938 | 89.94 | 90.58 | 84.40 | 85.55 | 0.08 | 0.08 | 9.35 | 0.64 |
| 2004 | 6669.41 | 7109 | 938 | 79.80 | 79.85 | 80.95 | 80.93 | 2.01 | 2.33 | 17.82 | 0.05 |
| 2005 | 7530.93 | 8075 | 938 | 91.25 | 91.55 | 91.65 | 92.18 | 0.70 | 0.64 | 7.81 | 0.30 |
| 2006 | 7660.99 | 8164 | 938 | 92.08 | 92.08 | 93.23 | 93.20 | 0.02 | 0.02 | 7.90 | 0.00 |
| 2007 | 7215.07 | 7796 | 938 | 87.81 | 87.81 | 87.81 | 89.00 | 3.81 | 3.47 | 8.72 | 0.00 |
| 2008 | 7077.15 | 7577 | 938 | 85.24 | 85.24 | 85.89 | 86.26 | 0.20 | 0.17 | 14.59 | 0.00 |
| 2009 | 7433.81 | 8052 | 938 | 90.89 | 90.89 | 90.47 | 91.92 | 0.01 | 0.01 | 9.09 | 0.00 |
| 2010 | 7505.55 | 8112 | 938 | 90.84 | 90.84 | 91.34 | 92.60 | 0.58 | 0.53 | 8.63 | 0.00 |
| 2011 | 7734.34 | 8284 | 938 | 93.74 | 93.74 | 94.13 | 94.57 | 0.02 | 0.02 | 6.24 | 0.00 |
| 2012 | 7474.47 | 8113 | 938 | 90.95 | 91.09 | 90.72 | 92.36 | 0.00 | 0.00 | 8.91 | 0.15 |
| 2013 | 7261.33 | 7804 | 950 | 87.91 | 88.62 | 87.25 | 89.09 | 0.02 | 0.02 | 11.36 | 0.71 |
| 2014 | 7773.26 | 8363 | 950 | 94.31 | 94.47 | 93.41 | 95.47 | 0.21 | 0.20 | 5.33 | 0.16 |
| 2015 | 7548.19 | 8114 | 950 | 93.63 | 93.68 | 90.70 | 92.63 | 0.03 | 0.03 | 6.29 | 0.05 |
| 2016 | 6969.06 | 7514 | 950 | 88.13 | 88.66 | 83.51 | 85.54 | 0.07 | 0.06 | 11.28 | 0.53 |
| 2017 | 7720.79 | 8404 | 950 | 95.50 | 96.32 | 92.78 | 95.94 | 0.48 | 0.46 | 3.21 | 0.82 |
| 2018 | 7269.80 | 8108 | 950 | 91.53 | 92.09 | 87.36 | 92.56 | 0.01 | 0.00 | 7.90 | 0.57 |
| 2019 | 6863.24 | 7531 | 950 | 88.63 | 89.17 | 82.47 | 85.97 | 0.00 | 0.00 | 10.83 | 0.54 |
| 2020 | 7007.26 | 7907 | 950 | 89.17 | 89.17 | 83.97 | 90.02 | 0.00 | 0.00 | 10.83 | 0.00 |
| 2021 | 8143.18 | 8760 | 950 | 98.00 | 99.98 | 97.85 | 100.00 | 0.00 | 0.00 | 0.02 | 1.98 |
| 2022 | 7593.07 | 8030 | 950 | 91.11 | 91.14 | 91.24 | 91.67 | 0.00 | 0.12 | 8.74 | 0.03 |
| 2023 | 6968.32 | 7453 | 950 | 84.56 | 84.56 | 83.73 | 85.08 | 0.00 | 0.00 | 15.44 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2003 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 20 | |
| C. Inspection, maintenance or repair combined with refuelling | 1308 | | | 726 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 13 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 42 |
| L. Human factor related | | | | | 0 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 0 | |
| Subtotal | 1308 | | | 739 | 20 | 43 |
| Total | | 1308 | | | 802 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2003 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 1 |
| 13. Reactor Auxiliary Systems | | 1 |
| 31. Turbine and auxiliaries | | 0 |
| 32. Feedwater and Main Steam System | | 2 |
| 33. Circulating Water System | | 1 |
| 41. Main Generator Systems | | 16 |
| Total | | 21 |

2023 Operating Experience

CN-12

LING AO-3

CHINA

Status at end of year : **Operational**
 Operator : DNMC (Daya Bay Nuclear Power Operations and Management Co, Ltd.)
 Owner : LDNPC (Lingdong Nuclear Power Company Ltd.)
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)

Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1086 MWe
 Reference unit power (net) : 1007 MWe

Key Dates

Construction Date : 2005-12-15
 Grid Date : 2010-07-15
 Commercial Date : 2010-09-15
 Age at end of year : 13 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.2
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 40
 Average discharge burnup [MWd/t] : 46000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.81
 Reactor outlet temperature [°C] : 327.6
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 3

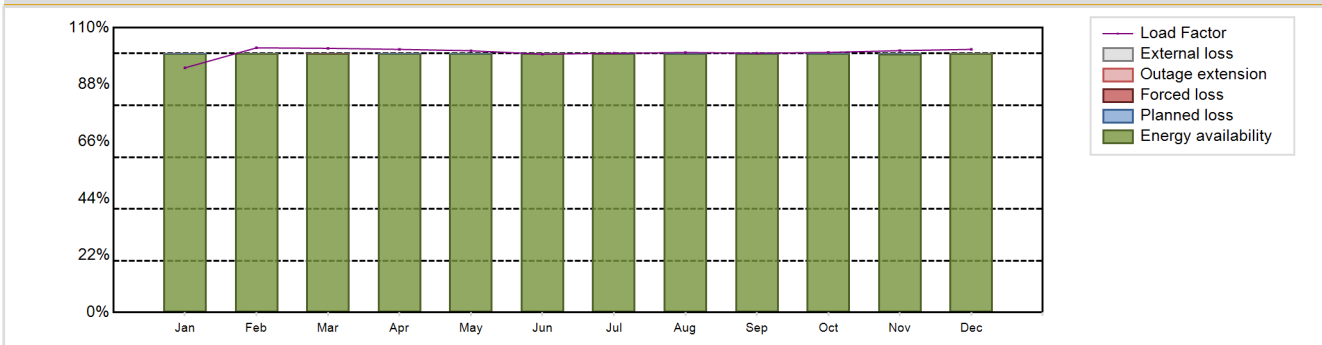
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8857.8 GW(e).h
 Energy Availability Factor (EAF) : 99.99 %
 Unit Capability Factor (UCF) : 99.99 %
 Load Factor (LF) : 100.41 %
 Operating Factor (OF) : 100 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.01 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

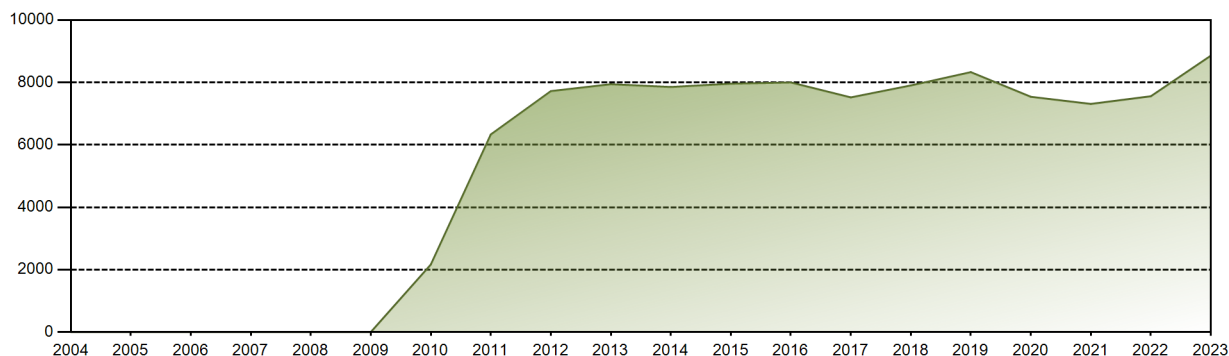


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 707.93 | 691.75 | 764.43 | 736.93 | 757.43 | 723.43 | 750.14 | 752.29 | 726.11 | 752.50 | 733.33 | 761.51 | 8857.80 |
| EAF [%] | 99.99 | 100.00 | 99.99 | 99.99 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.96 | 100.00 | 99.99 |
| UCF [%] | 99.99 | 100.00 | 99.99 | 99.99 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.96 | 100.00 | 99.99 |
| LF [%] | 94.49 | 102.22 | 102.03 | 101.64 | 101.10 | 99.78 | 100.12 | 100.41 | 100.15 | 100.44 | 101.14 | 101.64 | 100.41 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 102443.49 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.72 % |
| Cumulative Energy Availability Factor (EAF) | : 88.7 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.93 % |
| Cumulative Unit Capability Factor (UCF) | : 89 % | Cumulative Planned Unavailability Factor (PUF) | : 10.07 % |
| Cumulative Load Factor (LF) | : 87.18 % | Cumulative Externally cause unavailability (XUF) | : 0.3 % |
| Cumulative Operating Factor (OF) | : 89.38 % | | |

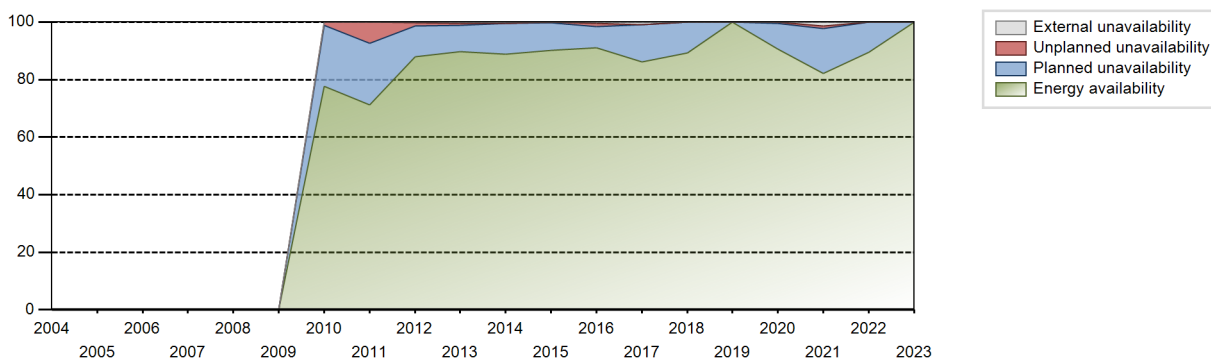
Electricity Production (net) [GWh]



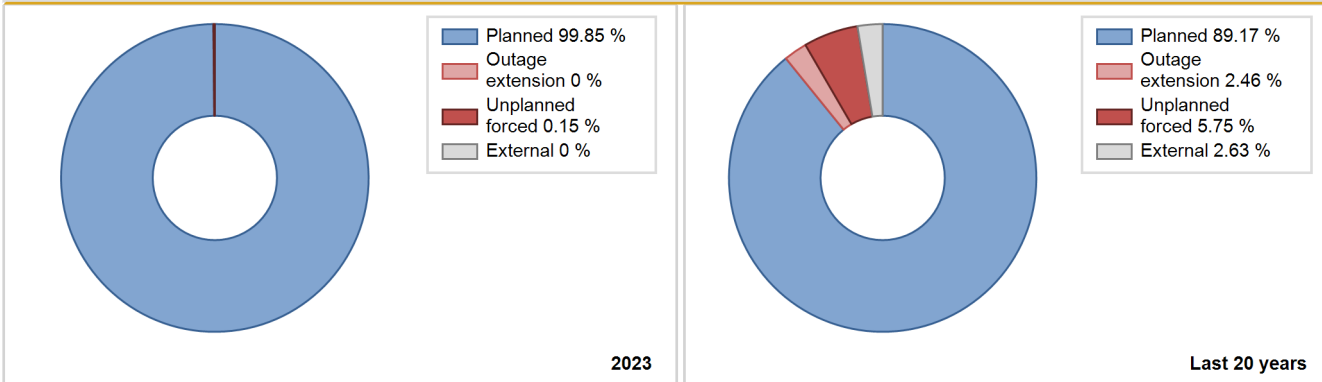
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2010 | 2164.44 | 2642 | 1007 | 77.65 | 77.65 | 62.01 | 64.34 | 1.39 | 1.09 | 21.26 | 0.00 |
| 2011 | 6333.19 | 6866 | 1007 | 71.31 | 71.31 | 71.79 | 78.38 | 7.44 | 7.39 | 21.30 | 0.00 |
| 2012 | 7720.90 | 7877 | 1020 | 88.02 | 88.26 | 86.82 | 89.67 | 1.18 | 1.06 | 10.69 | 0.24 |
| 2013 | 7942.05 | 8017 | 1007 | 89.63 | 90.10 | 90.03 | 91.52 | 0.71 | 0.64 | 9.26 | 0.48 |
| 2014 | 7854.08 | 7901 | 1007 | 88.91 | 89.37 | 89.04 | 90.19 | 0.05 | 0.05 | 10.58 | 0.46 |
| 2015 | 7958.52 | 7969 | 1007 | 90.10 | 90.10 | 90.22 | 90.97 | 0.23 | 0.35 | 9.55 | 0.00 |
| 2016 | 7999.24 | 8004 | 1007 | 91.09 | 91.63 | 90.43 | 91.12 | 0.01 | 1.03 | 7.34 | 0.53 |
| 2017 | 7519.94 | 7668 | 1007 | 86.12 | 86.99 | 85.25 | 87.53 | 0.03 | 0.02 | 12.99 | 0.86 |
| 2018 | 7903.44 | 7865 | 1007 | 89.32 | 89.32 | 89.59 | 89.78 | 0.01 | 0.01 | 10.67 | 0.00 |
| 2019 | 8329.82 | 8760 | 1007 | 99.98 | 99.98 | 94.43 | 100.00 | 0.00 | 0.00 | 0.02 | 0.00 |
| 2020 | 7539.38 | 7987 | 1007 | 90.71 | 90.71 | 85.23 | 90.93 | 0.56 | 0.51 | 8.78 | 0.00 |
| 2021 | 7311.51 | 7347 | 1007 | 82.09 | 83.40 | 82.88 | 83.87 | 0.02 | 0.90 | 15.70 | 1.31 |
| 2022 | 7556.80 | 7558 | 1007 | 89.58 | 89.65 | 85.67 | 86.28 | 0.04 | 0.03 | 10.32 | 0.07 |
| 2023 | 8857.80 | 8760 | 1007 | 99.99 | 99.99 | 100.41 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2010 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 30 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 782 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 73 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 25 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 12 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| Subtotal | | | | 855 | 30 | 39 |
| Total | | 0 | | | 924 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2010 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 6 |
| 15. Reactor Cooling Systems | | 11 |
| 31. Turbine and auxiliaries | | 2 |
| 32. Feedwater and Main Steam System | | 10 |
| 34. Miscellaneous Systems | | 5 |
| 41. Main Generator Systems | | 1 |
| Total | | 35 |

2023 Operating Experience

CN-13

LING AO-4

CHINA

Status at end of year : **Operational**
 Operator : DNMC (Daya Bay Nuclear Power Operations and Management Co, Ltd.)
 Owner : LDNPC (Lingdong Nuclear Power Company Ltd.)
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)

Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1086 MWe
 Reference unit power (net) : 1007 MWe

Key Dates

Construction Date : 2006-06-15
 Grid Date : 2011-05-03
 Commercial Date : 2011-08-07
 Age at end of year : 12 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.2
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 40
 Average discharge burnup [MWd/t] : 46000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.81
 Reactor outlet temperature [°C] : 327.6
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 3

Non-electrical applications

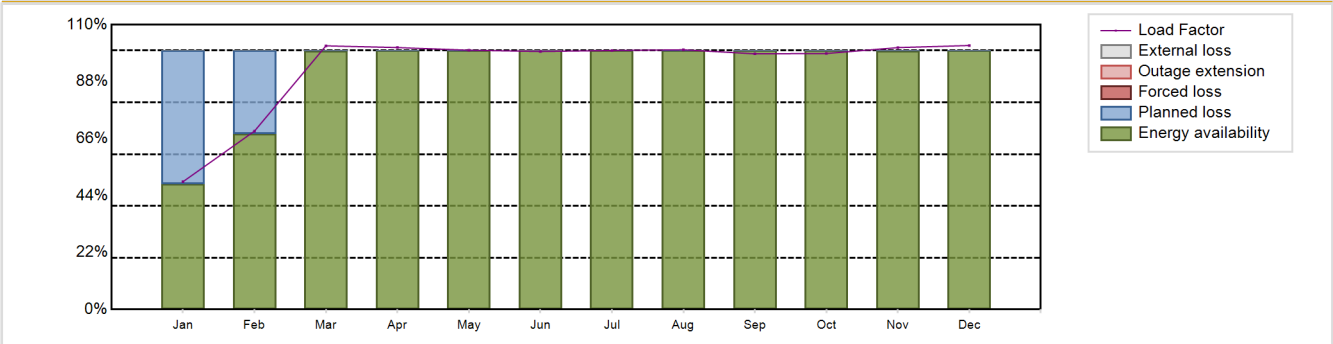
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8260.89 GW(e).h
 Energy Availability Factor (EAF) : 93.15 %
 Unit Capability Factor (UCF) : 93.15 %
 Load Factor (LF) : 93.65 %
 Operating Factor (OF) : 93.94 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 6.85 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 531 hours

Annual Summary

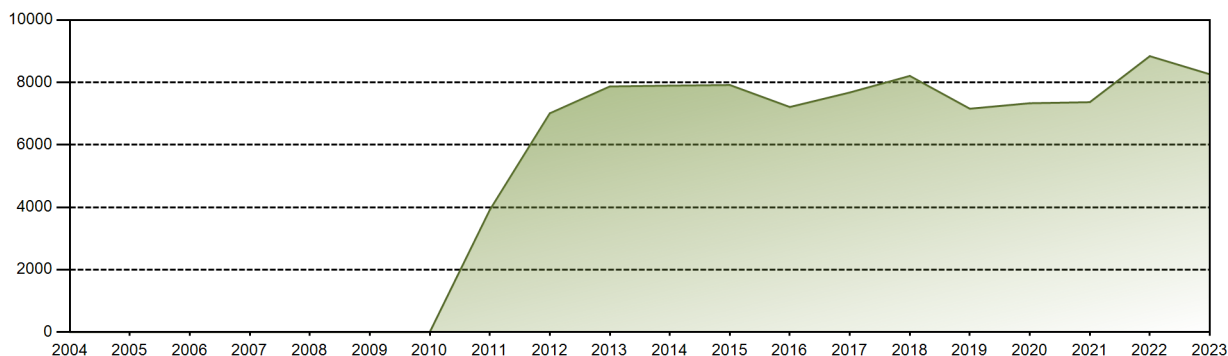


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 369.88 | 466.26 | 763.03 | 733.57 | 750.32 | 722.60 | 749.55 | 751.54 | 715.97 | 740.80 | 733.46 | 763.90 | 8260.89 |
| EAF [%] | 48.55 | 67.85 | 99.97 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 100.00 | 99.96 | 99.99 | 93.15 |
| UCF [%] | 48.55 | 67.85 | 99.97 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 100.00 | 99.96 | 99.99 | 93.15 |
| LF [%] | 49.37 | 68.90 | 101.85 | 101.18 | 100.15 | 99.66 | 100.05 | 100.31 | 98.75 | 98.88 | 101.16 | 101.96 | 93.65 |
| OF [%] | 49.46 | 76.93 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.94 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 51.45 | 32.15 | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.04 | 0.01 | 6.85 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 96297.47 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.21 % |
| Cumulative Energy Availability Factor (EAF) | : 90.5 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.45 % |
| Cumulative Unit Capability Factor (UCF) | : 91.01 % | Cumulative Planned Unavailability Factor (PUF) | : 8.54 % |
| Cumulative Load Factor (LF) | : 87.75 % | Cumulative Externally cause unavailability (XUF) | : 0.51 % |
| Cumulative Operating Factor (OF) | : 90.17 % | | |

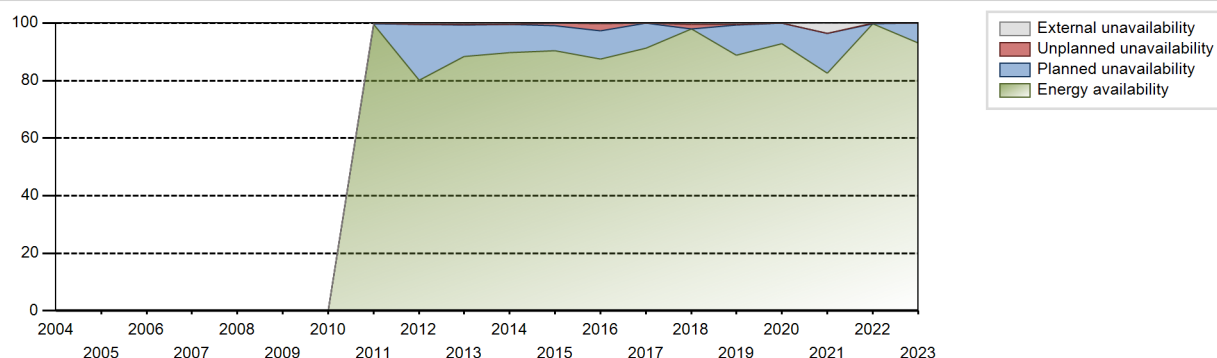
Electricity Production (net) [GWh]



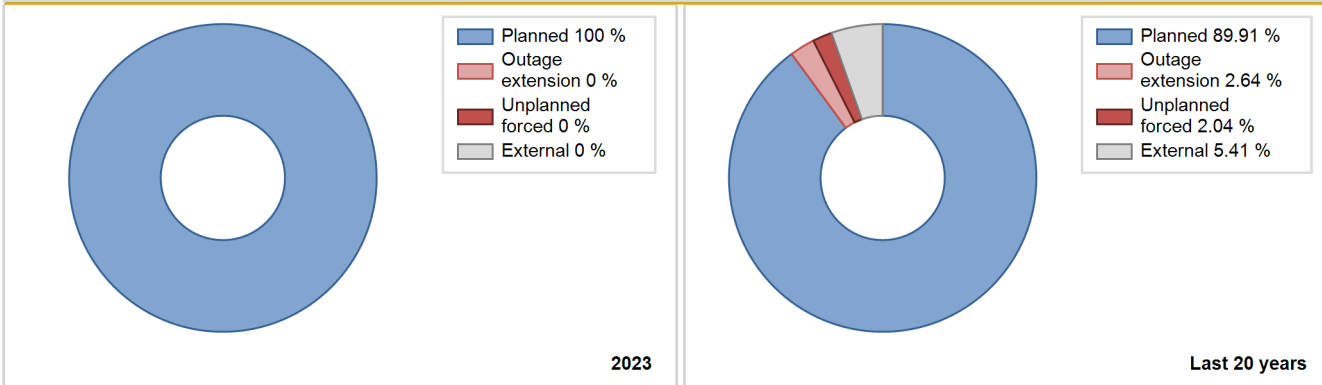
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2011 | 3914.72 | 5268 | 1007 | 99.60 | 99.60 | 96.00 | 100.00 | 0.35 | 0.35 | 0.05 | 0.00 |
| 2012 | 7009.72 | 7156 | 1020 | 80.10 | 80.55 | 78.24 | 81.47 | 0.01 | 0.01 | 19.44 | 0.45 |
| 2013 | 7870.25 | 7880 | 1007 | 88.42 | 88.99 | 89.22 | 89.95 | 0.19 | 0.17 | 10.84 | 0.58 |
| 2014 | 7895.97 | 7972 | 1007 | 89.82 | 90.25 | 89.51 | 91.00 | 0.00 | 0.00 | 9.75 | 0.43 |
| 2015 | 7916.59 | 7963 | 1007 | 90.29 | 90.29 | 89.74 | 90.90 | 0.00 | 0.88 | 8.83 | 0.00 |
| 2016 | 7211.42 | 7329 | 1007 | 87.55 | 87.85 | 81.53 | 83.44 | 0.18 | 2.39 | 9.76 | 0.30 |
| 2017 | 7677.26 | 7668 | 1007 | 91.24 | 91.33 | 87.03 | 87.53 | 0.00 | 0.00 | 8.67 | 0.09 |
| 2018 | 8207.81 | 8447 | 1007 | 97.86 | 98.34 | 93.05 | 96.43 | 1.65 | 1.65 | 0.01 | 0.48 |
| 2019 | 7157.30 | 7588 | 1007 | 88.75 | 89.29 | 81.14 | 86.62 | 0.07 | 0.06 | 10.65 | 0.55 |
| 2020 | 7333.57 | 8185 | 1007 | 92.77 | 92.77 | 82.91 | 93.18 | 0.00 | 0.00 | 7.23 | 0.00 |
| 2021 | 7366.90 | 7331 | 1007 | 82.58 | 86.11 | 83.51 | 83.69 | 0.00 | 0.00 | 13.89 | 3.52 |
| 2022 | 8841.24 | 8744 | 1007 | 99.77 | 99.77 | 100.23 | 99.82 | 0.22 | 0.22 | 0.01 | 0.00 |
| 2023 | 8260.89 | 8229 | 1007 | 93.15 | 93.15 | 93.65 | 93.94 | 0.00 | 0.00 | 6.85 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2011 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 17 | |
| C. Inspection, maintenance or repair combined with refuelling | 559 | | | 706 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 105 |
| L. Human factor related | | | | | 16 | |
| Z. Other | | | | | | 21 |
| Subtotal | 559 | | | 706 | 33 | 126 |
| Total | | 559 | | | 865 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2011 to 2023 | |
|------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 15. Reactor Cooling Systems | | | | 6 |
| 31. Turbine and auxiliaries | | | | 7 |
| 33. Circulating Water System | | | | 2 |
| 34. Miscellaneous Systems | | | | 24 |
| Total | | | | 39 |

2023 Operating Experience

CN-18 **NINGDE-1** **CHINA**

Status at end of year : **Operational**
 Operator : NDNP (Fujian Ningde Nuclear Power Company, Ltd.)
 Owner : NDNP (Fujian Ningde Nuclear Power Company, Ltd.)
 Reactor Supplier : DEC (Dongfang Electric Corporation)
 Turbine Supplier : DEC (Dongfang Electric Corporation)

| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / CPR-1000 | Construction Date | : 2008-02-18 |
| Thermal power | : 2905 MWth | Grid Date | : 2012-12-28 |
| Gross electrical power | : 1089 MWe | Commercial Date | : 2013-04-15 |
| Reference unit power (net) | : 1018 MWe | Age at end of year | : 11 years |

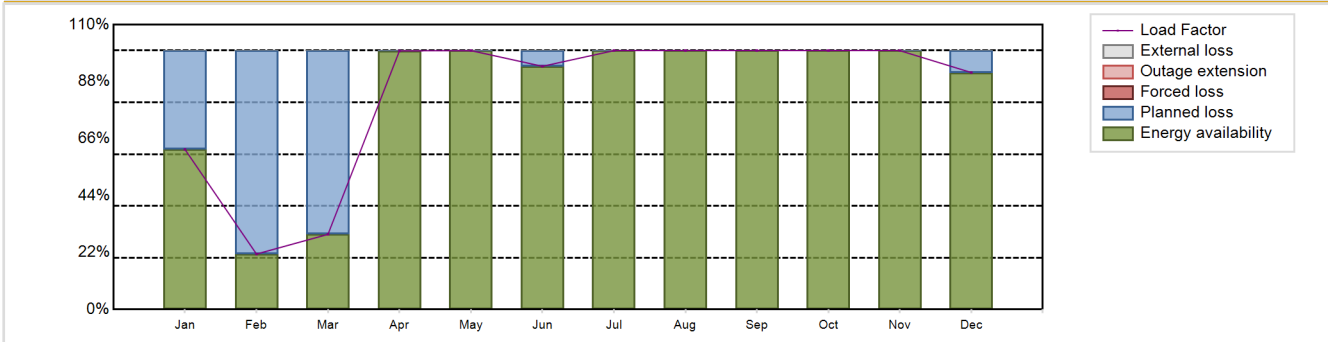
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.5 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 327.6 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 2.43 | Containment design pressure [MPa] | : 0.52 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 44.6 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 44000 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : 2 |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 6.43 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : 24 |
| Fuel linear heat generation rate [kW/m] | : 18.6 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 61 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 3 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 7443.81 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 83.47 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 83.47 % | Planned Unavailability Factor (PUF) | : 16.53 % |
| Load Factor (LF) | : 83.47 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 85.09 % | Total off-line time | : 1306 hours |

Annual Summary

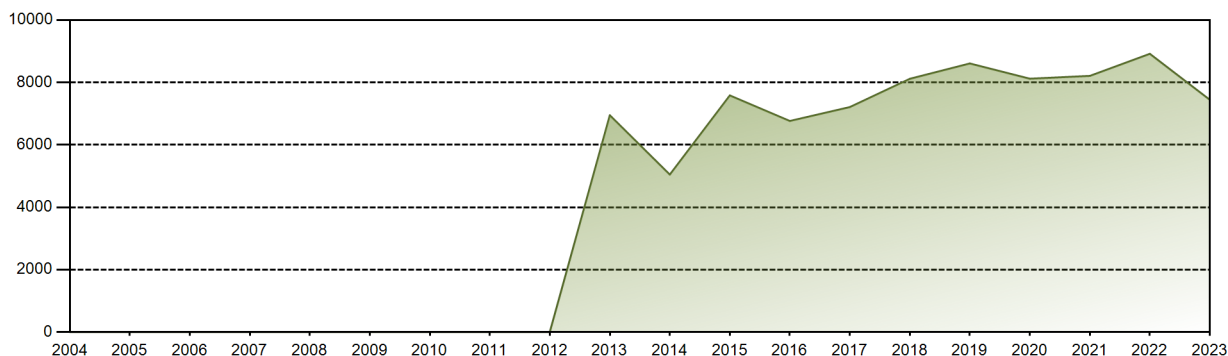


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 468.23 | 146.59 | 219.84 | 732.27 | 757.33 | 688.52 | 757.30 | 757.38 | 732.87 | 757.38 | 732.88 | 693.20 | 7443.81 |
| EAF [%] | 61.82 | 21.43 | 29.03 | 99.91 | 99.99 | 93.94 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 91.53 | 83.47 |
| UCF [%] | 61.82 | 21.43 | 29.03 | 99.91 | 99.99 | 93.94 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 91.53 | 83.47 |
| LF [%] | 61.82 | 21.43 | 29.03 | 99.91 | 99.99 | 93.94 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 91.53 | 83.47 |
| OF [%] | 61.83 | 21.58 | 38.44 | 100.00 | 100.00 | 94.86 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.09 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 38.18 | 78.57 | 70.97 | 0.09 | 0.01 | 6.06 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 8.47 | 16.53 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 82967.84 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.53 % |
| Cumulative Energy Availability Factor (EAF) | : 88.58 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.75 % |
| Cumulative Unit Capability Factor (UCF) | : 88.65 % | Cumulative Planned Unavailability Factor (PUF) | : 8.6 % |
| Cumulative Load Factor (LF) | : 86 % | Cumulative Externally cause unavailability (XUF) | : 0.07 % |
| Cumulative Operating Factor (OF) | : 87.5 % | | |

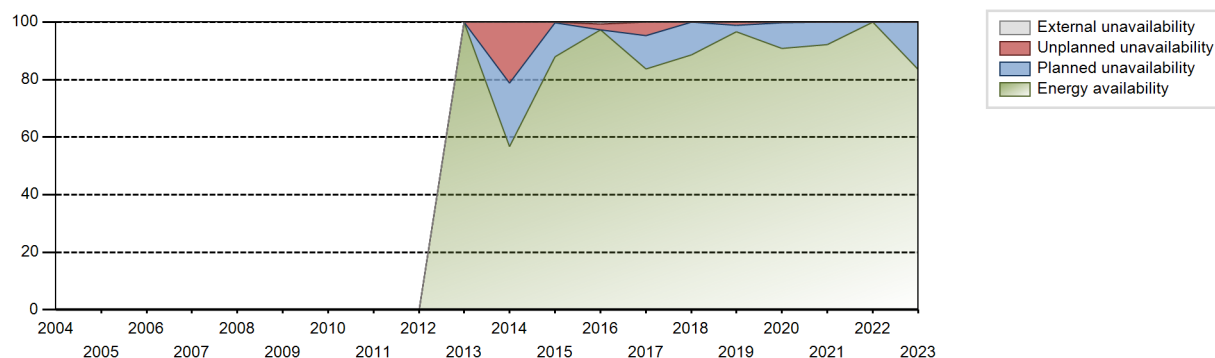
Electricity Production (net) [GWh]



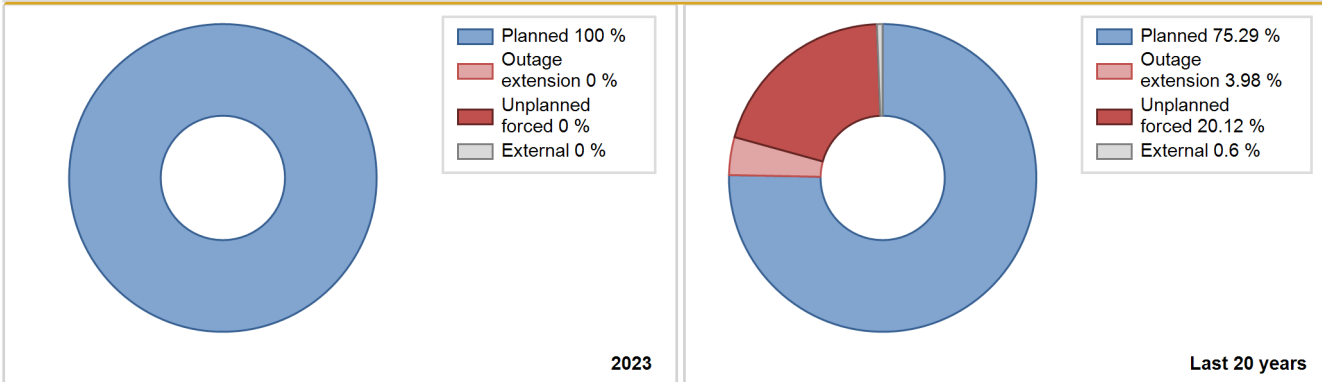
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2013 | 6947.98 | 7369 | 1018 | 99.94 | 99.94 | 96.64 | 99.33 | 0.03 | 0.03 | 0.04 | 0.00 |
| 2014 | 5047.23 | 5119 | 1018 | 56.73 | 56.73 | 56.60 | 58.44 | 23.57 | 21.32 | 21.96 | 0.00 |
| 2015 | 7583.95 | 7798 | 1018 | 88.02 | 88.02 | 85.04 | 89.02 | 0.20 | 0.18 | 11.80 | 0.00 |
| 2016 | 6764.98 | 7207 | 1018 | 97.33 | 98.07 | 75.65 | 82.05 | 1.93 | 1.93 | 0.00 | 0.74 |
| 2017 | 7210.58 | 7177 | 1018 | 83.79 | 83.79 | 80.86 | 81.93 | 4.26 | 4.80 | 11.40 | 0.00 |
| 2018 | 8116.45 | 7756 | 1018 | 88.50 | 88.50 | 91.02 | 88.54 | 0.00 | 0.00 | 11.50 | 0.00 |
| 2019 | 8608.23 | 8567 | 1018 | 96.53 | 96.53 | 96.53 | 97.80 | 1.09 | 1.07 | 2.40 | 0.00 |
| 2020 | 8119.41 | 8007 | 1018 | 90.80 | 90.80 | 90.80 | 91.15 | 0.33 | 0.30 | 8.90 | 0.00 |
| 2021 | 8209.23 | 8070 | 1018 | 92.06 | 92.06 | 92.06 | 92.12 | 0.00 | 0.00 | 7.94 | 0.00 |
| 2022 | 8917.03 | 8760 | 1018 | 99.99 | 99.99 | 99.99 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2023 | 7443.81 | 7454 | 1018 | 83.47 | 83.47 | 83.47 | 85.09 | 0.00 | 0.00 | 16.53 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2013 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 193 | |
| C. Inspection, maintenance or repair combined with refuelling | 1263 | | | 708 | | |
| D. Inspection, maintenance or repair without refuelling | 37 | | | 3 | | |
| H. Nuclear regulatory requirements | | | | | 29 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 152 |
| M. Governmental requirements or court decisions | | | | | | 1 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 9 | |
| Subtotal | 1300 | | | 711 | 231 | 153 |
| Total | | 1300 | | | 1095 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2013 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 16. Steam generation systems | | 5 |
| 31. Turbine and auxiliaries | | 136 |
| 32. Feedwater and Main Steam System | | 15 |
| 41. Main Generator Systems | | 9 |
| 42. Electrical Power Supply Systems | | 23 |
| Total | | 188 |

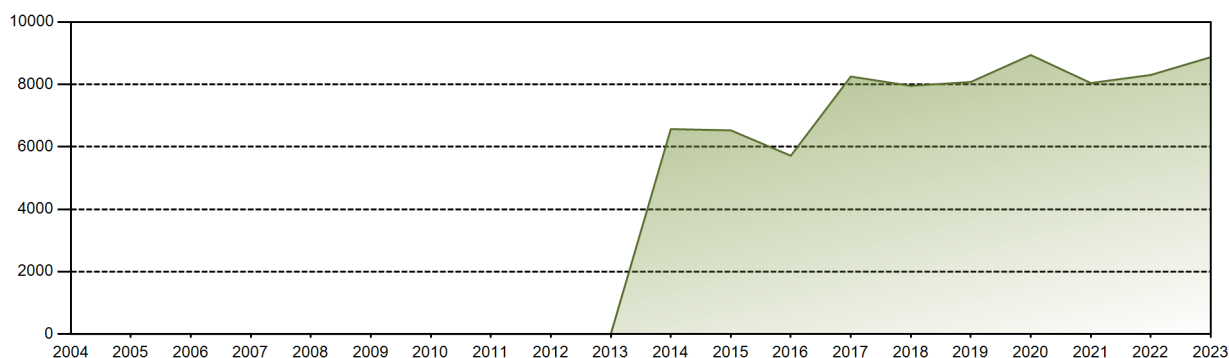
2023 Operating Experience

| CN-19 | | NINGDE-2 | | CHINA | | | | | | | | | |
|---|--|-----------------|--|--------|--------------------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : NDNP (Fujian Ningde Nuclear Power Company, Ltd.) | | | | | | | | | | | | |
| Owner | : NDNP (Fujian Ningde Nuclear Power Company, Ltd.) | | | | | | | | | | | | |
| Reactor Supplier | : SHE (Shanghai Electric) | | | | | | | | | | | | |
| Turbine Supplier | : DEC (Dongfang Electric Corporation) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PWR / CPR-1000 | Construction Date | : | 2008-11-12 | | | | | | | | |
| Thermal power | : | 2905 MWth | Grid Date | : | 2014-01-04 | | | | | | | | |
| Gross electrical power | : | 1089 MWe | Commercial Date | : | 2014-05-04 | | | | | | | | |
| Reference unit power (net) | : | 1018 MWe | Age at end of year | : | 9 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | : | 15.5 | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Reactor outlet temperature [°C] | : | 327.6 | | | | | | | | |
| Fuel material | : | UO2 | Number of SG | : | 3 | | | | | | | | |
| Refuelling type | : | OFF-line | Containment type | : | Single | | | | | | | | |
| Moderator material | : | H2O | Containment design pressure [MPa] | : | 0.52 | | | | | | | | |
| Average fuel enrichment [% of U235] | : | 2.43 | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : | 18 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Part of the core refuelled [%] | : | 44.6 | Turbine speed [rpm] | : | 1500 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | 44000 | Number of LP cylinders per turbine | : | 2 | | | | | | | | |
| Active core diameter [m] | : | 3.04 | HP cylinder inlet steam pressure [MPa] | : | 6.43 | | | | | | | | |
| Active core height/length [m] | : | 3.66 | Output voltage [kV] | : | 24 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 157 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 18.6 | Number of main condensate pumps | : | 3 | | | | | | | | |
| Number of control rod assemblies | : | 61 | Number of FW pumps for full power operation | : | 2 | | | | | | | | |
| Number of external reactor coolant loops | : | 3 | Number of on-site safety related diesel generators | : | 3 | | | | | | | | |
| Coolant type | : | H2O | Non-electrical applications | | | | | | | | | | |
| | | | | | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 8874.52 GW(e).h | Forced Loss Rate (FLR) | : | 0.48 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 99.52 % | Unplanned Capability Loss Factor (UCL) | : | 0.48 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 99.52 % | Planned Unavailability Factor (PUF) | : | 0.01 % | | | | | | | | |
| Load Factor (LF) | : | 99.52 % | Externally cause unavailability (XUF) | : | 0 % | | | | | | | | |
| Operating Factor (OF) | : | 99.52 % | Total off-line time | : | 42 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 757.33 | 684.09 | 757.29 | 690.47 | 757.30 | 732.82 | 757.37 | 757.31 | 732.96 | 757.30 | 732.96 | 757.31 | 8874.52 |
| EAF [%] | 99.99 | 100.00 | 99.99 | 94.20 | 99.99 | 99.98 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 99.52 |
| UCF [%] | 99.99 | 100.00 | 99.99 | 94.20 | 99.99 | 99.98 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 99.52 |
| LF [%] | 99.99 | 100.00 | 99.99 | 94.20 | 99.99 | 99.98 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 99.52 |
| OF [%] | 100.00 | 100.00 | 100.00 | 94.17 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.52 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 5.79 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 5.79 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 |
| PUF [%] | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 77259.23 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.29 % |
| Cumulative Energy Availability Factor (EAF) | : 92.54 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.41 % |
| Cumulative Unit Capability Factor (UCF) | : 92.56 % | Cumulative Planned Unavailability Factor (PUF) | : 7.03 % |
| Cumulative Load Factor (LF) | : 88.69 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 91.09 % | | |

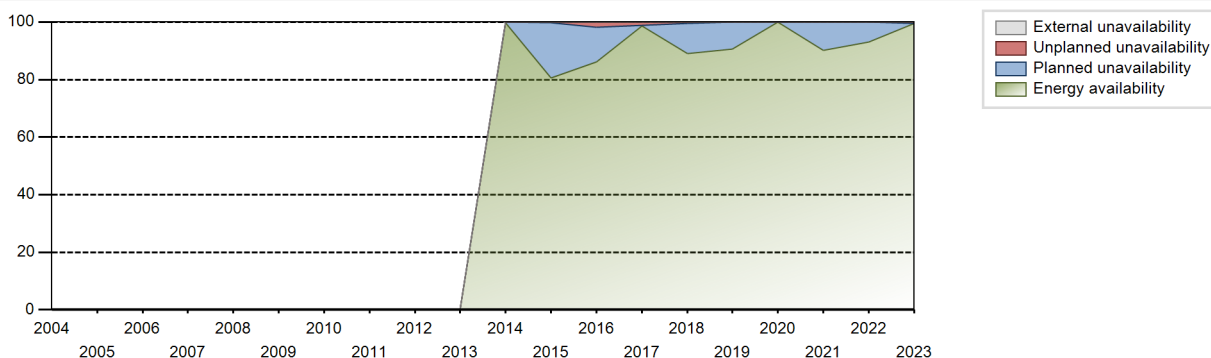
Electricity Production (net) [GWh]



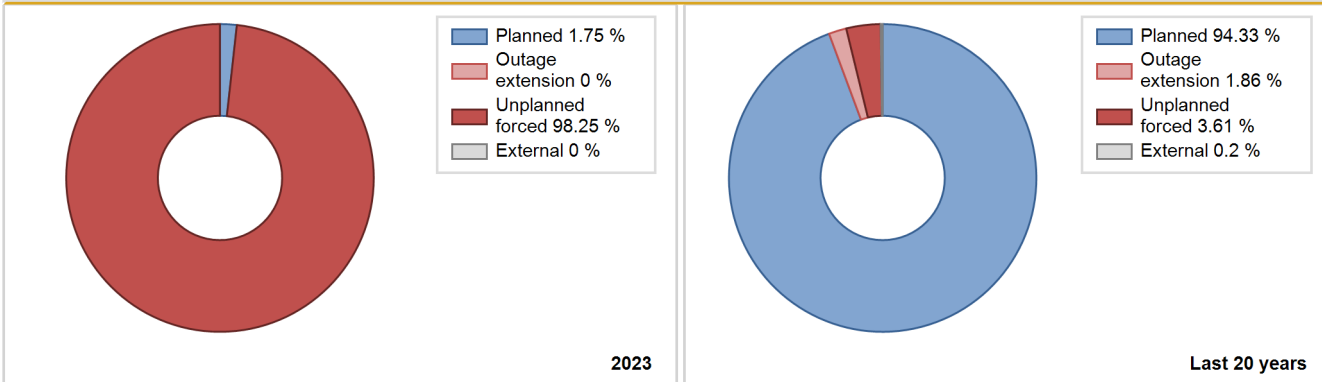
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2014 | 6568.05 | 7044 | 1018 | 99.85 | 99.85 | 97.55 | 100.00 | 0.02 | 0.01 | 0.14 | 0.00 |
| 2015 | 6528.23 | 7145 | 1018 | 80.58 | 80.58 | 73.21 | 81.56 | 0.22 | 0.18 | 19.24 | 0.00 |
| 2016 | 5714.85 | 6290 | 1018 | 86.24 | 86.39 | 63.91 | 71.61 | 0.32 | 1.62 | 12.00 | 0.14 |
| 2017 | 8252.86 | 8371 | 1018 | 98.72 | 98.72 | 92.54 | 95.56 | 1.26 | 1.26 | 0.02 | 0.00 |
| 2018 | 7953.87 | 7938 | 1018 | 89.03 | 89.03 | 89.19 | 90.62 | 0.44 | 0.40 | 10.57 | 0.00 |
| 2019 | 8079.09 | 8026 | 1018 | 90.60 | 90.60 | 90.60 | 91.62 | 0.01 | 0.00 | 9.40 | 0.00 |
| 2020 | 8940.50 | 8784 | 1018 | 99.98 | 99.98 | 99.98 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2021 | 8043.49 | 7904 | 1018 | 90.20 | 90.20 | 90.20 | 90.23 | 0.00 | 0.00 | 9.80 | 0.00 |
| 2022 | 8303.72 | 8158 | 1018 | 93.12 | 93.12 | 93.12 | 93.13 | 0.00 | 0.00 | 6.88 | 0.00 |
| 2023 | 8874.52 | 8718 | 1018 | 99.52 | 99.52 | 99.52 | 99.52 | 0.48 | 0.48 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2014 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 42 | | | 4 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 583 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 182 |
| Z. Other | | | | | 12 | |
| Subtotal | | 42 | | 583 | 16 | 182 |
| Total | | 42 | | | 781 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2014 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|---|
| | Hours Lost | | Average hours lost per reactor-year | |
| 32. Feedwater and Main Steam System | | 42 | | 4 |
| Total | | 42 | | 4 |

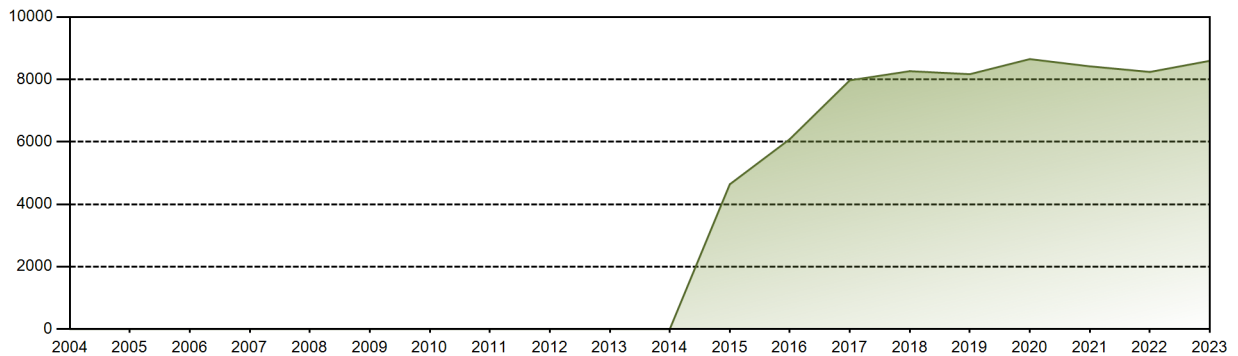
2023 Operating Experience

| CN-34 | | NINGDE-3 | | CHINA | | | | | | | | | |
|---|--|--|----------------------------------|--------------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : NDNF (Fujian Ningde Nuclear Power Company, Ltd.) | | | | | | | | | | | | |
| Owner | : NDNF (Fujian Ningde Nuclear Power Company, Ltd.) | | | | | | | | | | | | |
| Reactor Supplier | : CFHI (China First Heavy Industries) | | | | | | | | | | | | |
| Turbine Supplier | : DEC (Dongfang Electric Corporation) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : PWR / CPR-1000 | Construction Date | : 2010-01-08 | | | | | | | | | | |
| Thermal power | : 2905 MWth | Grid Date | : 2015-03-21 | | | | | | | | | | |
| Gross electrical power | : 1089 MWe | Commercial Date | : 2015-06-10 | | | | | | | | | | |
| Reference unit power (net) | : 1018 MWe | Age at end of year | : 8 years | | | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | : | 15.5 | | | | | | | | |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : | 327.6 | | | | | | | | | |
| Fuel material | : UO2 | Number of SG | : | 3 | | | | | | | | | |
| Refuelling type | : OFF-line | Containment type | : | Single | | | | | | | | | |
| Moderator material | : H2O | Containment design pressure [MPa] | : | 0.52 | | | | | | | | | |
| Average fuel enrichment [% of U235] | : 2.43 | Secondary systems | | | | | | | | | | | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | | |
| Part of the core refuelled [%] | : 44.6 | Turbine speed [rpm] | : | 1500 | | | | | | | | | |
| Average discharge burnup [MWd/t] | : 44000 | Number of LP cylinders per turbine | : | 2 | | | | | | | | | |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : | 6.43 | | | | | | | | | |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : | 24 | | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : 18.6 | Number of main condensate pumps | : | 3 | | | | | | | | | |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : | 2 | | | | | | | | | |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : | 3 | | | | | | | | | |
| Coolant type | : H2O | Non-electrical applications | | | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : 8595.73 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | | |
| Energy Availability Factor (EAF) | : 96.39 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | | |
| Unit Capability Factor (UCF) | : 96.39 % | Planned Unavailability Factor (PUF) | : | 3.61 % | | | | | | | | | |
| Load Factor (LF) | : 96.39 % | Externally cause unavailability (XUF) | : | 0 % | | | | | | | | | |
| Operating Factor (OF) | : 96.47 % | Total off-line time | : | 309 hours | | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 757.38 | 684.03 | 757.33 | 732.95 | 757.32 | 732.95 | 757.34 | 757.02 | 732.89 | 757.35 | 732.93 | 436.24 | 8595.73 |
| EAF [%] | 100.00 | 99.99 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 99.95 | 99.99 | 99.99 | 100.00 | 57.60 | 96.39 |
| UCF [%] | 100.00 | 99.99 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 99.95 | 99.99 | 99.99 | 100.00 | 57.60 | 96.39 |
| LF [%] | 100.00 | 99.99 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 99.95 | 99.99 | 99.99 | 100.00 | 57.60 | 96.39 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 58.47 | 96.47 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.05 | 0.01 | 0.01 | 0.00 | 42.40 | 3.61 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 68425.73 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.68 % |
| Cumulative Energy Availability Factor (EAF) | : 92.52 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.63 % |
| Cumulative Unit Capability Factor (UCF) | : 92.53 % | Cumulative Planned Unavailability Factor (PUF) | : 6.85 % |
| Cumulative Load Factor (LF) | : 89.56 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 91.57 % | | |

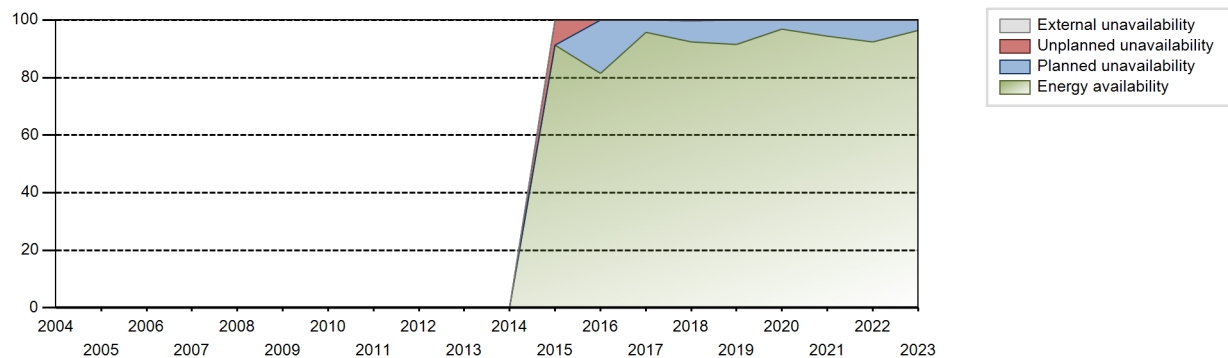
Electricity Production (net) [GWh]



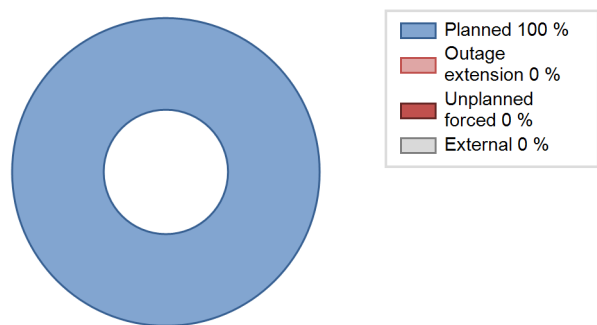
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2015 | 4638.75 | 5586 | 1018 | 91.25 | 91.25 | 80.88 | 92.85 | 8.74 | 8.74 | 0.01 | 0.00 |
| 2016 | 6086.41 | 6514 | 1018 | 81.37 | 81.37 | 68.06 | 74.16 | 0.02 | 0.02 | 18.62 | 0.00 |
| 2017 | 7971.03 | 8107 | 1018 | 95.64 | 95.64 | 89.38 | 92.55 | 0.01 | 0.00 | 4.35 | 0.00 |
| 2018 | 8264.16 | 8141 | 1018 | 92.40 | 92.44 | 92.67 | 92.93 | 0.28 | 0.26 | 7.29 | 0.05 |
| 2019 | 8167.27 | 8075 | 1018 | 91.59 | 91.59 | 91.59 | 92.18 | 0.00 | 0.00 | 8.41 | 0.00 |
| 2020 | 8650.70 | 8501 | 1018 | 96.74 | 96.74 | 96.74 | 96.78 | 0.00 | 0.00 | 3.26 | 0.00 |
| 2021 | 8418.61 | 8271 | 1018 | 94.40 | 94.40 | 94.40 | 94.42 | 0.00 | 0.00 | 5.60 | 0.00 |
| 2022 | 8239.00 | 8094 | 1018 | 92.39 | 92.39 | 92.39 | 92.40 | 0.00 | 0.00 | 7.61 | 0.00 |
| 2023 | 8595.73 | 8451 | 1018 | 96.39 | 96.39 | 96.39 | 96.47 | 0.00 | 0.00 | 3.61 | 0.00 |

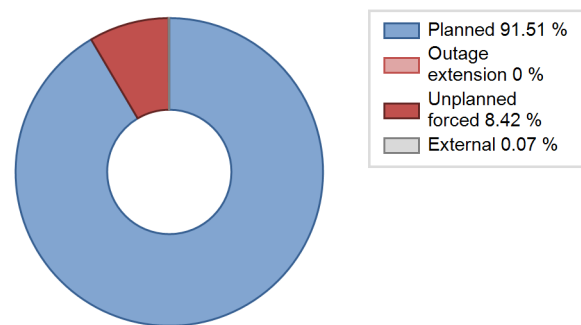
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2015 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 17 | |
| C. Inspection, maintenance or repair combined with refuelling | 309 | | | 584 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 109 |
| L. Human factor related | | | | | 32 | |
| Subtotal | 309 | | | 584 | 49 | 109 |
| Total | | 309 | | | 742 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2015 to 2023 | |
|------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 32 |
| 31. Turbine and auxiliaries | | | | 5 |
| 33. Circulating Water System | | | | 11 |
| Total | | | | 48 |

2023 Operating Experience

CN-35

NINGDE-4

CHINA

Status at end of year : **Operational**
 Operator : NDNP (Fujian Ningde Nuclear Power Company, Ltd.)
 Owner : NDNP (Fujian Ningde Nuclear Power Company, Ltd.)
 Reactor Supplier : CFHI (China First Heavy Industries)
 Turbine Supplier : DEC (Dongfang Electric Corporation)

Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1089 MWe
 Reference unit power (net) : 1018 MWe

Key Dates

Construction Date : 2010-09-29
 Grid Date : 2016-03-29
 Commercial Date : 2016-07-21
 Age at end of year : 7 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.43
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 44.6
 Average discharge burnup [MWd/t] : 44000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.6
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

Non-electrical applications

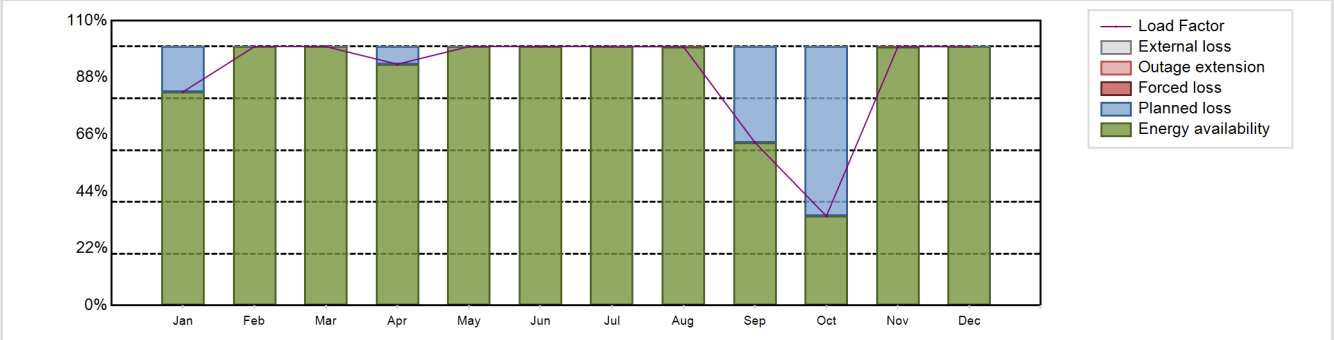
: none

Annual Production Results (2023)

Net Energy Production : 7967.67 GW(e).h
 Energy Availability Factor (EAF) : 89.35 %
 Unit Capability Factor (UCF) : 89.35 %
 Load Factor (LF) : 89.35 %
 Operating Factor (OF) : 90.34 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 10.65 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 846 hours

Annual Summary

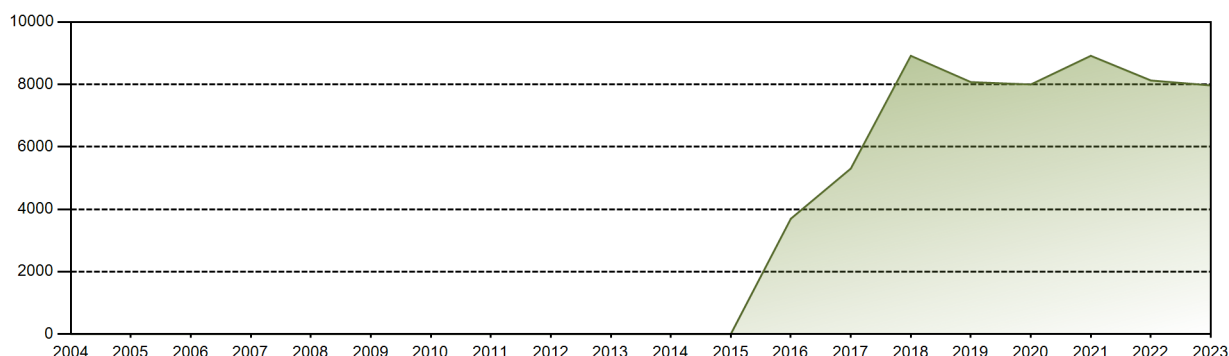


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 625.05 | 684.09 | 757.32 | 683.18 | 757.37 | 732.92 | 757.37 | 757.23 | 461.66 | 261.58 | 732.57 | 757.34 | 7967.67 |
| EAF [%] | 82.53 | 100.00 | 99.99 | 93.21 | 100.00 | 99.99 | 100.00 | 99.98 | 62.99 | 34.54 | 99.95 | 99.99 | 89.35 |
| UCF [%] | 82.53 | 100.00 | 99.99 | 93.21 | 100.00 | 99.99 | 100.00 | 99.98 | 62.99 | 34.54 | 99.95 | 99.99 | 89.35 |
| LF [%] | 82.53 | 100.00 | 99.99 | 93.21 | 100.00 | 99.99 | 100.00 | 99.98 | 62.99 | 34.54 | 99.95 | 99.99 | 89.35 |
| OF [%] | 82.53 | 100.00 | 100.00 | 93.19 | 100.00 | 100.00 | 100.00 | 100.00 | 63.89 | 45.30 | 100.00 | 100.00 | 90.34 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 17.47 | 0.00 | 0.01 | 6.79 | 0.00 | 0.01 | 0.00 | 0.01 | 37.01 | 65.46 | 0.05 | 0.01 | 10.65 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|-----------------|---|----------|
| Lifetime energy generation | : 58999 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.02 % |
| Cumulative Energy Availability Factor (EAF) | : 92.55 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.02 % |
| Cumulative Unit Capability Factor (UCF) | : 92.55 % | Cumulative Planned Unavailability Factor (PUF) | : 7.43 % |
| Cumulative Load Factor (LF) | : 88.74 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 90.29 % | | |

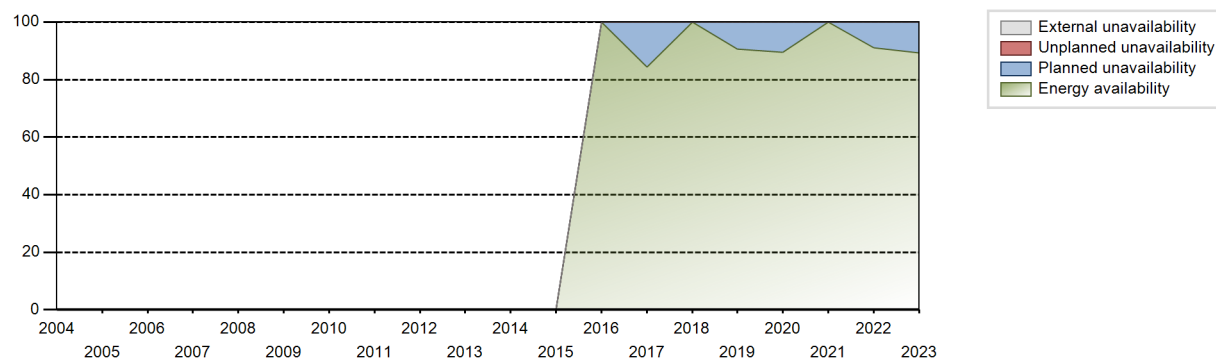
Electricity Production (net) [GWh]



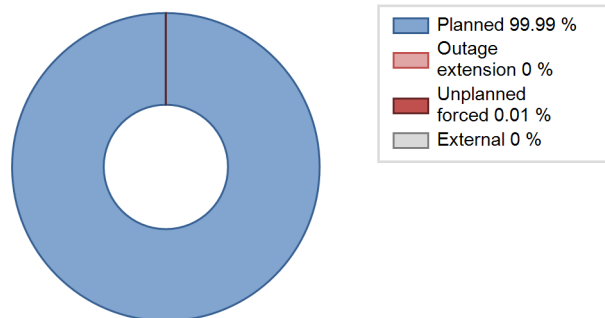
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 3694.87 | 3786 | 1018 | 99.87 | 99.87 | 91.83 | 95.92 | 0.12 | 0.12 | 0.00 | 0.00 |
| 2017 | 5303.77 | 5739 | 1018 | 84.33 | 84.33 | 59.47 | 65.51 | 0.12 | 0.10 | 15.57 | 0.00 |
| 2018 | 8917.08 | 8760 | 1018 | 99.99 | 99.99 | 99.99 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2019 | 8074.33 | 7992 | 1018 | 90.54 | 90.54 | 90.54 | 91.23 | 0.00 | 0.00 | 9.46 | 0.00 |
| 2020 | 7998.17 | 8033 | 1018 | 89.45 | 89.45 | 89.44 | 91.45 | 0.00 | 0.00 | 10.55 | 0.00 |
| 2021 | 8916.45 | 8760 | 1018 | 99.99 | 99.99 | 99.99 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2022 | 8126.58 | 7984 | 1018 | 91.13 | 91.13 | 91.13 | 91.14 | 0.01 | 0.01 | 8.87 | 0.00 |
| 2023 | 7967.67 | 7914 | 1018 | 89.35 | 89.35 | 89.35 | 90.34 | 0.00 | 0.00 | 10.65 | 0.00 |

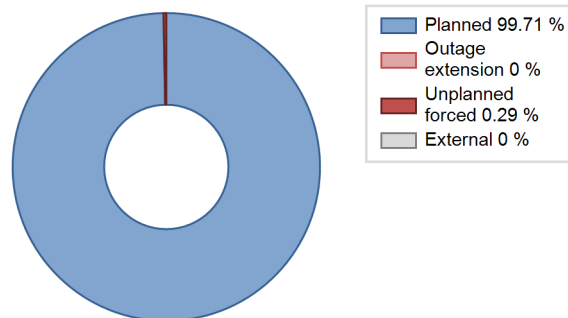
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| C. Inspection, maintenance or repair combined with refuelling | 667 | | | 575 | | |
| D. Inspection, maintenance or repair without refuelling | 49 | | | 7 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 141 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 111 |
| Z. Other | 130 | | | 18 | | |
| Subtotal | 846 | | | 600 | | 252 |
| Total | | 846 | | | 852 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|--------------|------------|--|-------------------------------------|--|
| | Hours Lost | | Average hours lost per reactor-year | |
| Total | | | | |

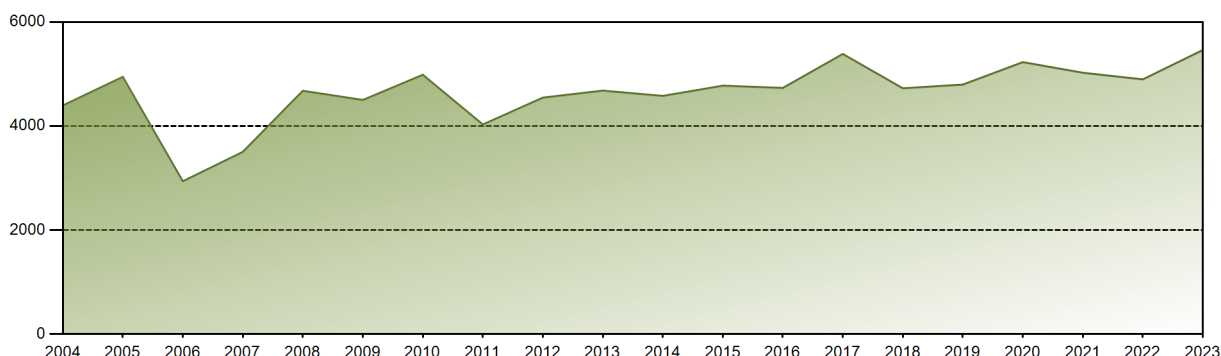
2023 Operating Experience

| CN-4 | | QINSHAN 2-1 | | CHINA | | | | | | | | | |
|---|---|-----------------|--|--------|--------------------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : CNNO (CNNC Nuclear Operation Management Company Limited) | | | | | | | | | | | | |
| Owner | : NPQJVC (NUCLEAR POWER PLANT QINSHAN JOINT VENTURE COMPANY LTD.) | | | | | | | | | | | | |
| Reactor Supplier | : CNNC (CHINA NATIONAL NUCLEAR CORPORATION) | | | | | | | | | | | | |
| Turbine Supplier | : HTC (HARBIN TURBINE COMPANY LIMITED) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PWR / CNP-600 | Construction Date | : | 1996-06-02 | | | | | | | | |
| Thermal power | : | 1930 MWth | Grid Date | : | 2002-02-06 | | | | | | | | |
| Gross electrical power | : | 650 MWe | Commercial Date | : | 2002-04-15 | | | | | | | | |
| Reference unit power (net) | : | 623 MWe | Age at end of year | : | 21 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | : | 15.5 | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Reactor outlet temperature [°C] | : | 315.2 | | | | | | | | |
| Fuel material | : | UO2 | Number of SG | : | 2 | | | | | | | | |
| Refuelling type | : | OFF-line | Containment type | : | Single | | | | | | | | |
| Moderator material | : | H2O | Containment design pressure [MPa] | : | 0.45 | | | | | | | | |
| Average fuel enrichment [% of U235] | : | 3.25 | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : | 12 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Part of the core refuelled [%] | : | 33.3 | Turbine speed [rpm] | : | 3000 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | - | Number of LP cylinders per turbine | : | 3 | | | | | | | | |
| Active core diameter [m] | : | 2.67 | HP cylinder inlet steam pressure [MPa] | : | 6.41 | | | | | | | | |
| Active core height/length [m] | : | 3.6576 | Output voltage [kV] | : | 20 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 121 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 16.09 | Number of main condensate pumps | : | 3 | | | | | | | | |
| Number of control rod assemblies | : | 33 | Number of FW pumps for full power operation | : | 2 | | | | | | | | |
| Number of external reactor coolant loops | : | 2 | Number of on-site safety related diesel generators | : | 2 | | | | | | | | |
| Coolant type | : | H2O | Non-electrical applications | | | | | | | | | | |
| | | | | : | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 5460.89 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 99.49 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 99.97 % | Planned Unavailability Factor (PUF) | : | 0.03 % | | | | | | | | |
| Load Factor (LF) | : | 100.06 % | Externally cause unavailability (XUF) | : | 0.48 % | | | | | | | | |
| Operating Factor (OF) | : | 100 % | Total off-line time | : | 0 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 465.67 | 411.88 | 471.48 | 431.97 | 470.89 | 453.66 | 456.65 | 457.16 | 446.84 | 468.04 | 455.88 | 470.79 | 5460.89 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.88 | 97.29 | 97.53 | 99.32 | 99.96 | 100.00 | 100.00 | 99.49 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.66 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.97 |
| LF [%] | 100.47 | 98.38 | 101.72 | 96.30 | 101.59 | 101.14 | 98.52 | 98.63 | 99.62 | 100.98 | 101.63 | 101.57 | 100.06 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 2.38 | 2.47 | 0.68 | 0.04 | 0.00 | 0.00 | 0.48 |

Historical Summary

| | | | |
|---|------------------|---|-----------|
| Lifetime energy generation | : 100272 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.8 % |
| Cumulative Energy Availability Factor (EAF) | : 85.33 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.66 % |
| Cumulative Unit Capability Factor (UCF) | : 85.41 % | Cumulative Planned Unavailability Factor (PUF) | : 12.93 % |
| Cumulative Load Factor (LF) | : 85.89 % | Cumulative Externally cause unavailability (XUF) | : 0.08 % |
| Cumulative Operating Factor (OF) | : 85.36 % | | |

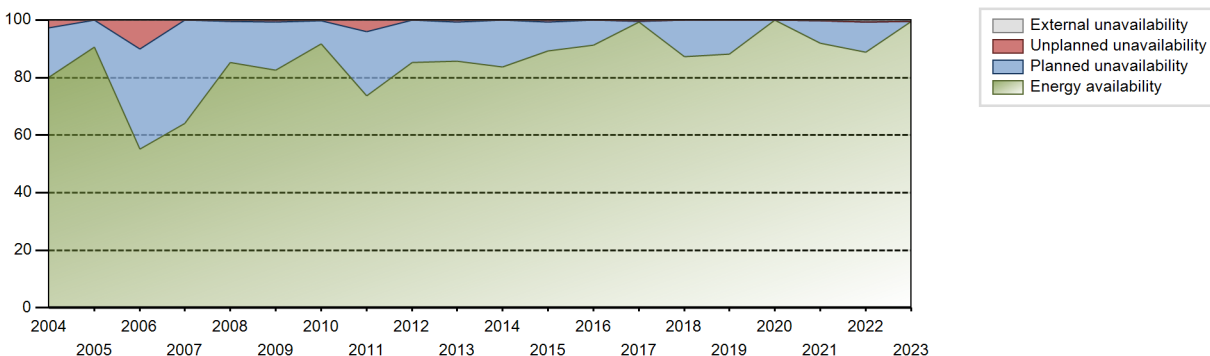
Electricity Production (net) [GWh]



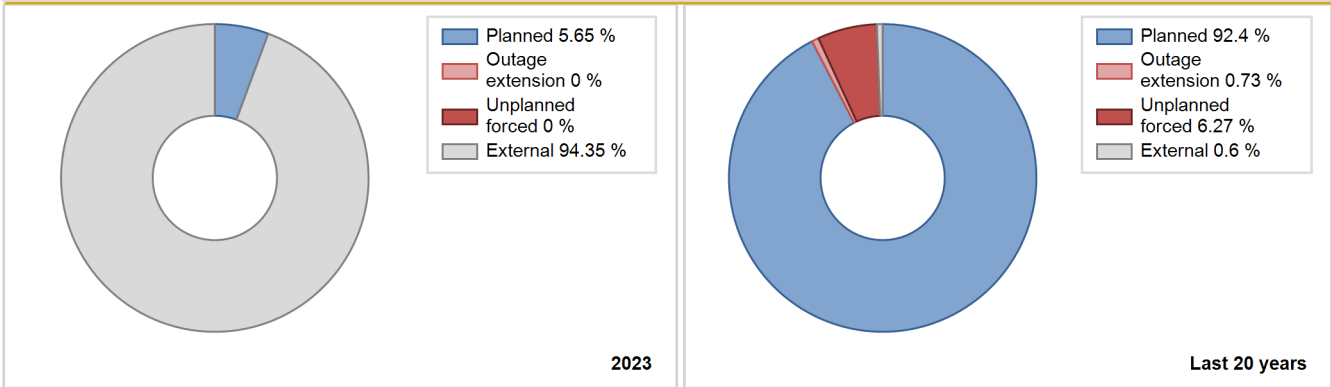
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2002 | 2965.29 | 4631 | 610 | 81.56 | 81.56 | 73.64 | 70.16 | 18.44 | 18.44 | 0.00 | 0.00 |
| 2003 | 4327.30 | 7123 | 610 | 80.90 | 80.95 | 80.98 | 81.31 | 2.61 | 2.17 | 16.88 | 0.05 |
| 2004 | 4395.68 | 7117 | 610 | 80.13 | 80.13 | 82.04 | 81.02 | 3.25 | 2.69 | 17.17 | 0.00 |
| 2005 | 4944.77 | 7982 | 610 | 90.61 | 90.61 | 92.54 | 91.12 | 0.01 | 0.01 | 9.37 | 0.00 |
| 2006 | 2938.16 | 4890 | 610 | 55.23 | 55.23 | 54.98 | 55.82 | 15.49 | 10.12 | 34.65 | 0.00 |
| 2007 | 3503.00 | 5681 | 610 | 64.12 | 64.12 | 65.56 | 64.85 | 0.00 | 0.00 | 35.88 | 0.00 |
| 2008 | 4677.61 | 7554 | 610 | 85.25 | 85.35 | 87.30 | 86.00 | 0.18 | 0.48 | 14.17 | 0.10 |
| 2009 | 4500.99 | 7256 | 610 | 82.66 | 82.66 | 84.23 | 82.83 | 0.74 | 0.62 | 16.72 | 0.00 |
| 2010 | 4985.39 | 8095 | 610 | 91.70 | 91.70 | 93.30 | 92.41 | 0.21 | 0.19 | 8.11 | 0.00 |
| 2011 | 4029.39 | 6521 | 610 | 73.66 | 73.66 | 75.41 | 74.44 | 2.90 | 3.97 | 22.37 | 0.00 |
| 2012 | 4545.92 | 7543 | 610 | 85.20 | 85.20 | 84.84 | 85.87 | 0.00 | 0.00 | 14.80 | 0.00 |
| 2013 | 4680.90 | 7561 | 610 | 85.75 | 85.75 | 87.60 | 86.31 | 0.87 | 0.75 | 13.50 | 0.00 |
| 2014 | 4579.16 | 7412 | 610 | 83.68 | 83.68 | 85.69 | 84.61 | 0.00 | 0.00 | 16.32 | 0.00 |
| 2015 | 4775.88 | 7859 | 610 | 89.35 | 89.35 | 89.38 | 89.71 | 0.84 | 0.76 | 9.90 | 0.00 |
| 2016 | 4732.19 | 7825 | 610 | 91.28 | 91.28 | 88.32 | 89.08 | 0.00 | 0.00 | 8.72 | 0.00 |
| 2017 | 5385.37 | 8732 | 610 | 99.32 | 99.52 | 100.78 | 99.68 | 0.36 | 0.36 | 0.13 | 0.20 |
| 2018 | 4725.63 | 7682 | 610 | 87.19 | 87.19 | 88.44 | 87.69 | 0.16 | 0.14 | 12.67 | 0.00 |
| 2019 | 4796.97 | 7781 | 610 | 88.15 | 88.20 | 89.77 | 88.82 | 0.00 | 0.00 | 11.80 | 0.06 |
| 2020 | 5228.19 | 8784 | 610 | 99.88 | 99.95 | 97.57 | 100.00 | 0.00 | 0.00 | 0.05 | 0.07 |
| 2021 | 5024.61 | 8118 | 610 | 91.98 | 92.17 | 94.03 | 92.67 | 0.00 | 0.00 | 7.83 | 0.19 |
| 2022 | 4897.42 | 7859 | 623 | 88.76 | 89.36 | 89.74 | 89.71 | 0.00 | 0.00 | 10.64 | 0.60 |
| 2023 | 5460.89 | 8760 | 623 | 99.49 | 99.97 | 100.06 | 100.00 | 0.00 | 0.00 | 0.03 | 0.48 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2002 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 77 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 938 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 21 | | |
| E. Testing of plant systems or components | | | | | 1 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 187 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 9 |
| Z. Other | | | | | 7 | |
| Subtotal | | | | 1146 | 85 | 9 |
| Total | | 0 | | | 1240 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2002 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 1 |
| 13. Reactor Auxiliary Systems | | 34 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 14 |
| 32. Feedwater and Main Steam System | | 3 |
| 41. Main Generator Systems | | 24 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 79 |

2023 Operating Experience

CN-5

QINSHAN 2-2

CHINA

Status at end of year : **Operational**
 Operator : CNNO (CNNC Nuclear Operation Management Company Limited)
 Owner : NPQJVC (NUCLEAR POWER PLANT QINSHAN JOINT VENTURE COMPANY LTD.)
 Reactor Supplier : CNNC (CHINA NATIONAL NUCLEAR CORPORATION)
 Turbine Supplier : HTC (HARBIN TURBINE COMPANY LIMITED)

Reactor Unit Details

Reactor type and model : PWR / CNP-600
 Thermal power : 1930 MWth
 Gross electrical power : 650 MWe
 Reference unit power (net) : 623 MWe

Key Dates

Construction Date : 1997-04-01
 Grid Date : 2004-03-11
 Commercial Date : 2004-05-03
 Age at end of year : 19 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.25
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : -
 Active core diameter [m] : 2.67
 Active core height/length [m] : 3.6576
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 16.09
 Number of control rod assemblies : 33
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 315.2
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.450

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.41
 Output voltage [kV] : 20
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

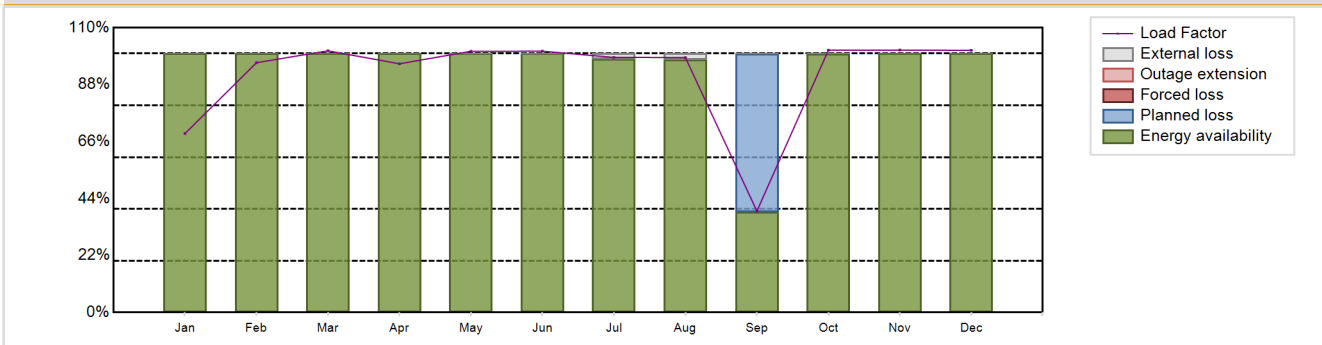
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5026.63 GW(e).h
 Energy Availability Factor (EAF) : 94.58 %
 Unit Capability Factor (UCF) : 94.99 %
 Load Factor (LF) : 92.11 %
 Operating Factor (OF) : 92.53 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 5.01 %
 Externally cause unavailability (XUF) : 0.41 %
 Total off-line time : 654 hours

Annual Summary

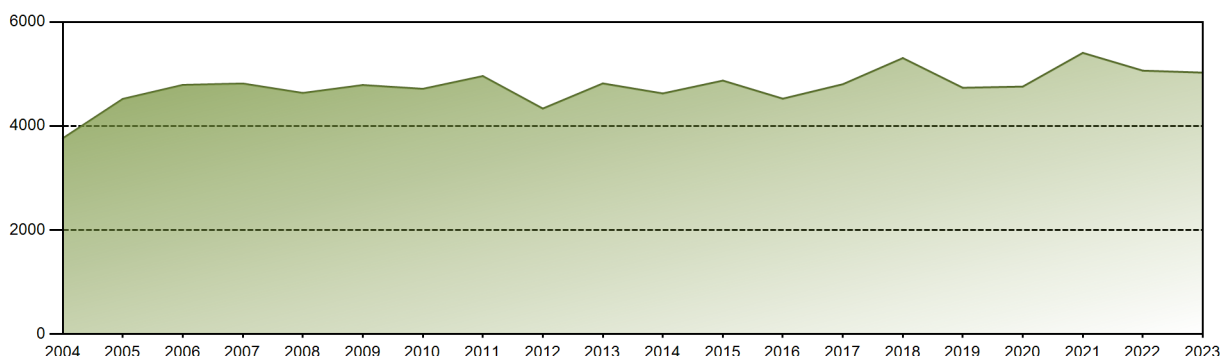


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 320.39 | 403.91 | 468.50 | 430.89 | 467.64 | 452.77 | 456.65 | 456.49 | 175.61 | 469.70 | 454.68 | 469.39 | 5026.63 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 | 97.76 | 97.64 | 38.89 | 99.98 | 100.00 | 100.00 | 94.58 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 39.08 | 100.00 | 100.00 | 100.00 | 94.99 |
| LF [%] | 69.12 | 96.48 | 101.08 | 96.06 | 100.89 | 100.94 | 98.52 | 98.48 | 39.15 | 101.33 | 101.36 | 101.27 | 92.11 |
| OF [%] | 68.82 | 99.11 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 42.22 | 100.00 | 100.00 | 100.00 | 92.53 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 60.92 | 0.00 | 0.00 | 0.00 | 5.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 2.24 | 2.36 | 0.19 | 0.02 | 0.00 | 0.00 | 0.41 |

Historical Summary

| | | | |
|---|-----------------|---|----------|
| Lifetime energy generation | : 95276 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.26 % |
| Cumulative Energy Availability Factor (EAF) | : 89.42 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.14 % |
| Cumulative Unit Capability Factor (UCF) | : 89.55 % | Cumulative Planned Unavailability Factor (PUF) | : 9.32 % |
| Cumulative Load Factor (LF) | : 90.25 % | Cumulative Externally cause unavailability (XUF) | : 0.13 % |
| Cumulative Operating Factor (OF) | : 89.72 % | | |

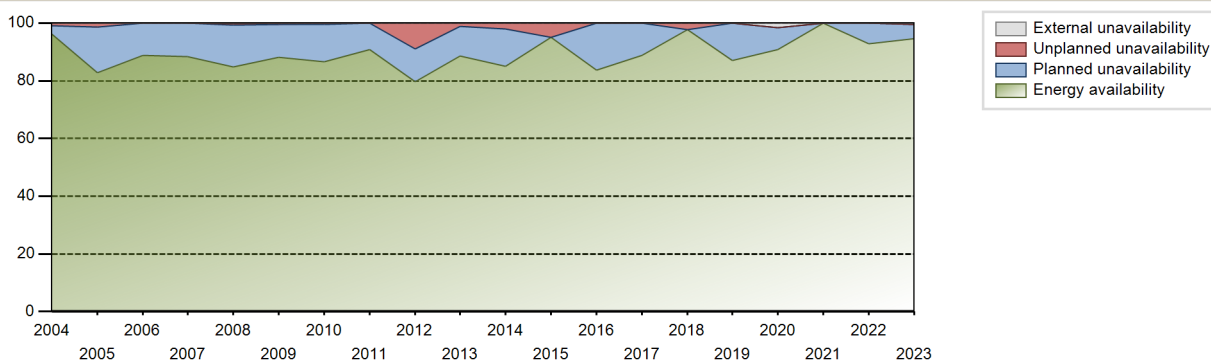
Electricity Production (net) [GWh]



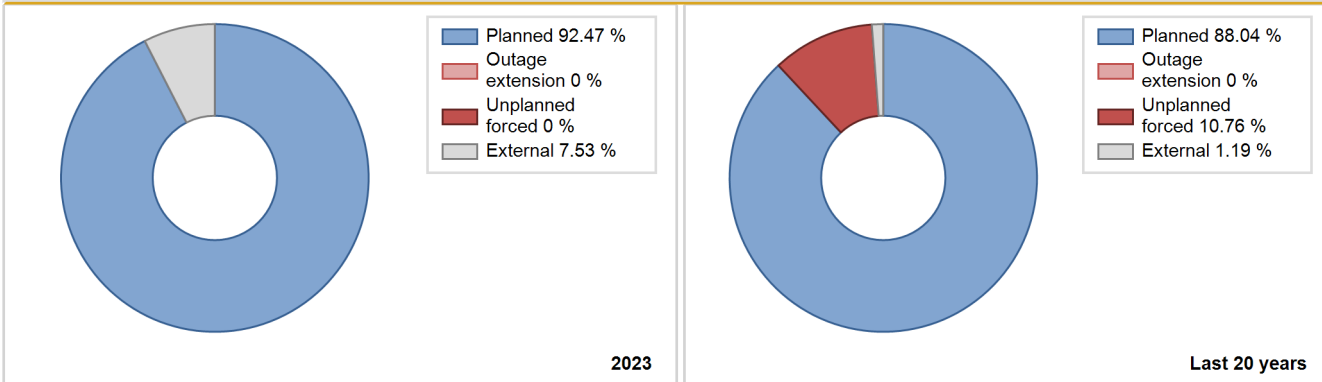
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|--------|-------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2004 | 3764.39 | 6381 | 610 | 96.24 | 96.24 | 97.96 | 96.62 | 0.90 | 0.87 | 2.88 | 0.00 |
| 2005 | 4521.51 | 7331 | 610 | 82.69 | 82.77 | 84.62 | 83.69 | 1.65 | 1.39 | 15.84 | 0.08 |
| 2006 | 4790.44 | 7822 | 610 | 88.78 | 88.78 | 89.65 | 89.29 | 0.00 | 0.00 | 11.21 | 0.00 |
| 2007 | 4817.01 | 7792 | 610 | 88.30 | 88.30 | 90.15 | 88.95 | 0.00 | 0.00 | 11.70 | 0.00 |
| 2008 | 4635.51 | 7545 | 610 | 84.89 | 85.21 | 86.51 | 85.89 | 0.36 | 0.31 | 14.48 | 0.32 |
| 2009 | 4787.80 | 7821 | 610 | 88.22 | 88.22 | 89.60 | 89.28 | 0.62 | 0.55 | 11.24 | 0.00 |
| 2010 | 4715.04 | 7645 | 610 | 86.64 | 86.64 | 88.24 | 87.27 | 0.43 | 0.37 | 12.98 | 0.00 |
| 2011 | 4960.23 | 8014 | 610 | 90.91 | 90.91 | 92.83 | 91.48 | 0.00 | 0.00 | 9.09 | 0.00 |
| 2012 | 4335.54 | 7072 | 610 | 79.63 | 79.63 | 80.91 | 80.51 | 10.13 | 8.98 | 11.39 | 0.00 |
| 2013 | 4818.51 | 7826 | 610 | 88.70 | 88.70 | 90.17 | 89.34 | 1.23 | 1.11 | 10.19 | 0.00 |
| 2014 | 4626.25 | 7514 | 610 | 85.00 | 85.00 | 86.58 | 85.78 | 2.26 | 1.96 | 13.04 | 0.00 |
| 2015 | 4872.99 | 7990 | 610 | 95.14 | 95.14 | 91.19 | 91.21 | 4.84 | 4.83 | 0.03 | 0.00 |
| 2016 | 4525.57 | 7377 | 610 | 83.79 | 83.79 | 84.46 | 83.98 | 0.02 | 0.01 | 16.20 | 0.00 |
| 2017 | 4803.39 | 7830 | 610 | 88.83 | 88.83 | 89.89 | 89.38 | 0.01 | 0.01 | 11.16 | 0.00 |
| 2018 | 5306.28 | 8574 | 610 | 97.65 | 97.65 | 99.30 | 97.88 | 2.30 | 2.29 | 0.05 | 0.00 |
| 2019 | 4735.26 | 7680 | 610 | 87.10 | 87.16 | 88.62 | 87.67 | 0.00 | 0.00 | 12.84 | 0.06 |
| 2020 | 4758.46 | 8156 | 610 | 90.79 | 92.31 | 88.81 | 92.85 | 0.00 | 0.00 | 7.69 | 1.52 |
| 2021 | 5406.39 | 8760 | 610 | 99.91 | 99.91 | 101.17 | 100.00 | 0.00 | 0.00 | 0.09 | 0.00 |
| 2022 | 5064.37 | 8159 | 610 | 92.77 | 92.86 | 94.77 | 93.14 | 0.00 | 0.00 | 7.14 | 0.09 |
| 2023 | 5026.63 | 8106 | 623 | 94.58 | 94.99 | 92.11 | 92.53 | 0.00 | 0.00 | 5.01 | 0.41 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2004 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 92 | |
| C. Inspection, maintenance or repair combined with refuelling | 414 | | | 767 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 19 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 5 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 238 | | | 32 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Subtotal | 414 | | 238 | 791 | 92 | 33 |
| Total | | 652 | | | 916 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2004 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 5 |
| 15. Reactor Cooling Systems | | 9 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 73 |
| 32. Feedwater and Main Steam System | | 1 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 91 |

RUP revision during the year (2023) due to power uprate

RUP at the end of previous year : 610 [MWe]

| Month | Capacity [MWe] | Power Uprate | Main modifications | Description |
|---------|----------------|-----------------------------|--------------------|--------------|
| January | 623 | Stretch power uprate (2-7%) | Balance of plant | Power Uprate |

Highlights (2023)

The unit was shutdown for 216 refuelling outage from September 1 to September 18.

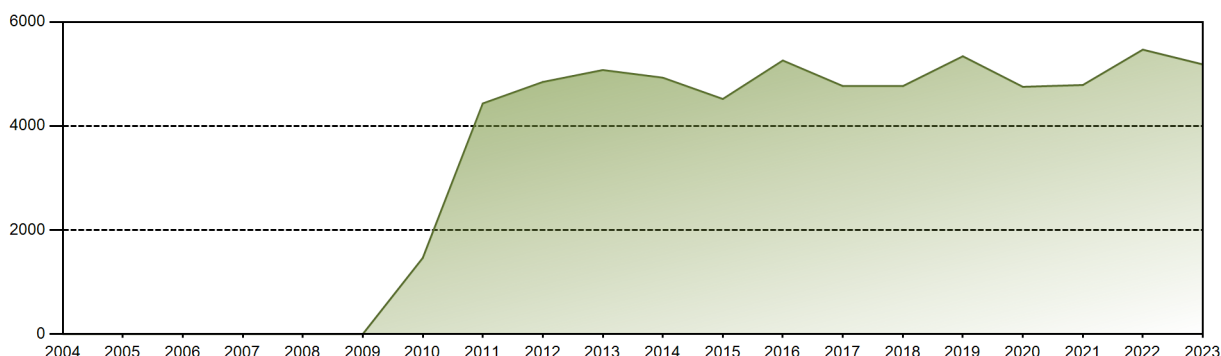
2023 Operating Experience

| CN-14 | | QINSHAN 2-3 | | CHINA | | | | | | | | | |
|---|---|--|----------------------------------|--------------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : CNNO (CNNC Nuclear Operation Management Company Limited) | | | | | | | | | | | | |
| Owner | : NPQJVC (NUCLEAR POWER PLANT QINSHAN JOINT VENTURE COMPANY LTD.) | | | | | | | | | | | | |
| Reactor Supplier | : CNNC (CHINA NATIONAL NUCLEAR CORPORATION) | | | | | | | | | | | | |
| Turbine Supplier | : HTC (HARBIN TURBINE COMPANY LIMITED) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : PWR / CNP-600 | Construction Date | : | 2006-04-28 | | | | | | | | | |
| Thermal power | : 1930 MWth | Grid Date | : | 2010-08-01 | | | | | | | | | |
| Gross electrical power | : 660 MWe | Commercial Date | : | 2010-10-05 | | | | | | | | | |
| Reference unit power (net) | : 623 MWe | Age at end of year | : | 13 years | | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | : | 15.5 | | | | | | | | |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : | 315.2 | | | | | | | | | |
| Fuel material | : UO2 | Number of SG | : | 2 | | | | | | | | | |
| Refuelling type | : OFF-line | Containment type | : | Single | | | | | | | | | |
| Moderator material | : H2O | Containment design pressure [MPa] | : | 0.45 | | | | | | | | | |
| Average fuel enrichment [% of U235] | : 3.25 | Secondary systems | | | | | | | | | | | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | | |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : | 3000 | | | | | | | | | |
| Average discharge burnup [MWd/t] | : - | Number of LP cylinders per turbine | : | 3 | | | | | | | | | |
| Active core diameter [m] | : 2.67 | HP cylinder inlet steam pressure [MPa] | : | 6.41 | | | | | | | | | |
| Active core height/length [m] | : 3.6576 | Output voltage [kV] | : | 20 | | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : 121 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : 16.09 | Number of main condensate pumps | : | 3 | | | | | | | | | |
| Number of control rod assemblies | : 33 | Number of FW pumps for full power operation | : | 3 | | | | | | | | | |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : | 2 | | | | | | | | | |
| Coolant type | : H2O | Non-electrical applications | | | | | | | | | | | |
| | | | : | none | | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : 5184.38 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | | |
| Energy Availability Factor (EAF) | : 94.92 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | | |
| Unit Capability Factor (UCF) | : 95.53 % | Planned Unavailability Factor (PUF) | : | 4.47 % | | | | | | | | | |
| Load Factor (LF) | : 95 % | Externally cause unavailability (XUF) | : | 0.61 % | | | | | | | | | |
| Operating Factor (OF) | : 95.86 % | Total off-line time | : | 363 hours | | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 447.47 | 410.61 | 470.06 | 186.76 | 470.91 | 452.41 | 454.22 | 453.61 | 445.77 | 468.74 | 454.71 | 469.11 | 5184.38 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 45.91 | 100.00 | 99.67 | 97.18 | 97.04 | 98.75 | 99.89 | 100.00 | 100.00 | 94.92 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 45.91 | 100.00 | 100.00 | 99.74 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.53 |
| LF [%] | 96.54 | 98.08 | 101.41 | 41.63 | 101.60 | 100.86 | 98.00 | 97.86 | 99.38 | 101.13 | 101.37 | 101.21 | 95.00 |
| OF [%] | 100.00 | 100.00 | 100.00 | 49.58 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.86 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 54.09 | 0.00 | 0.00 | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.47 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 2.57 | 2.96 | 1.25 | 0.11 | 0.00 | 0.00 | 0.61 |

Historical Summary

| | | | | | |
|---|---|---------------|---|---|--------|
| Lifetime energy generation | : | 65540 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 0.9 % |
| Cumulative Energy Availability Factor (EAF) | : | 91.65 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 0.83 % |
| Cumulative Unit Capability Factor (UCF) | : | 91.79 % | Cumulative Planned Unavailability Factor (PUF) | : | 7.38 % |
| Cumulative Load Factor (LF) | : | 91.29 % | Cumulative Externally cause unavailability (XUF) | : | 0.14 % |
| Cumulative Operating Factor (OF) | : | 91.85 % | | | |

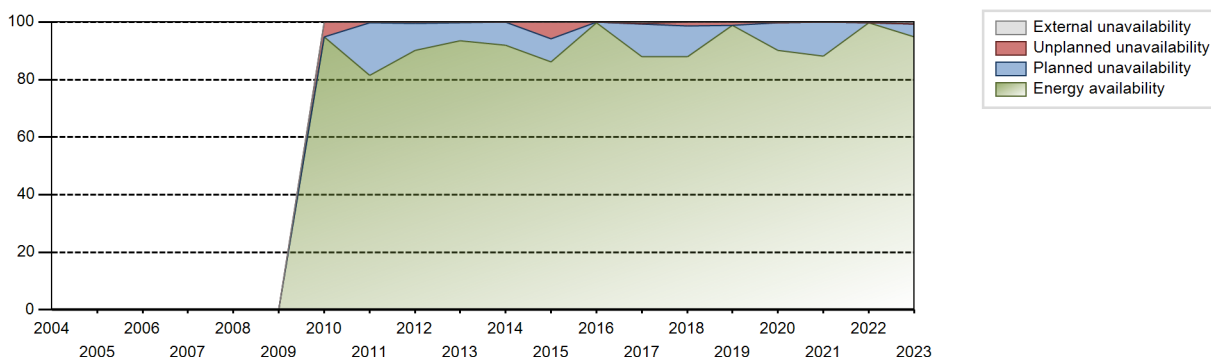
Electricity Production (net) [GWh]



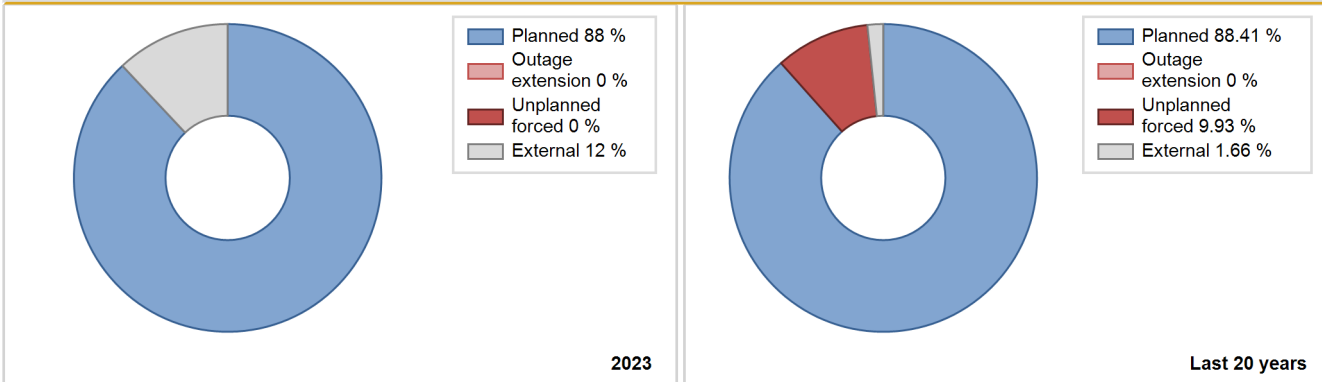
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2010 | 1465.17 | 2685 | 610 | 94.75 | 94.75 | 96.66 | 97.55 | 5.22 | 5.21 | 0.04 | 0.00 |
| 2011 | 4434.13 | 7226 | 610 | 81.55 | 81.56 | 82.98 | 82.49 | 0.21 | 0.17 | 18.27 | 0.01 |
| 2012 | 4846.78 | 7977 | 610 | 90.05 | 90.05 | 90.45 | 90.81 | 0.50 | 0.45 | 9.49 | 0.00 |
| 2013 | 5076.15 | 8243 | 610 | 93.46 | 93.46 | 94.99 | 94.10 | 0.17 | 0.16 | 6.38 | 0.00 |
| 2014 | 4929.31 | 8078 | 619 | 91.99 | 92.07 | 90.91 | 92.21 | 0.00 | 0.00 | 7.93 | 0.08 |
| 2015 | 4519.98 | 7410 | 619 | 86.17 | 86.17 | 83.36 | 84.59 | 6.43 | 5.93 | 7.91 | 0.00 |
| 2016 | 5259.45 | 8584 | 619 | 99.80 | 99.80 | 96.73 | 97.72 | 0.12 | 0.12 | 0.09 | 0.00 |
| 2017 | 4768.41 | 7804 | 619 | 87.96 | 88.41 | 87.94 | 89.09 | 0.38 | 0.34 | 11.25 | 0.45 |
| 2018 | 4767.33 | 7756 | 619 | 87.93 | 87.93 | 87.92 | 88.54 | 1.57 | 1.41 | 10.67 | 0.00 |
| 2019 | 5341.24 | 8664 | 619 | 98.82 | 98.82 | 98.50 | 98.90 | 1.11 | 1.11 | 0.07 | 0.00 |
| 2020 | 4753.88 | 7870 | 619 | 90.05 | 90.36 | 87.43 | 89.59 | 0.00 | 0.00 | 9.64 | 0.31 |
| 2021 | 4788.17 | 7768 | 619 | 88.15 | 88.19 | 88.30 | 88.68 | 0.00 | 0.00 | 11.81 | 0.04 |
| 2022 | 5468.09 | 8760 | 619 | 99.67 | 100.00 | 100.84 | 100.00 | 0.00 | 0.00 | 0.00 | 0.33 |
| 2023 | 5184.38 | 8397 | 623 | 94.92 | 95.53 | 95.00 | 95.86 | 0.00 | 0.00 | 4.47 | 0.61 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2010 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 64 | |
| C. Inspection, maintenance or repair combined with refuelling | 363 | | | 627 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 37 |
| L. Human factor related | | | | | 0 | |
| Subtotal | 363 | | | 627 | 64 | 37 |
| Total | | 363 | | | 728 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2010 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 15. Reactor Cooling Systems | | 9 |
| 16. Steam generation systems | | 9 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 40 |
| 32. Feedwater and Main Steam System | | 0 |
| 34. Miscellaneous Systems | | 9 |
| 42. Electrical Power Supply Systems | | 3 |
| Total | | 72 |

RUP revision during the year (2023) due to power uprate

RUP at the end of previous year : 619 [MWe]

| Month | Capacity [MWe] | Power Uprate | Main modifications | Description |
|---------|----------------|----------------------------|--------------------|--------------|
| January | 623 | Improved measurement (<2%) | Balance of plant | Power Uprate |

Highlights (2023)

The unit was shutdown for 310 refuelling outage from April 1 to April 16.

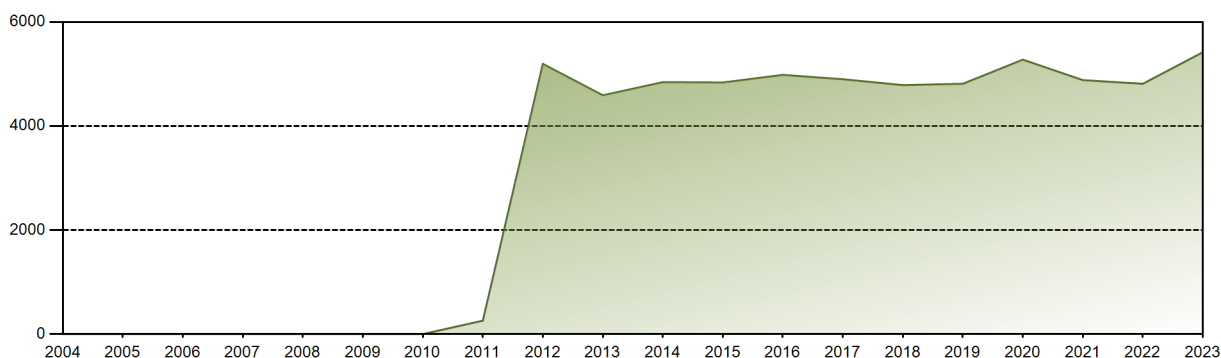
2023 Operating Experience

| CN-15 | | QINSHAN 2-4 | | CHINA | | | | | | | | | |
|---|---|-----------------|--|--------|--------------------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : CNNO (CNNC Nuclear Operation Management Company Limited) | | | | | | | | | | | | |
| Owner | : NPQJVC (NUCLEAR POWER PLANT QINSHAN JOINT VENTURE COMPANY LTD.) | | | | | | | | | | | | |
| Reactor Supplier | : CNNC (CHINA NATIONAL NUCLEAR CORPORATION) | | | | | | | | | | | | |
| Turbine Supplier | : HTC (HARBIN TURBINE COMPANY LIMITED) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PWR / CNP-600 | Construction Date | : | 2007-01-28 | | | | | | | | |
| Thermal power | : | 1930 MWth | Grid Date | : | 2011-11-25 | | | | | | | | |
| Gross electrical power | : | 660 MWe | Commercial Date | : | 2011-12-30 | | | | | | | | |
| Reference unit power (net) | : | 623 MWe | Age at end of year | : | 12 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | : | 15.5 | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Reactor outlet temperature [°C] | : | 315.2 | | | | | | | | |
| Fuel material | : | UO2 | Number of SG | : | 2 | | | | | | | | |
| Refuelling type | : | OFF-line | Containment type | : | Single | | | | | | | | |
| Moderator material | : | H2O | Containment design pressure [MPa] | : | 0.45 | | | | | | | | |
| Average fuel enrichment [% of U235] | : | 3.25 | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : | 12 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Part of the core refuelled [%] | : | 33.3 | Turbine speed [rpm] | : | 3000 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | 50000 | Number of LP cylinders per turbine | : | 3 | | | | | | | | |
| Active core diameter [m] | : | 2.67 | HP cylinder inlet steam pressure [MPa] | : | 6.41 | | | | | | | | |
| Active core height/length [m] | : | 3.6576 | Output voltage [kV] | : | 20 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 121 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 16.09 | Number of main condensate pumps | : | 3 | | | | | | | | |
| Number of control rod assemblies | : | 33 | Number of FW pumps for full power operation | : | 2 | | | | | | | | |
| Number of external reactor coolant loops | : | 2 | Number of on-site safety related diesel generators | : | 2 | | | | | | | | |
| Coolant type | : | H2O | Non-electrical applications | | | | | | | | | | |
| | | | | : | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 5419.73 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 99.35 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 99.96 % | Planned Unavailability Factor (PUF) | : | 0.04 % | | | | | | | | |
| Load Factor (LF) | : | 99.31 % | Externally cause unavailability (XUF) | : | 0.61 % | | | | | | | | |
| Operating Factor (OF) | : | 100 % | Total off-line time | : | 0 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 442.83 | 410.83 | 469.19 | 428.60 | 467.74 | 452.93 | 456.36 | 455.12 | 445.85 | 468.60 | 452.53 | 469.16 | 5419.73 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.92 | 97.28 | 97.04 | 98.42 | 99.84 | 99.78 | 100.00 | 99.35 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.75 | 100.00 | 100.00 | 100.00 | 99.78 | 100.00 | 99.96 |
| LF [%] | 95.54 | 98.13 | 101.23 | 95.55 | 100.91 | 100.97 | 98.46 | 98.19 | 99.40 | 101.10 | 100.89 | 101.22 | 99.31 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.22 | 0.00 | 0.04 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 2.48 | 2.96 | 1.58 | 0.16 | 0.00 | 0.00 | 0.61 |

Historical Summary

| | | | |
|---|-----------------|---|----------|
| Lifetime energy generation | : 59576 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.13 % |
| Cumulative Energy Availability Factor (EAF) | : 91.62 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.12 % |
| Cumulative Unit Capability Factor (UCF) | : 91.83 % | Cumulative Planned Unavailability Factor (PUF) | : 8.06 % |
| Cumulative Load Factor (LF) | : 91.64 % | Cumulative Externally cause unavailability (XUF) | : 0.21 % |
| Cumulative Operating Factor (OF) | : 91.99 % | | |

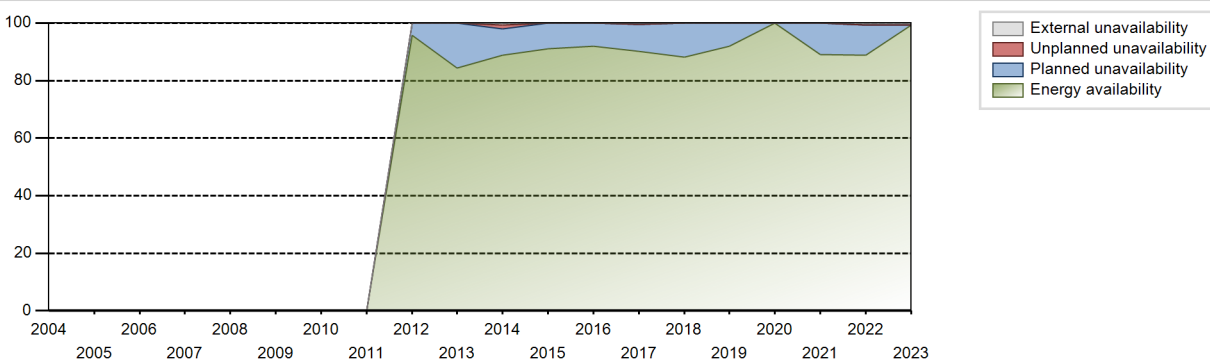
Electricity Production (net) [GWh]



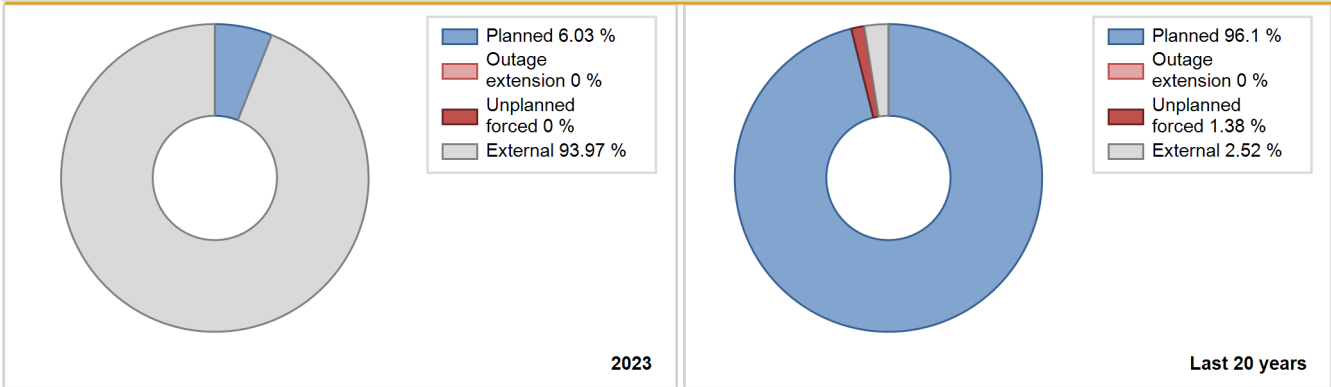
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2011 | 257.02 | 614 | 610 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 5195.81 | 8438 | 610 | 95.79 | 95.79 | 96.97 | 96.06 | 0.04 | 0.04 | 4.17 | 0.00 |
| 2013 | 4591.39 | 7428 | 610 | 84.25 | 84.25 | 85.92 | 84.79 | 0.00 | 0.00 | 15.75 | 0.00 |
| 2014 | 4844.49 | 7905 | 610 | 88.86 | 89.62 | 90.66 | 90.24 | 1.32 | 1.20 | 9.19 | 0.75 |
| 2015 | 4837.34 | 7994 | 610 | 91.06 | 91.06 | 90.53 | 91.26 | 0.00 | 0.00 | 8.94 | 0.00 |
| 2016 | 4983.82 | 8130 | 610 | 91.93 | 91.93 | 93.01 | 92.55 | 0.07 | 0.07 | 8.00 | 0.00 |
| 2017 | 4899.45 | 7993 | 619 | 90.14 | 90.61 | 90.35 | 91.24 | 0.00 | 0.00 | 9.39 | 0.48 |
| 2018 | 4786.77 | 7760 | 619 | 88.16 | 88.16 | 88.28 | 88.58 | 0.00 | 0.00 | 11.84 | 0.00 |
| 2019 | 4812.21 | 7815 | 619 | 91.91 | 91.91 | 88.75 | 89.21 | 0.10 | 0.09 | 8.00 | 0.00 |
| 2020 | 5276.68 | 8784 | 619 | 99.97 | 99.97 | 97.05 | 100.00 | 0.01 | 0.01 | 0.03 | 0.00 |
| 2021 | 4882.83 | 7898 | 619 | 88.97 | 89.04 | 90.05 | 90.16 | 0.00 | 0.00 | 10.96 | 0.07 |
| 2022 | 4812.10 | 7861 | 619 | 88.83 | 89.45 | 88.74 | 89.74 | 0.00 | 0.00 | 10.55 | 0.62 |
| 2023 | 5419.73 | 8760 | 623 | 99.35 | 99.96 | 99.31 | 100.00 | 0.00 | 0.00 | 0.04 | 0.61 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2011 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 1 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 644 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 22 | | |
| E. Testing of plant systems or components | | | | 7 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 22 |
| Subtotal | | | | 673 | 1 | 22 |
| Total | | 0 | | | 696 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2011 to 2023 | |
|---------------------------|------------|--|-------------------------------------|---|
| | Hours Lost | | Average hours lost per reactor-year | |
| 35. All other I&C Systems | | | | 1 |
| Total | | | | 1 |

RUP revision during the year (2023) due to power uprate

RUP at the end of previous year : 619 [MWe]

| Month | Capacity [MWe] | Power Uprate | Main modifications | Description |
|---------|----------------|----------------------------|--------------------|--------------|
| January | 623 | Improved measurement (<2%) | Balance of plant | Power Uprate |

2023 Operating Experience

CN-8

QINSHAN 3-1

CHINA

Status at end of year : **Operational**
 Operator : CNNO (CNNC Nuclear Operation Management Company Limited)
 Owner : TQNPC (Qinshan Third nuclear power Co., LTD)
 Reactor Supplier : AECL (ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : Hit (Japan Hitachi Company.)



Reactor Unit Details

Reactor type and model : PHWR / CANDU 6
 Thermal power : 2064 MWth
 Gross electrical power : 728 MWe
 Reference unit power (net) : 677 MWe

Key Dates

Construction Date : 1998-06-08
 Grid Date : 2002-11-19
 Commercial Date : 2002-12-31
 Age at end of year : 21 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : 0.71
 Refuelling frequency [month] : 60
 Part of the core refuelled [%] : NA
 Average discharge burnup [MWd/t] : 7186
 Active core diameter [m] : 6.28
 Active core height/length [m] : 5.94
 Number of fissile fuel assemblies/bundles : 4560
 Fuel linear heat generation rate [kW/m] : 25.35
 Number of control rod assemblies : 21
 Number of external reactor coolant loops : 2
 Coolant type : D2O

Operating coolant pressure [MPa] : 9.89
 Reactor outlet temperature [°C] : 310
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 0.124

Secondary systems

Number of turbine-generators per unit/reactor : -
 Turbine speed [rpm] : -
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : -
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

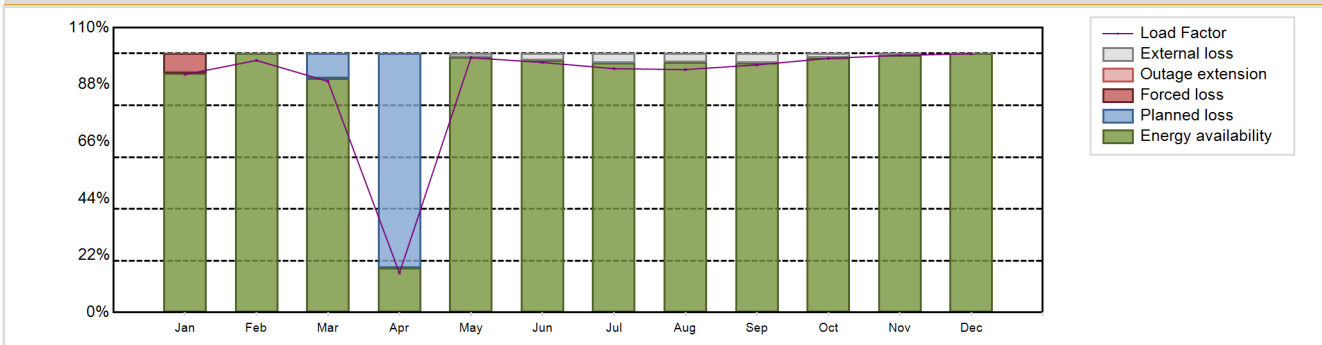
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 5291.35 GW(e).h
 Energy Availability Factor (EAF) : 90.32 %
 Unit Capability Factor (UCF) : 91.74 %
 Load Factor (LF) : 89.22 %
 Operating Factor (OF) : 92.09 %
 Forced Loss Rate (FLR) : 0.69 %
 Unplanned Capability Loss Factor (UCL) : 0.64 %
 Planned Unavailability Factor (PUF) : 7.62 %
 Externally cause unavailability (XUF) : 1.42 %
 Total off-line time : 693 hours

Annual Summary

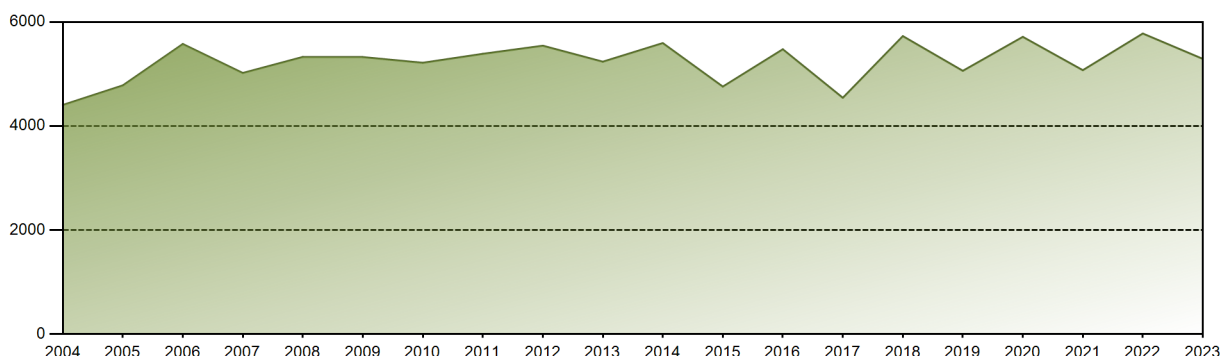


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 463.10 | 442.95 | 449.65 | 74.29 | 495.57 | 470.76 | 474.37 | 472.60 | 466.18 | 494.38 | 484.19 | 503.32 | 5291.35 |
| EAF [%] | 92.47 | 100.00 | 90.34 | 17.30 | 98.57 | 97.35 | 96.37 | 96.57 | 96.47 | 98.31 | 99.38 | 100.00 | 90.32 |
| UCF [%] | 92.47 | 100.00 | 90.34 | 17.30 | 100.00 | 100.00 | 99.98 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.74 |
| LF [%] | 91.94 | 97.36 | 89.27 | 15.24 | 98.39 | 96.58 | 94.18 | 93.83 | 95.64 | 98.15 | 99.33 | 99.93 | 89.22 |
| OF [%] | 93.68 | 100.00 | 90.46 | 20.14 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.09 |
| FLR [%] | 7.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.69 |
| UCL [%] | 7.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.64 |
| PUF [%] | 0.00 | 0.00 | 9.66 | 82.70 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.62 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.43 | 2.65 | 3.61 | 3.43 | 3.53 | 1.69 | 0.62 | 0.00 | 1.42 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 110243.35 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.43 % |
| Cumulative Energy Availability Factor (EAF) | : 90.17 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.31 % |
| Cumulative Unit Capability Factor (UCF) | : 90.72 % | Cumulative Planned Unavailability Factor (PUF) | : 7.96 % |
| Cumulative Load Factor (LF) | : 90.34 % | Cumulative Externally cause unavailability (XUF) | : 0.55 % |
| Cumulative Operating Factor (OF) | : 90.9 % | | |

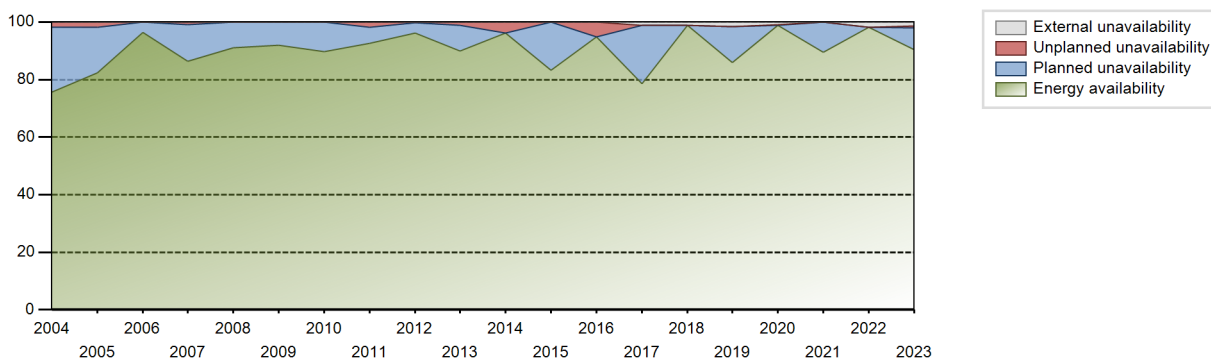
Electricity Production (net) [GWh]



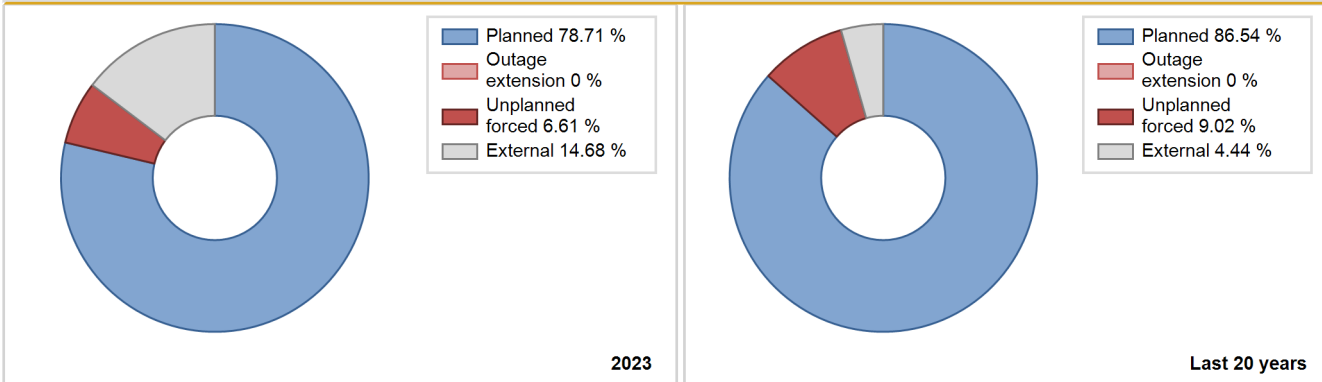
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|-------------------|---------------------------|---------------------------------|-------|-------|-------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2002 | Data not provided | | | | | | | | | | |
| 2003 | 5174.75 | 7977 | 650 | 86.59 | 89.65 | 90.88 | 91.06 | 10.35 | 10.35 | 0.00 | 3.06 |
| 2004 | 4405.52 | 6745 | 650 | 75.60 | 75.61 | 77.16 | 76.79 | 2.31 | 1.78 | 22.61 | 0.01 |
| 2005 | 4781.60 | 7249 | 650 | 82.43 | 82.50 | 83.98 | 82.75 | 2.18 | 1.84 | 15.66 | 0.07 |
| 2006 | 5577.79 | 8484 | 650 | 96.34 | 96.34 | 97.96 | 96.85 | 0.07 | 0.07 | 3.60 | 0.00 |
| 2007 | 5020.40 | 7597 | 650 | 86.41 | 86.41 | 88.17 | 86.72 | 0.95 | 0.82 | 12.76 | 0.00 |
| 2008 | 5328.57 | 8051 | 650 | 91.11 | 91.21 | 93.33 | 91.66 | 0.00 | 0.00 | 8.79 | 0.10 |
| 2009 | 5326.22 | 8076 | 650 | 91.91 | 91.91 | 93.54 | 92.19 | 0.00 | 0.00 | 8.09 | 0.00 |
| 2010 | 5216.34 | 7884 | 650 | 89.71 | 89.71 | 91.61 | 90.00 | 0.03 | 0.03 | 10.27 | 0.00 |
| 2011 | 5388.51 | 8131 | 650 | 92.55 | 92.55 | 94.63 | 92.82 | 1.96 | 1.85 | 5.60 | 0.00 |
| 2012 | 5544.58 | 8462 | 650 | 96.25 | 96.25 | 97.11 | 96.33 | 0.34 | 0.33 | 3.41 | 0.00 |
| 2013 | 5237.40 | 7949 | 650 | 89.89 | 89.89 | 91.98 | 90.74 | 1.22 | 1.11 | 9.00 | 0.00 |
| 2014 | 5594.85 | 8451 | 650 | 96.13 | 96.13 | 98.26 | 96.47 | 3.83 | 3.83 | 0.04 | 0.00 |
| 2015 | 4758.34 | 7292 | 677 | 83.19 | 83.19 | 80.23 | 83.24 | 0.00 | 0.00 | 16.81 | 0.00 |
| 2016 | 5476.06 | 8351 | 677 | 94.90 | 94.90 | 92.08 | 95.07 | 5.08 | 5.08 | 0.02 | 0.00 |
| 2017 | 4542.77 | 7000 | 677 | 78.63 | 79.83 | 76.60 | 79.91 | 0.00 | 0.00 | 20.17 | 1.20 |
| 2018 | 5729.05 | 8657 | 677 | 98.76 | 99.96 | 96.60 | 98.82 | 0.00 | 0.00 | 0.04 | 1.20 |
| 2019 | 5061.34 | 7709 | 677 | 86.01 | 87.63 | 85.34 | 88.00 | 0.03 | 0.03 | 12.34 | 1.62 |
| 2020 | 5714.70 | 8699 | 677 | 98.95 | 99.92 | 96.10 | 99.03 | 0.07 | 0.07 | 0.01 | 0.97 |
| 2021 | 5073.94 | 7745 | 677 | 89.51 | 89.51 | 85.56 | 88.41 | 0.00 | 0.00 | 10.49 | 0.00 |
| 2022 | 5778.63 | 8760 | 677 | 98.11 | 99.90 | 97.44 | 100.00 | 0.00 | 0.00 | 0.09 | 1.80 |
| 2023 | 5291.35 | 8067 | 677 | 90.32 | 91.74 | 89.22 | 92.09 | 0.69 | 0.64 | 7.62 | 1.42 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2002 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 48 | | | 100 | |
| D. Inspection, maintenance or repair without refuelling | 646 | | | 680 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 11 |
| Z. Other | | | | | | 4 |
| Subtotal | 646 | 48 | | 680 | 100 | 15 |
| Total | | 694 | | | 795 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2002 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 6 |
| 15. Reactor Cooling Systems | | 33 |
| 16. Steam generation systems | | 9 |
| 21. Fuel Handling and Storage Facilities | | 9 |
| 31. Turbine and auxiliaries | 48 | 2 |
| 32. Feedwater and Main Steam System | | 2 |
| 34. Miscellaneous Systems | | 10 |
| 42. Electrical Power Supply Systems | | 35 |
| Total | 48 | 109 |

Highlights (2023)

The unit was shutdown for 12th planned outage from March 29 to April 24.

2023 Operating Experience

CN-9

QINSHAN 3-2

CHINA

Status at end of year : **Operational**
 Operator : CNNO (CNNC Nuclear Operation Management Company Limited)
 Owner : TQNPC (Qinshan Third nuclear power Co., LTD)
 Reactor Supplier : AECL (ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : Hit (Japan Hitachi Company.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 6 | Construction Date | : 1998-09-25 |
| Thermal power | : 2064 MWth | Grid Date | : 2003-06-12 |
| Gross electrical power | : 728 MWe | Commercial Date | : 2003-07-24 |
| Reference unit power (net) | : 677 MWe | Age at end of year | : 20 years |

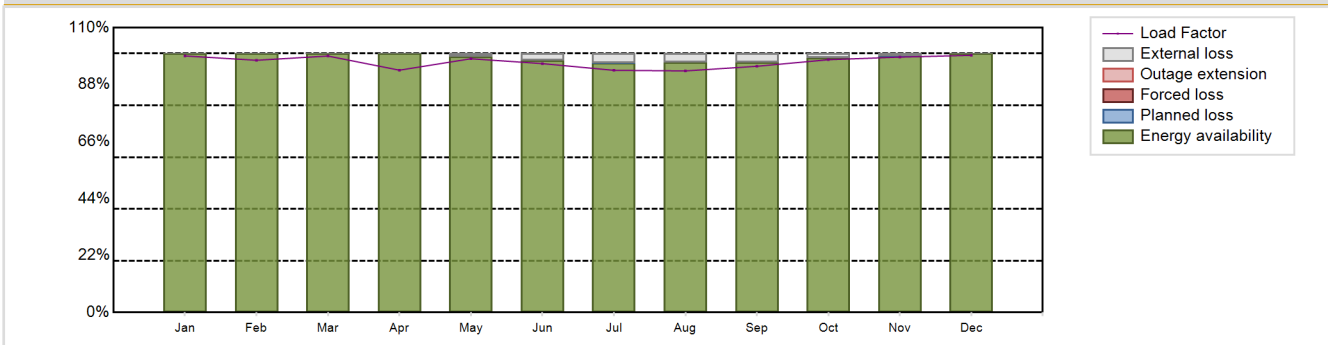
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|----------------------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 9.89 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 310 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : D2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 0.71 | Containment design pressure [MPa] | : 0.124 |
| Refuelling frequency [month] | : 60 | Secondary systems | |
| Part of the core refuelled [%] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 7186 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 6.28 | Number of LP cylinders per turbine | : 2 |
| Active core height/length [m] | : 5.94 | HP cylinder inlet steam pressure [MPa] | : 4.51 |
| Number of fissile fuel assemblies/bundles | : 4560 | Output voltage [kV] | : 22 |
| Fuel linear heat generation rate [kW/m] | : 25.35 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 21 | Number of main condensate pumps | : 2 |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : 3 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 5737.33 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 98.61 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 100 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 96.74 % | Externally cause unavailability (XUF) | : 1.39 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

Annual Summary

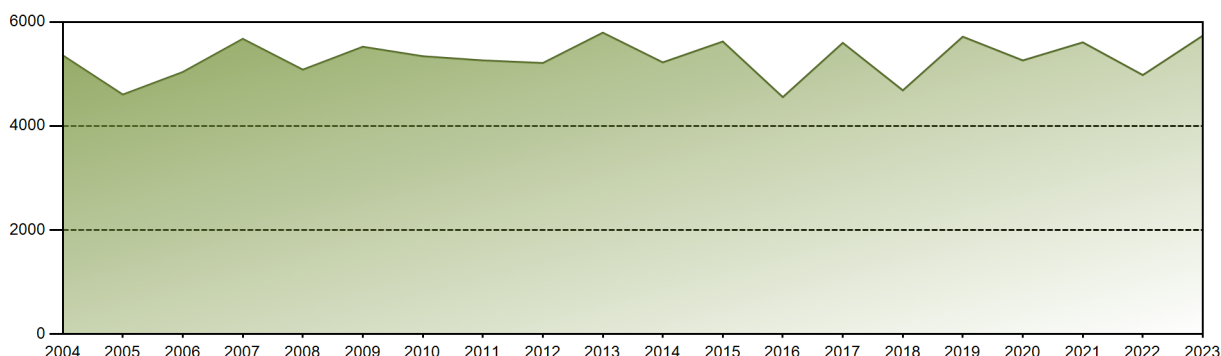


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 499.11 | 443.20 | 498.94 | 456.21 | 493.68 | 468.57 | 471.17 | 469.98 | 463.56 | 491.78 | 480.84 | 500.30 | 5737.33 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 98.77 | 97.43 | 96.43 | 96.59 | 96.68 | 98.31 | 99.17 | 100.00 | 98.61 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.97 | 100.00 | 100.00 | 100.00 | 99.98 | 100.00 | 100.00 |
| LF [%] | 99.09 | 97.42 | 99.06 | 93.59 | 98.01 | 96.13 | 93.54 | 93.31 | 95.10 | 97.64 | 98.65 | 99.33 | 96.74 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.23 | 2.57 | 3.54 | 3.41 | 3.32 | 1.69 | 0.81 | 0.00 | 1.39 |

Historical Summary

| | | | |
|---|------------------|---|----------|
| Lifetime energy generation | : 107901 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.52 % |
| Cumulative Energy Availability Factor (EAF) | : 91.46 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.54 % |
| Cumulative Unit Capability Factor (UCF) | : 91.92 % | Cumulative Planned Unavailability Factor (PUF) | : 7.54 % |
| Cumulative Load Factor (LF) | : 91 % | Cumulative Externally cause unavailability (XUF) | : 0.46 % |
| Cumulative Operating Factor (OF) | : 91.91 % | | |

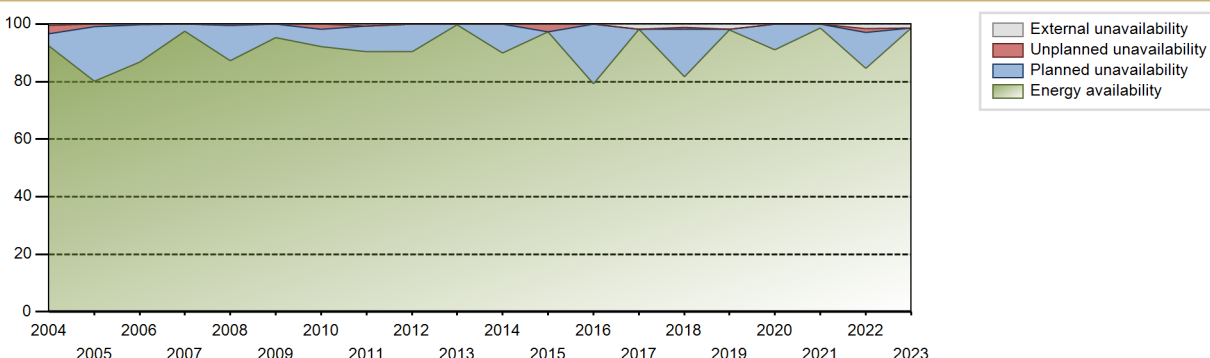
Electricity Production (net) [GWh]



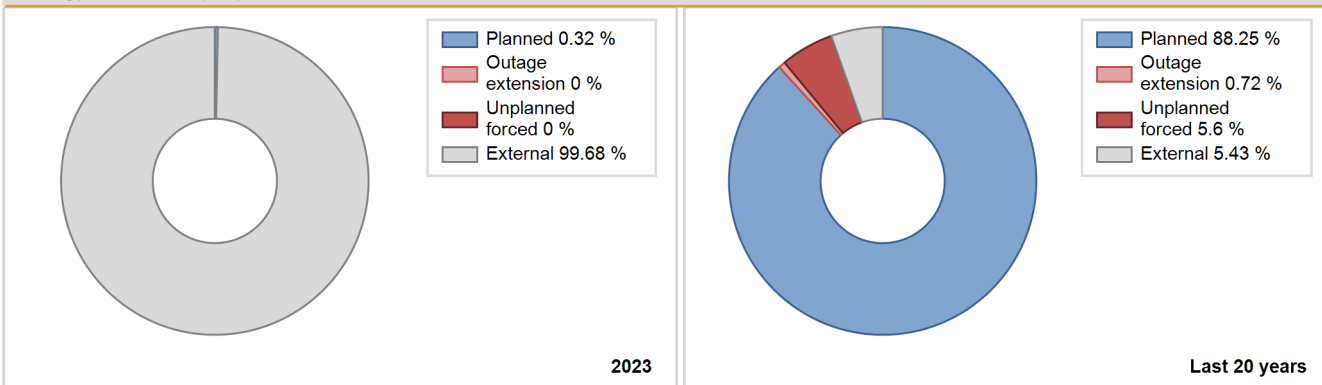
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|-------------------|---------------------------|---------------------------------|-------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2003 | Data not provided | | | | | | | | | | |
| 2004 | 5358.59 | 8236 | 665 | 92.43 | 93.00 | 91.74 | 93.76 | 2.84 | 2.72 | 4.28 | 0.57 |
| 2005 | 4604.65 | 7014 | 665 | 80.14 | 80.24 | 79.04 | 80.07 | 0.90 | 0.73 | 19.03 | 0.11 |
| 2006 | 5038.17 | 7721 | 650 | 86.72 | 86.72 | 88.48 | 88.14 | 0.25 | 0.22 | 13.06 | 0.00 |
| 2007 | 5675.70 | 8559 | 650 | 97.55 | 97.55 | 99.68 | 97.71 | 0.00 | 0.00 | 2.45 | 0.00 |
| 2008 | 5083.41 | 7697 | 650 | 87.21 | 87.32 | 89.03 | 87.63 | 0.55 | 0.48 | 12.20 | 0.11 |
| 2009 | 5523.74 | 8359 | 650 | 95.36 | 95.36 | 97.01 | 95.42 | 0.00 | 0.00 | 4.64 | 0.00 |
| 2010 | 5341.46 | 8099 | 650 | 92.06 | 92.06 | 93.81 | 92.45 | 1.93 | 1.82 | 6.13 | 0.00 |
| 2011 | 5261.09 | 7951 | 650 | 90.34 | 91.00 | 92.40 | 90.76 | 0.00 | 0.00 | 9.00 | 0.66 |
| 2012 | 5210.75 | 7980 | 650 | 90.44 | 90.44 | 91.26 | 90.85 | 0.03 | 0.03 | 9.53 | 0.00 |
| 2013 | 5794.09 | 8760 | 650 | 99.85 | 99.85 | 101.76 | 100.00 | 0.00 | 0.00 | 0.15 | 0.00 |
| 2014 | 5223.32 | 7892 | 650 | 89.99 | 89.99 | 91.73 | 90.09 | 0.04 | 0.03 | 9.98 | 0.00 |
| 2015 | 5623.82 | 8553 | 677 | 97.30 | 97.30 | 94.83 | 97.64 | 2.69 | 2.69 | 0.02 | 0.00 |
| 2016 | 4555.03 | 6979 | 677 | 79.27 | 79.27 | 76.60 | 79.45 | 0.02 | 0.02 | 20.71 | 0.00 |
| 2017 | 5598.62 | 8580 | 677 | 98.19 | 99.96 | 94.40 | 97.95 | 0.03 | 0.03 | 0.01 | 1.76 |
| 2018 | 4685.15 | 7183 | 677 | 81.58 | 82.62 | 79.00 | 82.00 | 0.94 | 0.78 | 16.60 | 1.03 |
| 2019 | 5716.87 | 8686 | 677 | 98.02 | 99.85 | 96.40 | 99.16 | 0.00 | 0.00 | 0.15 | 1.83 |
| 2020 | 5261.05 | 8014 | 677 | 91.04 | 91.04 | 88.47 | 91.23 | 0.00 | 0.00 | 8.96 | 0.00 |
| 2021 | 5607.86 | 8540 | 677 | 98.61 | 98.61 | 94.56 | 97.49 | 0.00 | 0.00 | 1.39 | 0.00 |
| 2022 | 4979.49 | 7573 | 677 | 84.62 | 86.31 | 83.96 | 86.45 | 0.00 | 1.20 | 12.49 | 1.69 |
| 2023 | 5737.33 | 8760 | 677 | 98.61 | 100.00 | 96.74 | 100.00 | 0.00 | 0.00 | 0.00 | 1.39 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2003 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 32 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 90 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 547 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 23 |
| L. Human factor related | | | | | 5 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 5 |
| Z. Other | | | | | 5 | |
| Subtotal | | | | 637 | 42 | 28 |
| Total | | 0 | | | 707 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2003 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 10 |
| 12. Reactor I&C Systems | | 5 |
| 14. Safety Systems | | 9 |
| 16. Steam generation systems | | 3 |
| 21. Fuel Handling and Storage Facilities | | 3 |
| 31. Turbine and auxiliaries | | 2 |
| 32. Feedwater and Main Steam System | | 3 |
| 34. Miscellaneous Systems | | 5 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | | 44 |

2023 Operating Experience

CN-1 **QINSHAN-1** **CHINA**

Status at end of year : **Operational**
 Operator : CNNO (CNNC Nuclear Operation Management Company Limited)
 Owner : QNPC (QINSHAN NUCLEAR POWER COMPANY)
 Reactor Supplier : CNNC (CHINA NATIONAL NUCLEAR CORPORATION)
 Turbine Supplier : STC (Shanghai Turbine Co.)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-----------------|--------------------|--------------|
| Reactor type and model | : PWR / CNP-300 | Construction Date | : 1985-03-20 |
| Thermal power | : 966 MWth | Grid Date | : 1991-12-15 |
| Gross electrical power | : 330 MWe | Commercial Date | : 1994-04-01 |
| Reference unit power (net) | : 326 MWe | Age at end of year | : 32 years |

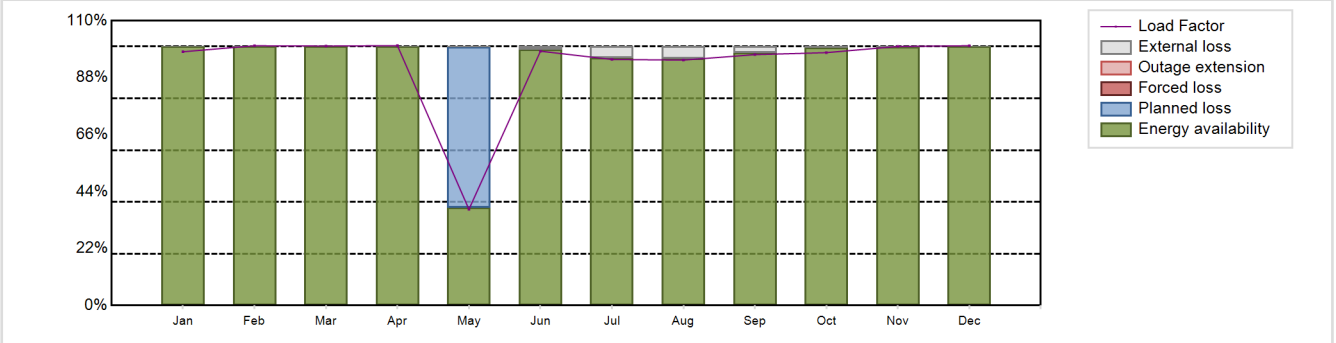
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.2 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 308.5 |
| Refuelling type | : OFF-line | Number of SG | : 2 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 3.4 | Containment design pressure [MPa] | : 2.65 |
| Refuelling frequency [month] | : 12 | Secondary systems | |
| Part of the core refuelled [%] | : 33.33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 33000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 2.486 | Number of LP cylinders per turbine | : 2 |
| Active core height/length [m] | : 2.9 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Number of fissile fuel assemblies/bundles | : 121 | Output voltage [kV] | : 18 |
| Fuel linear heat generation rate [kW/m] | : 13.5 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 37 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 3 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 2659.67 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 93.61 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 94.72 % | Planned Unavailability Factor (PUF) | : 5.28 % |
| Load Factor (LF) | : 93.13 % | Externally cause unavailability (XUF) | : 1.1 % |
| Operating Factor (OF) | : 95.1 % | Total off-line time | : 429 hours |

Annual Summary

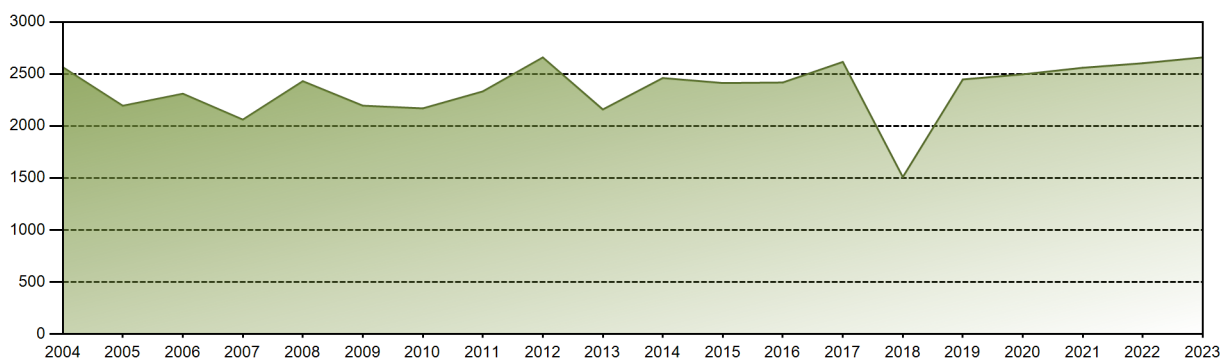


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 237.71 | 219.76 | 243.11 | 235.57 | 90.08 | 230.55 | 230.47 | 229.89 | 227.42 | 236.89 | 234.86 | 243.35 | 2659.67 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 37.74 | 98.79 | 95.70 | 95.46 | 97.51 | 99.56 | 99.92 | 100.00 | 93.61 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 37.80 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.72 |
| LF [%] | 98.01 | 100.32 | 100.23 | 100.36 | 37.14 | 98.22 | 95.02 | 94.78 | 96.89 | 97.67 | 100.06 | 100.33 | 93.13 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 42.34 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.10 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 62.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.28 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 1.21 | 4.30 | 4.54 | 2.49 | 0.44 | 0.08 | 0.00 | 1.10 |

Historical Summary

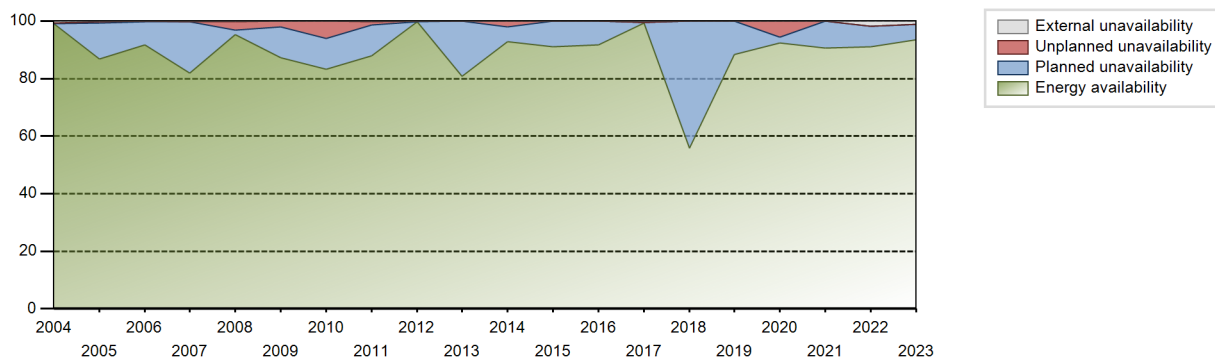
| | | | | | |
|---|---|---------------|---|---|---------|
| Lifetime energy generation | : | 66886 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 3.53 % |
| Cumulative Energy Availability Factor (EAF) | : | 83.06 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 3.37 % |
| Cumulative Unit Capability Factor (UCF) | : | 84.05 % | Cumulative Planned Unavailability Factor (PUF) | : | 12.59 % |
| Cumulative Load Factor (LF) | : | 84.33 % | Cumulative Externally cause unavailability (XUF) | : | 0.98 % |
| Cumulative Operating Factor (OF) | : | 84.62 % | | | |

Electricity Production (net) [GWh]

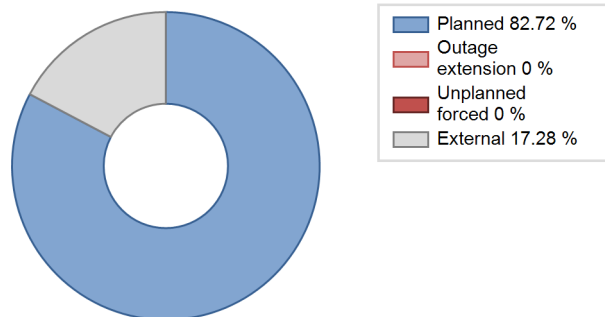


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1994 | 1648.58 | 6439 | 279 | 62.02 | 67.45 | 62.67 | 70.06 | 3.98 | 2.80 | 29.75 | 5.44 |
| 1995 | 2063.90 | 7886 | 300 | 82.32 | 86.80 | 78.53 | 90.02 | 2.25 | 2.00 | 11.20 | 4.49 |
| 1996 | 2073.72 | 7479 | 279 | 81.19 | 81.19 | 84.62 | 85.14 | 1.17 | 0.96 | 17.85 | 0.00 |
| 1997 | 2011.67 | 7185 | 300 | 76.11 | 81.78 | 76.55 | 82.02 | 2.87 | 2.42 | 15.80 | 5.67 |
| 1998 | 1149.49 | 4331 | 279 | 42.59 | 48.78 | 47.03 | 49.44 | 0.98 | 0.48 | 50.74 | 6.19 |
| 1999 | 680.88 | 2519 | 279 | 27.76 | 27.76 | 27.86 | 28.76 | 71.97 | 71.28 | 0.96 | 0.00 |
| 2000 | 2035.48 | 6840 | 300 | 77.61 | 77.61 | 77.24 | 77.87 | 2.79 | 2.23 | 20.16 | 0.00 |
| 2001 | 2319.37 | 8370 | 279 | 92.82 | 93.47 | 94.90 | 95.55 | 0.51 | 0.48 | 6.05 | 0.64 |
| 2002 | 1783.25 | 5989 | 279 | 66.31 | 69.21 | 72.96 | 68.37 | 1.40 | 0.98 | 29.81 | 2.90 |
| 2003 | 2256.57 | 7798 | 288 | 88.44 | 88.46 | 89.44 | 89.02 | 0.24 | 0.21 | 11.33 | 0.01 |
| 2004 | 2565.24 | 8784 | 288 | 99.08 | 99.79 | 101.40 | 100.00 | 0.11 | 0.11 | 0.10 | 0.71 |
| 2005 | 2194.56 | 7693 | 288 | 86.83 | 87.02 | 86.99 | 87.82 | 0.53 | 0.46 | 12.52 | 0.19 |
| 2006 | 2310.41 | 8086 | 288 | 91.81 | 91.81 | 91.58 | 92.31 | 0.05 | 0.29 | 7.89 | 0.00 |
| 2007 | 2061.43 | 7218 | 288 | 81.99 | 82.22 | 81.71 | 82.40 | 0.10 | 0.08 | 17.70 | 0.23 |
| 2008 | 2430.72 | 8434 | 288 | 95.38 | 95.54 | 96.08 | 96.02 | 1.02 | 2.99 | 1.47 | 0.16 |
| 2009 | 2195.44 | 7704 | 288 | 87.33 | 87.41 | 87.02 | 87.95 | 2.20 | 1.96 | 10.62 | 0.08 |
| 2010 | 2169.32 | 7398 | 298 | 83.24 | 83.33 | 84.27 | 84.45 | 0.47 | 6.03 | 10.64 | 0.09 |
| 2011 | 2332.64 | 7762 | 298 | 87.88 | 88.06 | 89.36 | 88.61 | 0.41 | 1.20 | 10.75 | 0.18 |
| 2012 | 2659.07 | 8784 | 298 | 99.80 | 99.94 | 101.58 | 100.00 | 0.02 | 0.02 | 0.05 | 0.14 |
| 2013 | 2158.84 | 7199 | 298 | 80.86 | 80.98 | 82.70 | 82.18 | 0.02 | 0.02 | 19.00 | 0.12 |
| 2014 | 2461.14 | 8221 | 298 | 92.93 | 92.93 | 94.28 | 93.85 | 2.07 | 1.97 | 5.10 | 0.00 |
| 2015 | 2413.17 | 8003 | 298 | 91.14 | 91.14 | 92.44 | 91.36 | 0.11 | 0.10 | 8.76 | 0.00 |
| 2016 | 2418.29 | 8084 | 298 | 91.75 | 91.75 | 92.38 | 92.03 | 0.02 | 0.02 | 8.23 | 0.00 |
| 2017 | 2615.97 | 8760 | 298 | 99.37 | 99.96 | 100.21 | 100.00 | 0.00 | 0.00 | 0.04 | 0.60 |
| 2018 | 1509.11 | 5147 | 298 | 55.80 | 55.80 | 57.81 | 58.76 | 0.00 | 0.00 | 44.20 | 0.00 |
| 2019 | 2447.78 | 7782 | 298 | 88.27 | 88.27 | 93.77 | 88.84 | 0.00 | 0.00 | 11.73 | 0.00 |
| 2020 | 2496.95 | 8132 | 308 | 92.28 | 92.28 | 92.29 | 92.58 | 5.67 | 5.54 | 2.18 | 0.00 |
| 2021 | 2560.13 | 7982 | 308 | 90.71 | 90.71 | 94.89 | 91.12 | 0.00 | 0.00 | 9.29 | 0.00 |
| 2022 | 2603.50 | 8161 | 326 | 91.09 | 92.97 | 91.17 | 93.16 | 0.00 | 0.00 | 7.03 | 1.88 |
| 2023 | 2659.67 | 8331 | 326 | 93.61 | 94.72 | 93.13 | 95.10 | 0.00 | 0.00 | 5.28 | 1.10 |

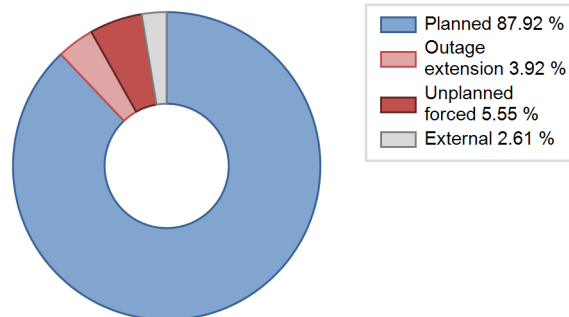
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1994 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 70 | |
| C. Inspection, maintenance or repair combined with refuelling | 437 | | | 1012 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 42 | | |
| E. Testing of plant systems or components | | | | 0 | 2 | |
| L. Human factor related | | | | | 12 | |
| Z. Other | | | | | 208 | 1 |
| Subtotal | 437 | | | 1054 | 292 | 1 |
| Total | | 437 | | | 1347 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1994 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 16 |
| 12. Reactor I&C Systems | | 11 |
| 13. Reactor Auxiliary Systems | | 3 |
| 15. Reactor Cooling Systems | | 6 |
| 16. Steam generation systems | | 0 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 4 |
| 32. Feedwater and Main Steam System | | 9 |
| 33. Circulating Water System | | 3 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 17 |
| Total | | 72 |

Highlights (2023)

The unit was shutdown for 22th planned outage from May 1 to May 19.

2023 Operating Experience

CN-28

SANMEN-1

CHINA

Status at end of year : **Operational**
 Operator : SMNPC (SANMEN NUCLEAR POWER CO., LTD.)
 Owner : SMNPC (SANMEN NUCLEAR POWER CO., LTD.)
 Reactor Supplier : WH/MHI (WESTINGHOUSE ELECTRIC CORPORATION / MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



Reactor Unit Details

Reactor type and model : PWR / AP-1000
 Thermal power : 3400 MWth
 Gross electrical power : 1251 MWe
 Reference unit power (net) : 1157 MWe

Key Dates

Construction Date : 2009-04-19
 Grid Date : 2018-06-30
 Commercial Date : 2018-09-21
 Age at end of year : 5 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.7239
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 40.8
 Average discharge burnup [MWd/t] : 50558
 Active core diameter [m] : 3.04
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.77
 Number of control rod assemblies : 69
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 321
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.407

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.38
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : NA

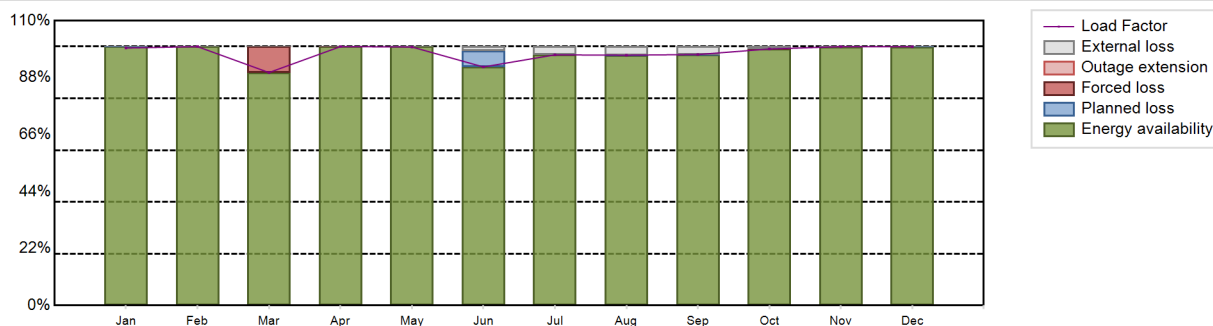
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9887.28 GW(e).h
 Energy Availability Factor (EAF) : 97.62 %
 Unit Capability Factor (UCF) : 98.63 %
 Load Factor (LF) : 97.55 %
 Operating Factor (OF) : 98.94 %
 Forced Loss Rate (FLR) : 0.86 %
 Unplanned Capability Loss Factor (UCL) : 0.85 %
 Planned Unavailability Factor (PUF) : 0.52 %
 Externally cause unavailability (XUF) : 1.01 %
 Total off-line time : 93 hours

Annual Summary

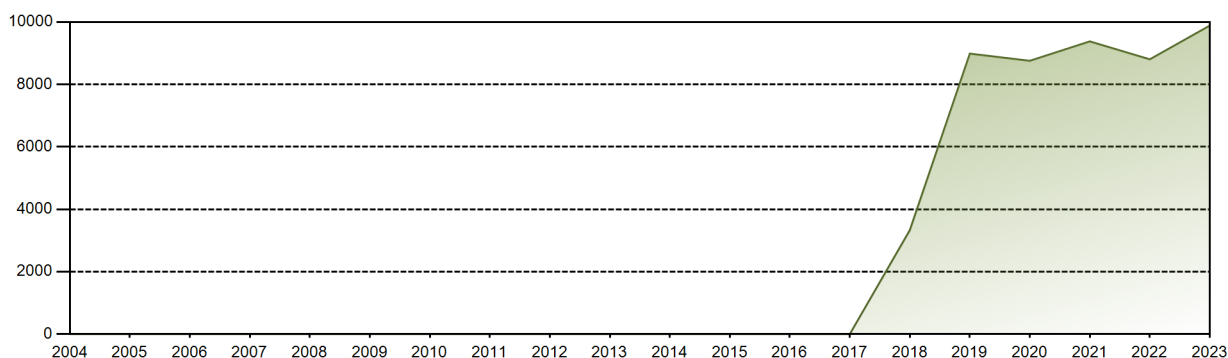


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 856.02 | 777.50 | 774.50 | 832.93 | 859.51 | 767.58 | 833.38 | 832.34 | 807.48 | 852.90 | 832.89 | 860.24 | 9887.28 |
| EAF [%] | 100.00 | 100.00 | 89.97 | 99.99 | 100.00 | 92.14 | 96.81 | 96.69 | 96.93 | 99.18 | 99.98 | 99.93 | 97.62 |
| UCF [%] | 100.00 | 100.00 | 89.97 | 99.99 | 100.00 | 93.79 | 100.00 | 100.00 | 100.00 | 99.98 | 99.98 | 99.93 | 98.63 |
| LF [%] | 99.44 | 100.00 | 89.97 | 99.99 | 99.85 | 92.14 | 96.81 | 96.69 | 96.93 | 99.08 | 99.98 | 99.93 | 97.55 |
| OF [%] | 100.00 | 100.00 | 91.80 | 100.00 | 100.00 | 95.56 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.94 |
| FLR [%] | 0.00 | 0.00 | 10.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.86 |
| UCL [%] | 0.00 | 0.00 | 10.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.85 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.07 | 0.52 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.65 | 3.19 | 3.31 | 3.07 | 0.80 | 0.00 | 0.00 | 1.01 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 49147.96 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.89 % |
| Cumulative Energy Availability Factor (EAF) | : 91.88 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.78 % |
| Cumulative Unit Capability Factor (UCF) | : 92.8 % | Cumulative Planned Unavailability Factor (PUF) | : 5.41 % |
| Cumulative Load Factor (LF) | : 90.79 % | Cumulative Externally cause unavailability (XUF) | : 0.93 % |
| Cumulative Operating Factor (OF) | : 92.77 % | | |

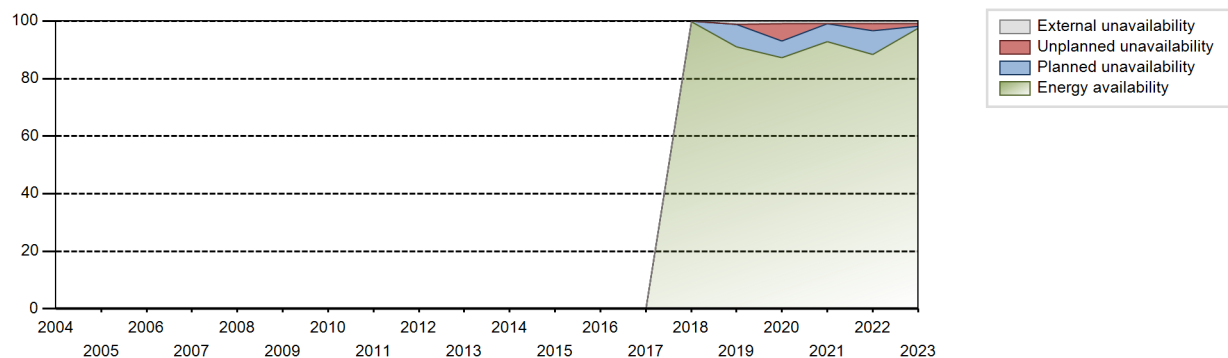
Electricity Production (net) [GWh]



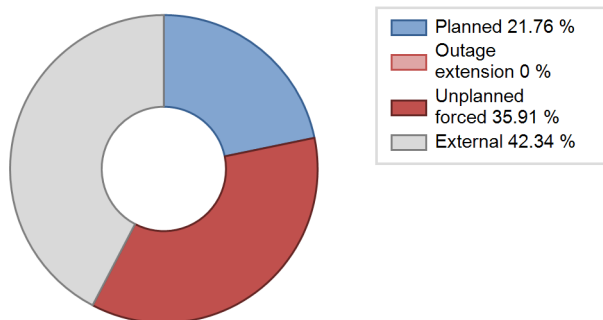
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2018 | 3330.63 | 3840 | 1157 | 99.85 | 99.98 | 99.39 | 100.00 | 0.00 | 0.00 | 0.02 | 0.13 |
| 2019 | 8987.29 | 7909 | 1157 | 91.14 | 92.26 | 88.67 | 90.29 | 0.00 | 0.00 | 7.74 | 1.12 |
| 2020 | 8757.82 | 7832 | 1157 | 87.29 | 88.13 | 86.17 | 89.16 | 6.47 | 6.09 | 5.78 | 0.84 |
| 2021 | 9379.74 | 8268 | 1157 | 92.91 | 93.90 | 92.55 | 94.38 | 0.00 | 0.00 | 6.10 | 0.99 |
| 2022 | 8805.20 | 7821 | 1157 | 88.42 | 89.31 | 86.88 | 89.28 | 2.63 | 2.41 | 8.29 | 0.88 |
| 2023 | 9887.28 | 8667 | 1157 | 97.62 | 98.63 | 97.55 | 98.94 | 0.86 | 0.85 | 0.52 | 1.01 |

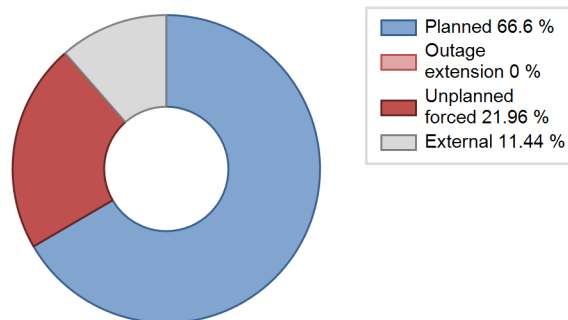
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2018 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 61 | | | 142 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 404 | | |
| D. Inspection, maintenance or repair without refuelling | 32 | | | 60 | | |
| E. Testing of plant systems or components | | | | 59 | | |
| I. Grid capacity limitation | | | | | | 21 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 33 |
| Z. Other | | | | 27 | | |
| Subtotal | 32 | 61 | | 550 | 142 | 54 |
| Total | | 93 | | | 746 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2018 to 2023 | |
|-----------------------------|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 7 |
| 15. Reactor Cooling Systems | | 61 | | 126 |
| 41. Main Generator Systems | | | | 20 |
| Total | | 61 | | 153 |

Highlights (2023)

The overall operation of Unit 1 in 2023 is good, with a total of 7 peak shaving operations, 1 unplanned minor repair, and 1 planned minor repair.

2023 Operating Experience

CN-29

SANMEN-2

CHINA

Status at end of year : **Operational**
 Operator : SMNPC (SANMEN NUCLEAR POWER CO., LTD.)
 Owner : SMNPC (SANMEN NUCLEAR POWER CO., LTD.)
 Reactor Supplier : WH/MHI (WESTINGHOUSE ELECTRIC CORPORATION / MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



Reactor Unit Details

Reactor type and model : PWR / AP-1000
 Thermal power : 3400 MWth
 Gross electrical power : 1251 MWe
 Reference unit power (net) : 1157 MWe

Key Dates

Construction Date : 2009-12-15
 Grid Date : 2018-08-24
 Commercial Date : 2018-11-05
 Age at end of year : 5 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.7239
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 40.8
 Average discharge burnup [MWd/t] : 50558
 Active core diameter [m] : 3.04
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.77
 Number of control rod assemblies : 69
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 321
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.407

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.38
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : -

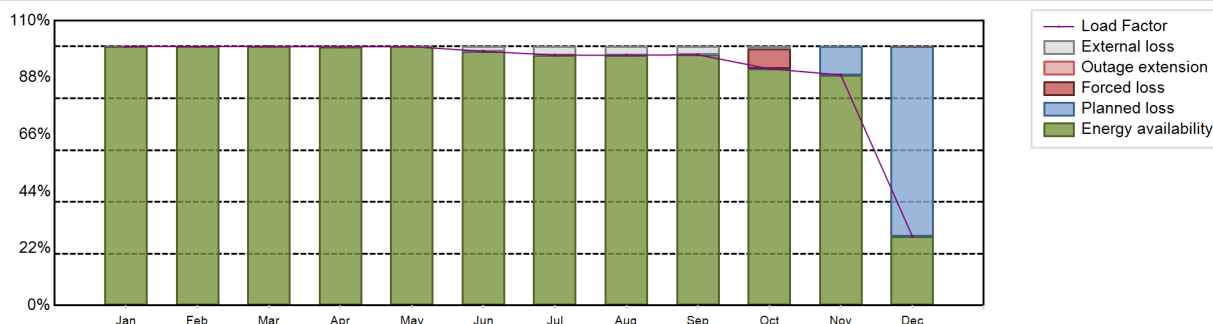
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9240.77 GW(e).h
 Energy Availability Factor (EAF) : 91.17 %
 Unit Capability Factor (UCF) : 92.21 %
 Load Factor (LF) : 91.17 %
 Operating Factor (OF) : 92.58 %
 Forced Loss Rate (FLR) : 0.71 %
 Unplanned Capability Loss Factor (UCL) : 0.66 %
 Planned Unavailability Factor (PUF) : 7.12 %
 Externally cause unavailability (XUF) : 1.04 %
 Total off-line time : 650 hours

Annual Summary

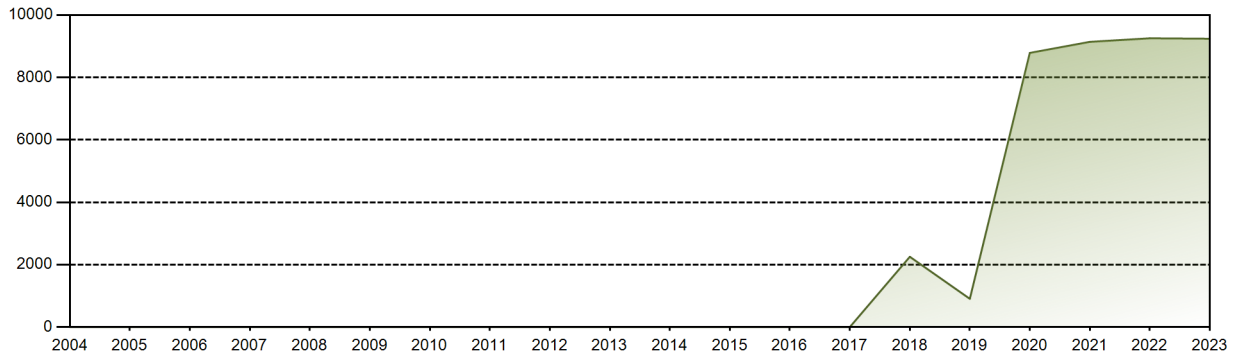


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 860.76 | 777.48 | 860.80 | 832.89 | 860.81 | 817.65 | 832.71 | 831.85 | 806.78 | 787.01 | 741.82 | 230.21 | 9240.77 |
| EAF [%] | 99.99 | 100.00 | 100.00 | 99.98 | 100.00 | 98.15 | 96.74 | 96.64 | 96.85 | 91.43 | 89.05 | 26.74 | 91.17 |
| UCF [%] | 99.99 | 100.00 | 100.00 | 99.98 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.23 | 89.05 | 26.74 | 92.21 |
| LF [%] | 99.99 | 100.00 | 100.00 | 99.98 | 100.00 | 98.15 | 96.74 | 96.64 | 96.85 | 91.43 | 89.05 | 26.74 | 91.17 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.82 | 89.44 | 29.03 | 92.58 |
| FLR [%] | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.77 | 0.00 | 0.04 | 0.71 |
| UCL [%] | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.77 | 0.00 | 0.01 | 0.66 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.95 | 73.25 | 7.12 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.85 | 3.26 | 3.36 | 3.15 | 0.80 | 0.00 | 0.00 | 1.04 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 39579.91 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 19.02 % |
| Cumulative Energy Availability Factor (EAF) | : 76.09 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 18.36 % |
| Cumulative Unit Capability Factor (UCF) | : 77.22 % | Cumulative Planned Unavailability Factor (PUF) | : 4.43 % |
| Cumulative Load Factor (LF) | : 74.01 % | Cumulative Externally cause unavailability (XUF) | : 1.13 % |
| Cumulative Operating Factor (OF) | : 75.55 % | | |

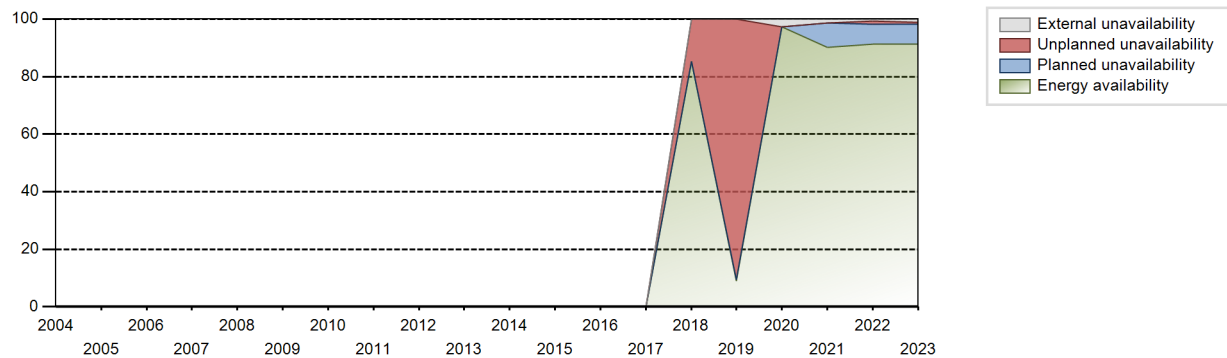
Electricity Production (net) [GWh]



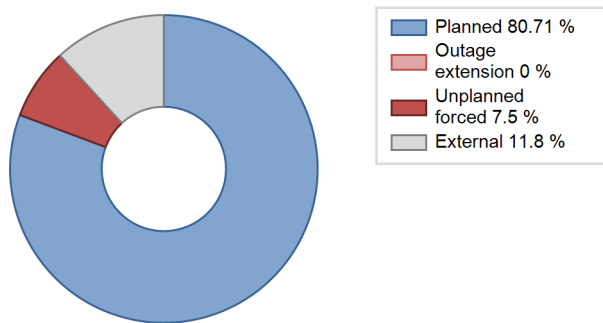
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2018 | 2252.77 | 2381 | 1157 | 85.14 | 85.14 | 85.84 | 85.18 | 14.85 | 14.84 | 0.02 | 0.00 |
| 2019 | 905.96 | 817 | 1157 | 8.94 | 8.94 | 8.94 | 9.33 | 91.02 | 90.64 | 0.42 | 0.00 |
| 2020 | 8786.18 | 7871 | 1157 | 97.25 | 99.99 | 86.45 | 89.61 | 0.00 | 0.00 | 0.01 | 2.74 |
| 2021 | 9140.14 | 8085 | 1157 | 90.21 | 91.48 | 90.18 | 92.29 | 0.00 | 0.00 | 8.52 | 1.27 |
| 2022 | 9254.09 | 8087 | 1157 | 91.31 | 92.09 | 91.31 | 92.32 | 0.00 | 1.11 | 6.80 | 0.78 |
| 2023 | 9240.77 | 8110 | 1157 | 91.17 | 92.21 | 91.17 | 92.58 | 0.71 | 0.66 | 7.12 | 1.04 |

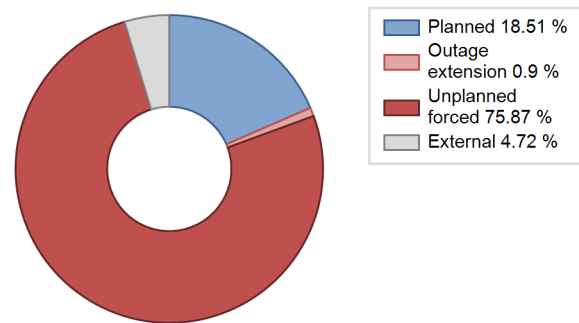
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2018 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 46 | | | 1588 | |
| C. Inspection, maintenance or repair combined with refuelling | 604 | | | 359 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 61 | | |
| E. Testing of plant systems or components | | | | 37 | | |
| O. Load dispatching, prioritization | | | | | | 177 |
| Z. Other | | | | | 19 | |
| Subtotal | 604 | 46 | | 457 | 1607 | 177 |
| Total | | 650 | | | 2241 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2018 to 2023 | |
|-----------------------------|------------|----|-------------------------------------|------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 15. Reactor Cooling Systems | | 46 | | 1515 |
| 41. Main Generator Systems | | | | 18 |
| Total | | 46 | | 1533 |

Highlights (2023)

1. The overall operation of Unit 2 in 2023 is good, with one unplanned shutdown and minor repair.
2. At 23:45 on December 22, 2023, the outage of Unit 203 of Unit 2 was completed, lasting 25.17 days.

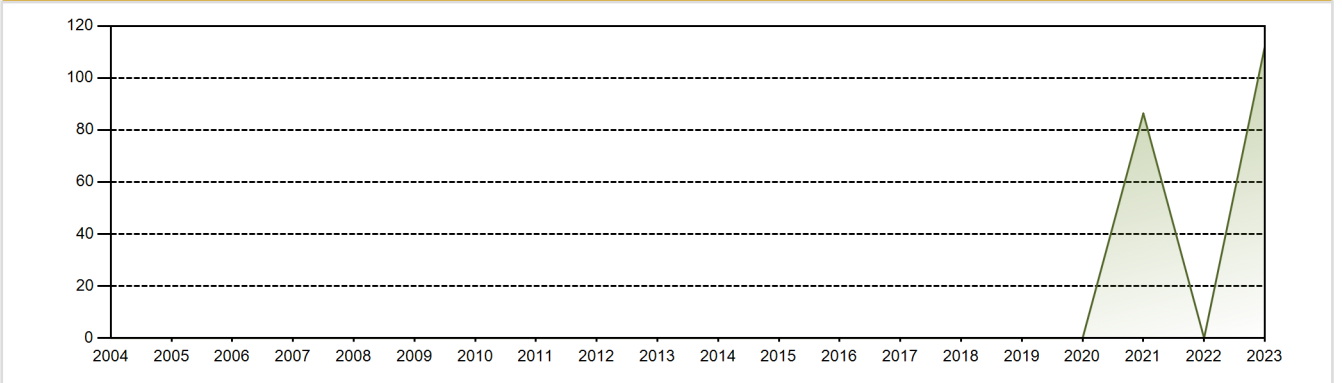
2023 Operating Experience

| CN-44 | | SHIDAO BAY-1 | | CHINA | | | | | | | | | |
|---|---|--|----------------------------------|--------------------|-----|-----|-----|-----|-----|-----|-----|--------|--------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : HSNPC (Huaneng Shandong Shidao Bay Nuclear Power Company, Ltd.) | | | | | | | | | | | | |
| Owner | : CHNG (China Huaneng Group) | | | | | | | | | | | | |
| Reactor Supplier | : TSINGHUA (Tsinghua university) | | | | | | | | | | | | |
| Turbine Supplier | : STC (Shanghai Turbine Co.) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : HTGR / HTR-PM | Construction Date | : | 2012-12-09 | | | | | | | | | |
| Thermal power | : 500 MWth | Grid Date | : | 2021-12-14 | | | | | | | | | |
| Gross electrical power | : 211 MWe | Commercial Date | : | 2023-12-06 | | | | | | | | | |
| Reference unit power (net) | : 150 MWe | Age at end of year | : | 2 years | | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | | | | | | | | | | |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : | 750 | | | | | | | | | |
| Fuel material | : UO2 | Number of SG | : | 2 | | | | | | | | | |
| Refuelling type | : ON-line | Containment type | : | Single | | | | | | | | | |
| Moderator material | : GRAPHITE | Containment design pressure [MPa] | : | 0.13 | | | | | | | | | |
| Average fuel enrichment [% of U235] | : 8.5 | Secondary systems | | | | | | | | | | | |
| Refuelling frequency [month] | : - | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | | |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : | 3000 | | | | | | | | | |
| Average discharge burnup [MWd/t] | : 90000 | Number of LP cylinders per turbine | : | 2 | | | | | | | | | |
| Active core diameter [m] | : 3 | HP cylinder inlet steam pressure [MPa] | : | 13.24 | | | | | | | | | |
| Active core height/length [m] | : 11 | Output voltage [kV] | : | 18 | | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : 420000 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : - | Number of main condensate pumps | : | 3 | | | | | | | | | |
| Number of control rod assemblies | : 24 | Number of FW pumps for full power operation | : | 2 | | | | | | | | | |
| Number of external reactor coolant loops | : 1 | Number of on-site safety related diesel generators | : | - | | | | | | | | | |
| Coolant type | : Other | Non-electrical applications | | | | | | | | | | | |
| | | | : | none | | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : 112.09 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | | |
| Energy Availability Factor (EAF) | : 100 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | | |
| Unit Capability Factor (UCF) | : 100 % | Planned Unavailability Factor (PUF) | : | 0 % | | | | | | | | | |
| Load Factor (LF) | : 100.44 % | Externally cause unavailability (XUF) | : | 0 % | | | | | | | | | |
| Operating Factor (OF) | : 100 % | Total off-line time | : | 0 hours | | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Oct | Nov | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Dec | Annual |
| GW(e)-h | | | | | | | | | | | | 112.09 | 112.09 |
| EAF [%] | | | | | | | | | | | | 100.00 | 100.00 |
| UCF [%] | | | | | | | | | | | | 100.00 | 100.00 |
| LF [%] | | | | | | | | | | | | 100.44 | 100.44 |
| OF [%] | | | | | | | | | | | | 100.00 | 100.00 |
| FLR [%] | | | | | | | | | | | | 0.00 | 0.00 |
| UCL [%] | | | | | | | | | | | | 0.00 | 0.00 |
| PUF [%] | | | | | | | | | | | | 0.00 | 0.00 |
| XUF [%] | | | | | | | | | | | | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|------------------|---|-------|
| Lifetime energy generation | : 112.09 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0 % |
| Cumulative Energy Availability Factor (EAF) | : 100 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0 % |
| Cumulative Unit Capability Factor (UCF) | : 100 % | Cumulative Planned Unavailability Factor (PUF) | : 0 % |
| Cumulative Load Factor (LF) | : 100.44 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 100 % | | |

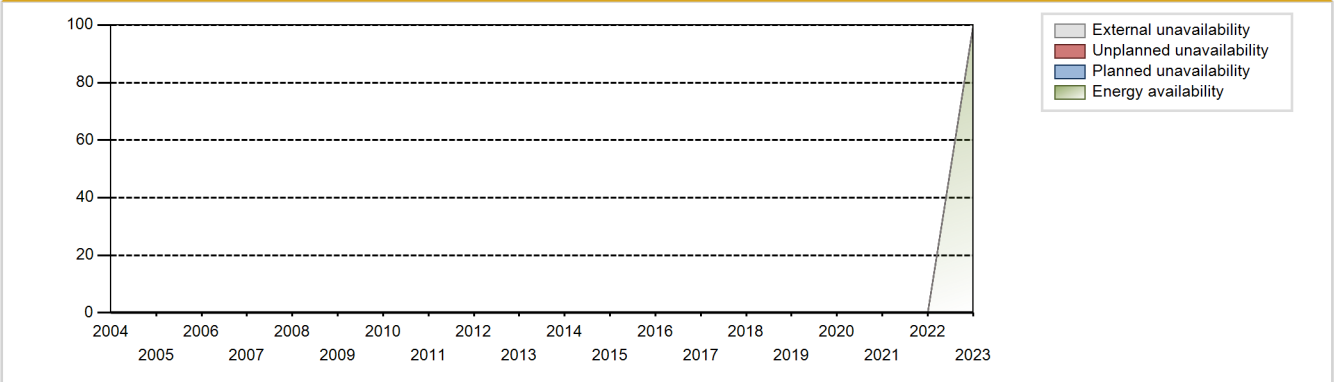
Electricity Production (net) [GWh]



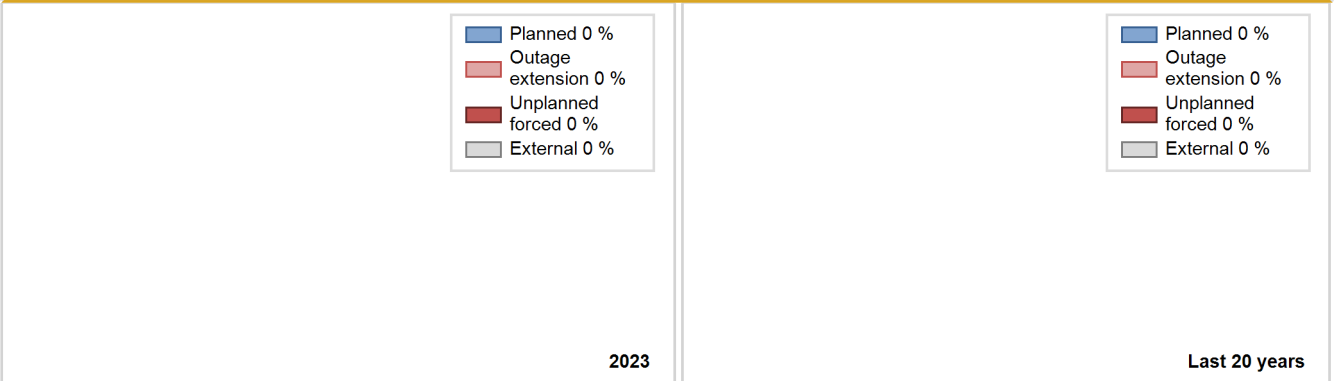
Performance for Years of Commercial Operation

| Year | Energy | Time Online | Reference Unit Power | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|--------|-------------|----------------------|--------|--------|--------|--------|------|------|------|------|
| | [GW-h] | [Hours] | [MW] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2023 | 112.09 | 744 | 150 | 100.00 | 100.00 | 100.44 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2023 to 2023 | | |
|--------------|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| Subtotal | | | | | | |
| Total | | 0 | | | 0 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2023 to 2023 |
|--------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| Total | | |

Highlights (2023)

During the year, Shidao Bay Nuclear Power Plant Unit 1 maintained power operation, and no manual or automatic emergency shutdown occurred.

2023 Operating Experience

CN-32

TAISHAN-1

CHINA

Status at end of year : **Operational**
 Operator : TNPJVC (Taishan Nuclear Power Joint Venture Company Limited)
 Owner : TNPJVC (Taishan Nuclear Power Joint Venture Company Limited)
 Reactor Supplier : ORANO (ORANO)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / EPR-1750
 Thermal power : 4590 MWth
 Gross electrical power : 1750 MWe
 Reference unit power (net) : 1660 MWe

Key Dates

Construction Date : 2009-11-18
 Grid Date : 2018-06-29
 Commercial Date : 2018-12-13
 Age at end of year : 5 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.98
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 29.88
 Average discharge burnup [MWd/t] : 59000
 Active core diameter [m] : 3.657
 Active core height/length [m] : 4.2
 Number of fissile fuel assemblies/bundles : 241
 Fuel linear heat generation rate [kW/m] : 16.6
 Number of control rod assemblies : 89
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 329.9
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 0.55

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : NA
 Output voltage [kV] : 27
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 6

Non-electrical applications

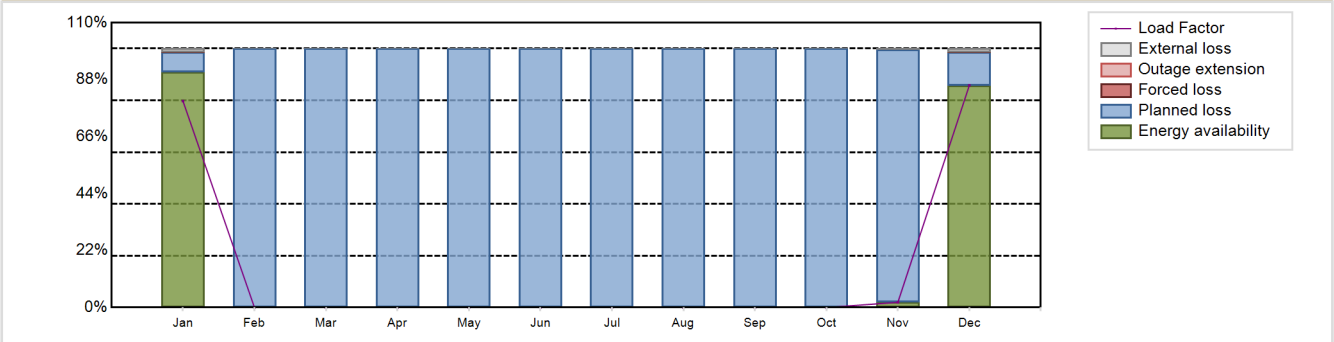
: none

Annual Production Results (2023)

Net Energy Production : 2068.28 GW(e).h
 Energy Availability Factor (EAF) : 15.18 %
 Unit Capability Factor (UCF) : 15.45 %
 Load Factor (LF) : 14.22 %
 Operating Factor (OF) : 17.64 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 84.54 %
 Externally cause unavailability (XUF) : 0.27 %
 Total off-line time : 7215 hours

Annual Summary

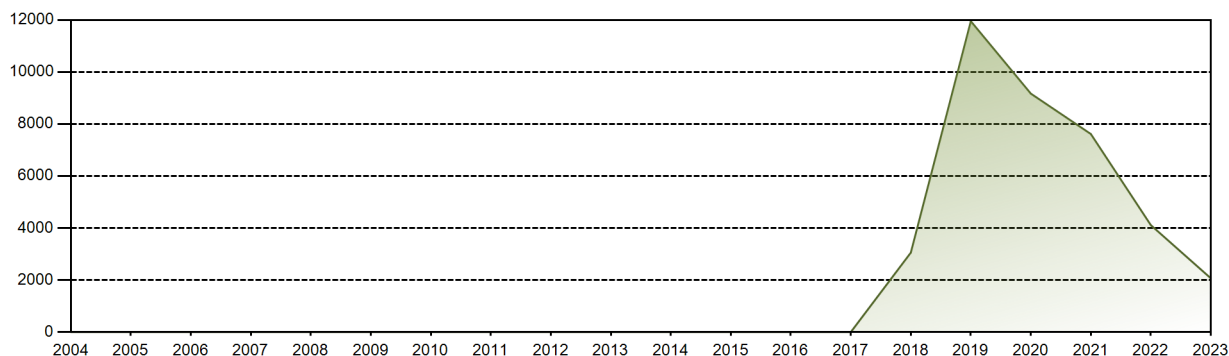


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|---------|---------|
| GW(e)-h | 984.49 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 23.99 | 1059.80 | 2068.27 |
| EAF [%] | 91.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.01 | 85.81 | 15.18 |
| UCF [%] | 92.45 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.43 | 87.16 | 15.45 |
| LF [%] | 79.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.01 | 85.81 | 14.22 |
| OF [%] | 97.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.28 | 100.00 | 17.64 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| PUF [%] | 7.55 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.57 | 12.83 | 84.54 |
| XUF [%] | 1.45 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.43 | 1.35 | 0.27 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 37924.66 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.16 % |
| Cumulative Energy Availability Factor (EAF) | : 52.52 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.35 % |
| Cumulative Unit Capability Factor (UCF) | : 53.05 % | Cumulative Planned Unavailability Factor (PUF) | : 45.59 % |
| Cumulative Load Factor (LF) | : 48.59 % | Cumulative Externally cause unavailability (XUF) | : 0.53 % |
| Cumulative Operating Factor (OF) | : 55.55 % | | |

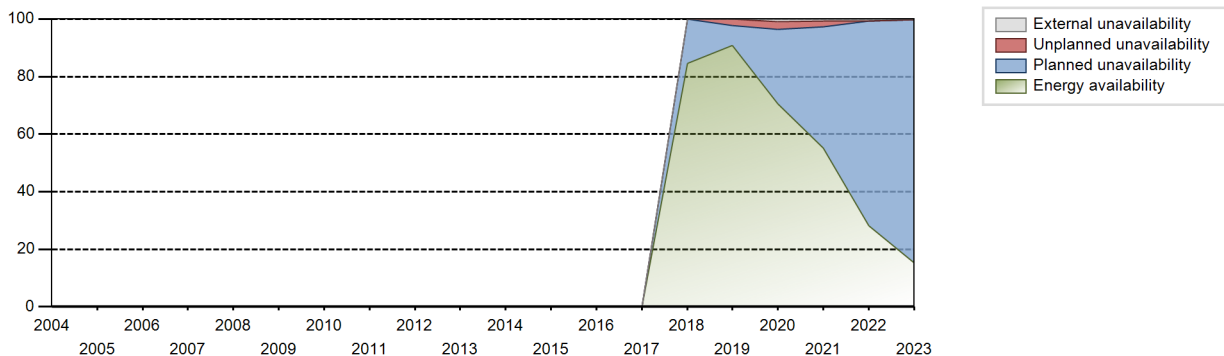
Electricity Production (net) [GWh]



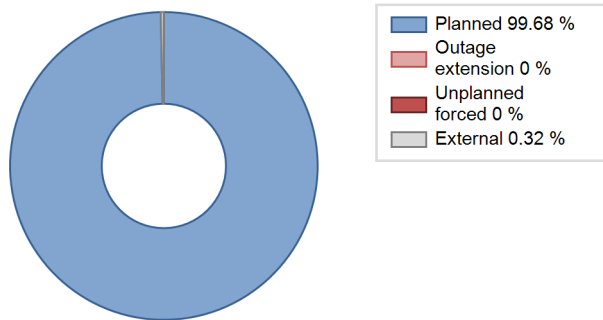
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2018 | 3056.09 | 3958 | 1660 | 84.52 | 84.52 | 83.51 | 100.00 | 0.00 | 0.00 | 15.48 | 0.00 |
| 2019 | 11952.73 | 7836 | 1660 | 90.77 | 90.77 | 82.20 | 89.45 | 0.73 | 2.26 | 6.97 | 0.00 |
| 2020 | 9169.83 | 6377 | 1660 | 70.53 | 71.56 | 62.89 | 72.60 | 0.53 | 2.49 | 25.95 | 1.03 |
| 2021 | 7616.68 | 4933 | 1660 | 55.07 | 55.79 | 52.38 | 56.31 | 3.56 | 2.06 | 42.15 | 0.72 |
| 2022 | 4113.09 | 3322 | 1660 | 28.28 | 28.97 | 28.28 | 37.92 | 0.23 | 0.07 | 70.96 | 0.69 |
| 2023 | 2068.28 | 1545 | 1660 | 15.18 | 15.45 | 14.22 | 17.64 | 0.00 | 0.00 | 84.54 | 0.27 |

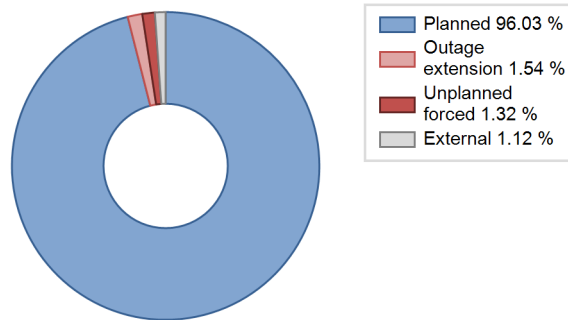
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2018 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 44 | |
| C. Inspection, maintenance or repair combined with refuelling | 7215 | | | 1797 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 1931 | | |
| E. Testing of plant systems or components | | | | 6 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 66 |
| L. Human factor related | | | | | 113 | |
| Z. Other | | | | | 37 | |
| Subtotal | 7215 | | | 3734 | 194 | 66 |
| Total | | 7215 | | | 3994 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2018 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 1 |
| 15. Reactor Cooling Systems | | 14 |
| 16. Steam generation systems | | 15 |
| 31. Turbine and auxiliaries | | 15 |
| 32. Feedwater and Main Steam System | | 56 |
| 33. Circulating Water System | | 17 |
| 34. Miscellaneous Systems | | 90 |
| Total | | 208 |

Highlights (2023)

There wasn't unplanned scram in CN32 in 2023

2023 Operating Experience

CN-33

TAISHAN-2

CHINA

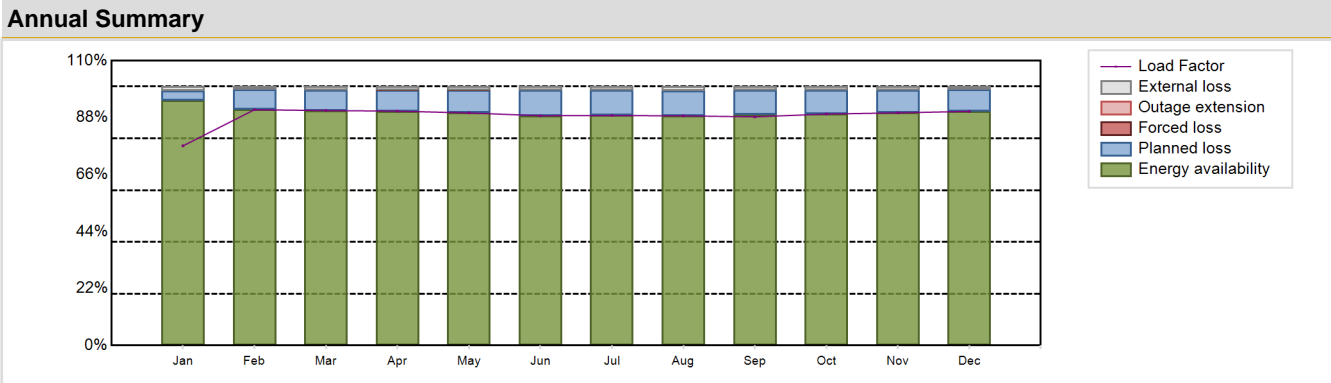
Status at end of year : **Operational**
 Operator : TNPJVC (Taishan Nuclear Power Joint Venture Company Limited)
 Owner : TNPJVC (Taishan Nuclear Power Joint Venture Company Limited)
 Reactor Supplier : ORANO (ORANO)
 Turbine Supplier : ALSTOM (ALSTOM)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / EPR-1750 | Construction Date | : 2010-04-15 |
| Thermal power | : 4590 MWth | Grid Date | : 2019-06-23 |
| Gross electrical power | : 1750 MWe | Commercial Date | : 2019-09-07 |
| Reference unit power (net) | : 1660 MWe | Age at end of year | : 4 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 329.9 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.55 |
| Average fuel enrichment [% of U235] | : 2.98 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 29.8755 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 59000 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.657 | HP cylinder inlet steam pressure [MPa] | : NA |
| Active core height/length [m] | : 4.2 | Output voltage [kV] | : 27 |
| Number of fissile fuel assemblies/bundles | : 241 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 16.6 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 89 | Number of FW pumps for full power operation | : 3 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 6 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|-----------|
| Net Energy Production | : 12884.09 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 90.17 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 91.55 % | Planned Unavailability Factor (PUF) | : 8.45 % |
| Load Factor (LF) | : 88.6 % | Externally cause unavailability (XUF) | : 1.38 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

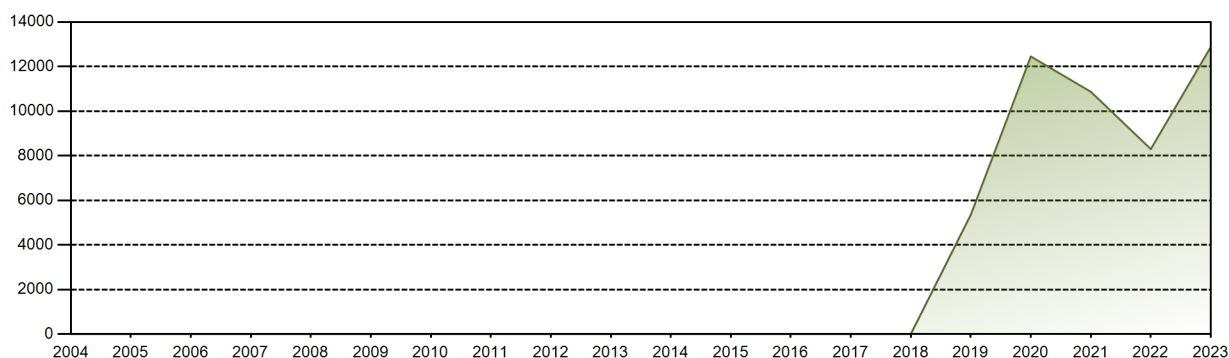


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|
| GW(e)-h | 952.36 | 1015.85 | 1120.76 | 1081.80 | 1109.29 | 1060.76 | 1097.14 | 1095.60 | 1055.45 | 1104.10 | 1074.14 | 1116.84 | 12884.09 |
| EAF [%] | 94.67 | 91.07 | 90.75 | 90.51 | 89.82 | 88.75 | 88.83 | 88.71 | 89.28 | 89.40 | 89.87 | 90.43 | 90.17 |
| UCF [%] | 96.23 | 92.28 | 92.01 | 91.81 | 91.18 | 90.22 | 90.27 | 90.23 | 90.76 | 90.79 | 91.17 | 91.66 | 91.55 |
| LF [%] | 77.11 | 91.07 | 90.75 | 90.51 | 89.82 | 88.75 | 88.83 | 88.71 | 88.31 | 89.40 | 89.87 | 90.43 | 88.60 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 3.77 | 7.72 | 7.99 | 8.19 | 8.82 | 9.78 | 9.73 | 9.77 | 9.24 | 9.21 | 8.83 | 8.34 | 8.45 |
| XUF [%] | 1.57 | 1.22 | 1.26 | 1.30 | 1.36 | 1.47 | 1.44 | 1.52 | 1.48 | 1.39 | 1.30 | 1.24 | 1.38 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 49863.38 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.37 % |
| Cumulative Energy Availability Factor (EAF) | : 81.94 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.31 % |
| Cumulative Unit Capability Factor (UCF) | : 82.91 % | Cumulative Planned Unavailability Factor (PUF) | : 16.78 % |
| Cumulative Load Factor (LF) | : 77.69 % | Cumulative Externally cause unavailability (XUF) | : 0.96 % |
| Cumulative Operating Factor (OF) | : 87.12 % | | |

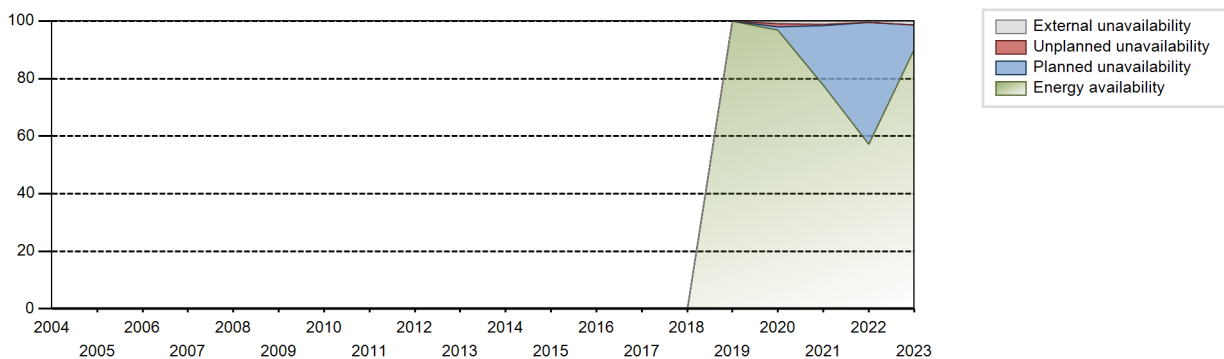
Electricity Production (net) [GWh]



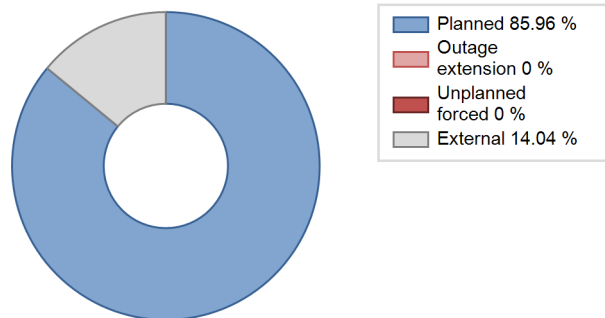
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2019 | 5356.14 | 3817 | 1660 | 100.00 | 100.00 | 92.33 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 12454.80 | 8667 | 1660 | 96.77 | 97.71 | 85.42 | 98.67 | 1.03 | 1.02 | 1.27 | 0.95 |
| 2021 | 10870.50 | 7089 | 1660 | 77.70 | 78.97 | 74.75 | 80.92 | 0.40 | 0.32 | 20.72 | 1.27 |
| 2022 | 8297.85 | 5654 | 1660 | 57.06 | 57.65 | 57.06 | 64.54 | 0.00 | 0.00 | 42.35 | 0.58 |
| 2023 | 12884.09 | 8760 | 1660 | 90.17 | 91.55 | 88.60 | 100.00 | 0.00 | 0.00 | 8.45 | 1.38 |

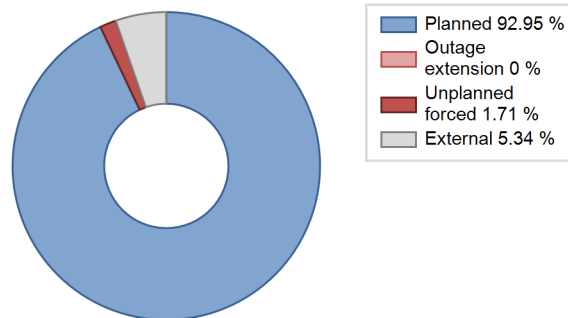
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2019 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 20 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1098 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 15 | | |
| E. Testing of plant systems or components | | | | 163 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 12 |
| Subtotal | | | | 1276 | 20 | 12 |
| Total | | 0 | | | 1308 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2019 to 2023 |
|----------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 34. Miscellaneous Systems | | 27 |
| 41. Main Generator Systems | | 4 |
| Total | | 31 |

Highlights (2023)

There wasn't unplanned scram in CN33 in 2023.

2023 Operating Experience

| | | |
|--------------|------------------|--------------|
| CN-10 | TIANWAN-1 | CHINA |
|--------------|------------------|--------------|

Status at end of year : **Operational**
 Operator : JNPC (Jiangsu Nuclear Power Corporation)
 Owner : JNPC (Jiangsu Nuclear Power Corporation)
 Reactor Supplier : IZ (Izhorskiye Zavody)
 Turbine Supplier : LMZ (JOINT-STOCK COMPANY "LENINGRADSKIY METALLICHESKIY ZAVOD")

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-428 | Construction Date | : 1999-10-20 |
| Thermal power | : 3000 MWth | Grid Date | : 2006-05-12 |
| Gross electrical power | : 1060 MWe | Commercial Date | : 2007-05-17 |
| Reference unit power (net) | : 1000 MWe | Age at end of year | : 17 years |

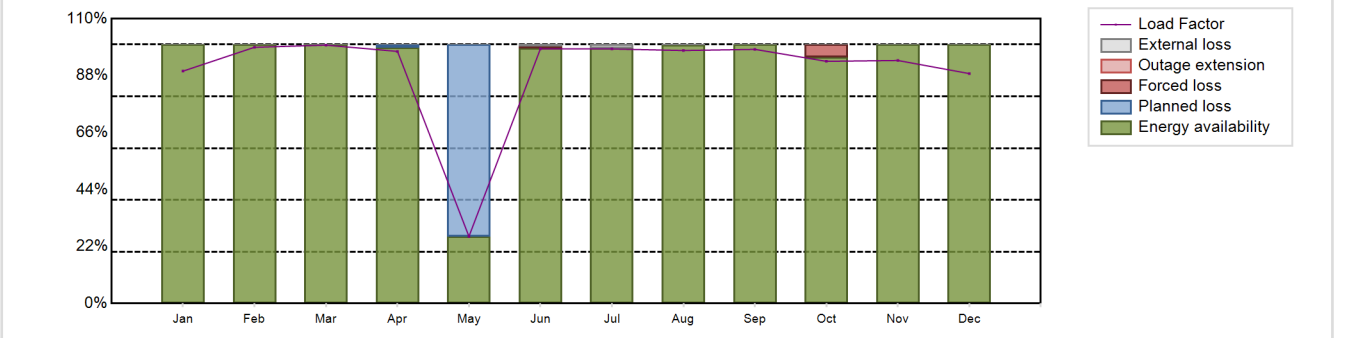
Design Characteristics

| Primary Systems | | | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 321 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 0.46 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : - | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 3.16 | Number of LP cylinders per turbine | : 4 |
| Active core height/length [m] | : - | HP cylinder inlet steam pressure [MPa] | : 5.78 |
| Number of fissile fuel assemblies/bundles | : 163 | Output voltage [kV] | : 24 |
| Fuel linear heat generation rate [kW/m] | : - | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 103 | Number of main condensate pumps | : 4 |
| Number of external reactor coolant loops | : 4 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 3 |
| | | Non-electrical applications | |
| | | | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 7875.04 GW(e).h | Forced Loss Rate (FLR) | : 0.5 % |
| Energy Availability Factor (EAF) | : 92.97 % | Unplanned Capability Loss Factor (UCL) | : 0.47 % |
| Unit Capability Factor (UCF) | : 93.15 % | Planned Unavailability Factor (PUF) | : 6.38 % |
| Load Factor (LF) | : 89.9 % | Externally cause unavailability (XUF) | : 0.18 % |
| Operating Factor (OF) | : 93.44 % | Total off-line time | : 575 hours |

Annual Summary

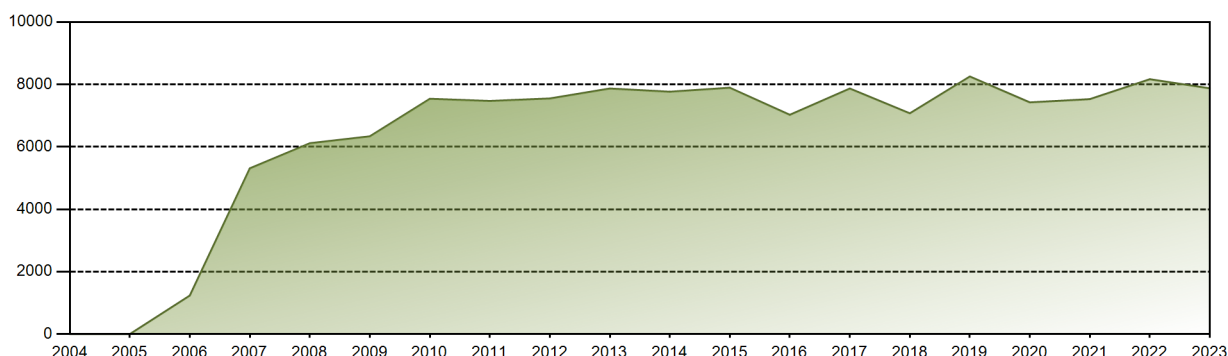


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 667.74 | 665.01 | 742.50 | 701.06 | 192.71 | 708.38 | 731.43 | 726.95 | 706.77 | 695.91 | 675.86 | 660.71 | 7875.04 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 98.93 | 25.91 | 98.73 | 98.66 | 99.77 | 100.00 | 95.11 | 100.00 | 100.00 | 92.97 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 98.93 | 25.91 | 99.33 | 100.00 | 100.00 | 100.00 | 95.11 | 100.00 | 100.00 | 93.15 |
| LF [%] | 89.75 | 98.96 | 99.80 | 97.37 | 25.90 | 98.39 | 98.31 | 97.71 | 98.16 | 93.54 | 93.87 | 88.81 | 89.90 |
| OF [%] | 100.00 | 100.00 | 100.00 | 99.72 | 27.82 | 100.00 | 100.00 | 100.00 | 100.00 | 95.16 | 100.00 | 100.00 | 93.44 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.67 | 0.00 | 0.00 | 0.00 | 4.89 | 0.00 | 0.00 | 0.50 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.67 | 0.00 | 0.00 | 0.00 | 4.89 | 0.00 | 0.00 | 0.47 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 1.07 | 74.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.38 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 | 1.34 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 126335.84 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.68 % |
| Cumulative Energy Availability Factor (EAF) | : 88.02 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.62 % |
| Cumulative Unit Capability Factor (UCF) | : 88.17 % | Cumulative Planned Unavailability Factor (PUF) | : 11.21 % |
| Cumulative Load Factor (LF) | : 86.95 % | Cumulative Externally cause unavailability (XUF) | : 0.15 % |
| Cumulative Operating Factor (OF) | : 87.68 % | | |

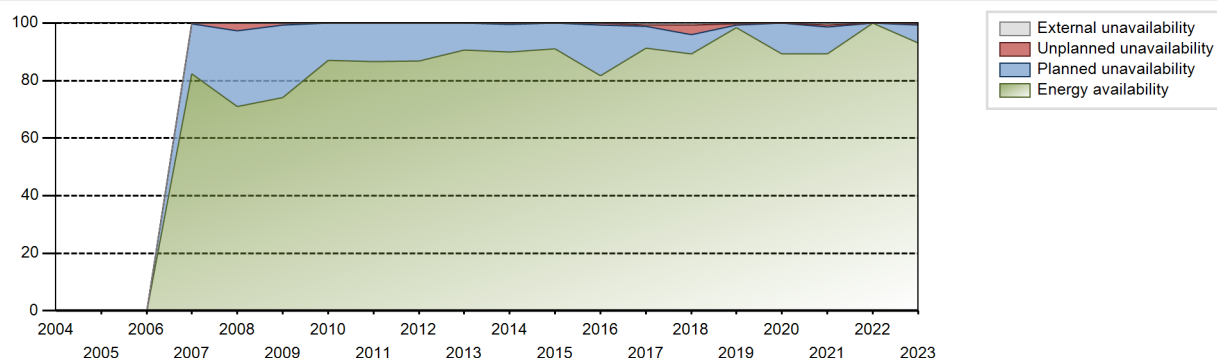
Electricity Production (net) [GWh]



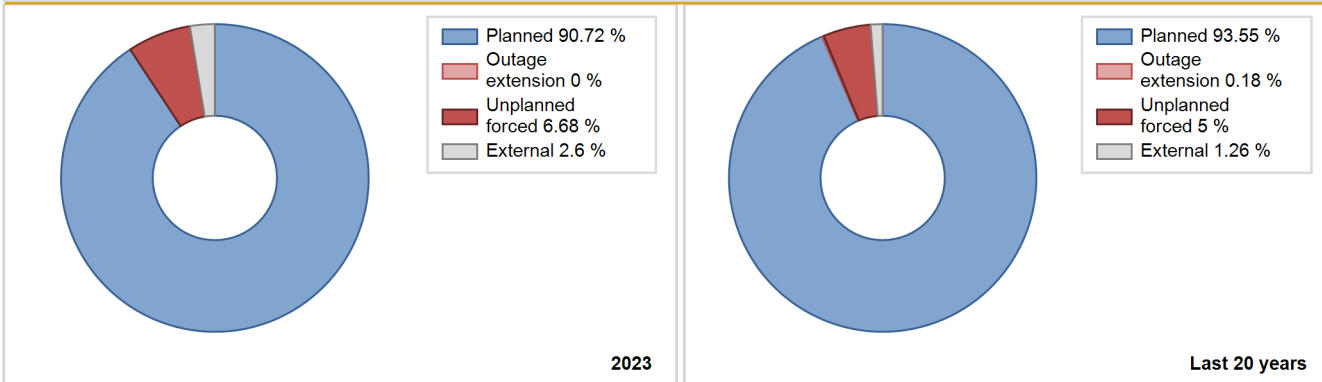
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2007 | 5311.00 | 5688 | 933 | 82.44 | 82.44 | 84.77 | 82.71 | 0.44 | 0.36 | 17.20 | 0.00 |
| 2008 | 6116.16 | 6270 | 933 | 70.97 | 70.97 | 74.63 | 71.38 | 3.60 | 2.65 | 26.38 | 0.00 |
| 2009 | 6337.71 | 6553 | 933 | 74.12 | 74.12 | 77.54 | 74.81 | 0.97 | 0.73 | 25.16 | 0.00 |
| 2010 | 7539.59 | 7643 | 933 | 87.02 | 87.02 | 92.25 | 87.25 | 0.00 | 0.00 | 12.98 | 0.00 |
| 2011 | 7470.08 | 7606 | 990 | 86.55 | 86.55 | 86.14 | 86.83 | 0.07 | 0.06 | 13.39 | 0.00 |
| 2012 | 7550.16 | 7635 | 990 | 86.78 | 86.78 | 86.82 | 86.92 | 0.00 | 0.00 | 13.22 | 0.00 |
| 2013 | 7869.05 | 7959 | 990 | 90.71 | 90.71 | 90.74 | 90.86 | 0.00 | 0.00 | 9.29 | 0.00 |
| 2014 | 7766.80 | 7888 | 990 | 89.83 | 89.83 | 89.56 | 90.05 | 0.09 | 0.44 | 9.73 | 0.00 |
| 2015 | 7894.21 | 7996 | 990 | 91.07 | 91.07 | 91.03 | 91.28 | 0.00 | 0.00 | 8.92 | 0.00 |
| 2016 | 7027.54 | 7295 | 990 | 81.71 | 81.71 | 80.81 | 83.05 | 0.90 | 0.74 | 17.54 | 0.00 |
| 2017 | 7869.01 | 8081 | 990 | 91.25 | 92.05 | 90.74 | 92.25 | 0.40 | 0.37 | 7.58 | 0.80 |
| 2018 | 7074.55 | 7450 | 990 | 89.28 | 89.91 | 81.58 | 85.05 | 3.66 | 3.42 | 6.67 | 0.64 |
| 2019 | 8254.54 | 8501 | 990 | 98.43 | 98.68 | 95.18 | 97.04 | 0.52 | 0.52 | 0.80 | 0.25 |
| 2020 | 7424.97 | 7854 | 990 | 89.31 | 89.31 | 85.38 | 89.41 | 0.00 | 0.00 | 10.69 | 0.00 |
| 2021 | 7528.83 | 7686 | 1000 | 89.35 | 89.96 | 85.95 | 87.74 | 0.87 | 0.78 | 9.26 | 0.61 |
| 2022 | 8167.00 | 8630 | 1000 | 100.00 | 100.00 | 93.23 | 98.52 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 7875.04 | 8185 | 1000 | 92.97 | 93.15 | 89.90 | 93.44 | 0.50 | 0.47 | 6.38 | 0.18 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2007 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 36 | | | 44 | |
| C. Inspection, maintenance or repair combined with refuelling | 540 | | | 892 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 84 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 59 |
| L. Human factor related | | | | | 2 | |
| Subtotal | 540 | 36 | | 976 | 46 | 59 |
| Total | | 576 | | | 1081 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2007 to 2023 | |
|--|------------|-----------|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 6 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 2 |
| 32. Feedwater and Main Steam System | | 36 | | 4 |
| 34. Miscellaneous Systems | | | | 22 |
| 41. Main Generator Systems | | | | 17 |
| 42. Electrical Power Supply Systems | | | | 15 |
| Total | | 36 | | 66 |

Highlights (2023)

This year, Unit 1 underwent a unit outage and one minor power reduction repair, and cooperated with the power grid to reduce power multiple times. At other times, it maintained power operation and experienced an automatic emergency shutdown event.

On April 30th at 21:50, the steam turbine generator of Unit 1 was disconnected and the OT114 refueling outage began. On May 23rd at 09:35, Unit 1 was reconnected to the grid for operation after completing major repairs. On May 25th at 20:30, the unit rose to full power operation.

On June 20th at 08:30, due to the shutdown and maintenance of 1PAC21AP001, Unit 1 reduced its power to 900MW for operation. On June 21st at 09:30, the maintenance of the circulating cooling water pump 1PAC21AP001 was completed, and the unit was put into full power operation.

On October 29th at 23:29, the condensate control valve in the second circuit of Unit 1 malfunctioned and closed, causing fluctuations in feedwater flow and resulting in low steam generator liquid level. This triggered a shutdown protection action and caused the unit to shut down. The unit was reconnected to the grid after completing defect elimination at 05:40 on October 31st.

2023 Operating Experience

CN-11

TIANWAN-2

CHINA

| | |
|-----------------------|--|
| Status at end of year | : Operational |
| Operator | : JNPC (Jiangsu Nuclear Power Corporation) |
| Owner | : JNPC (Jiangsu Nuclear Power Corporation) |
| Reactor Supplier | : IZ (Izhorskiye Zavody) |
| Turbine Supplier | : LMZ (JOINT-STOCK COMPANY "LENINGRADSKIY METALLICHESKIY ZAVOD") |

Reactor Unit Details

| | |
|----------------------------|--------------------|
| Reactor type and model | : PWR / VVER V-428 |
| Thermal power | : 3000 MWth |
| Gross electrical power | : 1060 MWe |
| Reference unit power (net) | : 1000 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 2000-09-20 |
| Grid Date | : 2007-05-14 |
| Commercial Date | : 2007-08-16 |
| Age at end of year | : 16 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : 18 |
| Part of the core refuelled [%] | : 40.49 |
| Average discharge burnup [MWd/t] | : 47500 |
| Active core diameter [m] | : 3.16 |
| Active core height/length [m] | : 3.68 |
| Number of fissile fuel assemblies/bundles | : 163 |
| Fuel linear heat generation rate [kW/m] | : - |
| Number of control rod assemblies | : 103 |
| Number of external reactor coolant loops | : 4 |
| Coolant type | : H2O |

| | |
|-----------------------------------|----------|
| Operating coolant pressure [MPa] | : 15.7 |
| Reactor outlet temperature [°C] | : 321 |
| Number of SG | : 4 |
| Containment type | : Single |
| Containment design pressure [MPa] | : 0.46 |

Secondary systems

| | |
|--|----------------------|
| Number of turbine-generators per unit/reactor | : 1 |
| Turbine speed [rpm] | : 3000 |
| Number of LP cylinders per turbine | : 4 |
| HP cylinder inlet steam pressure [MPa] | : 5.78 |
| Output voltage [kV] | : 24 |
| Primary means of condenser cooling | : Sea (once-through) |
| Number of main condensate pumps | : 4 |
| Number of FW pumps for full power operation | : 2 |
| Number of on-site safety related diesel generators | : 3 |

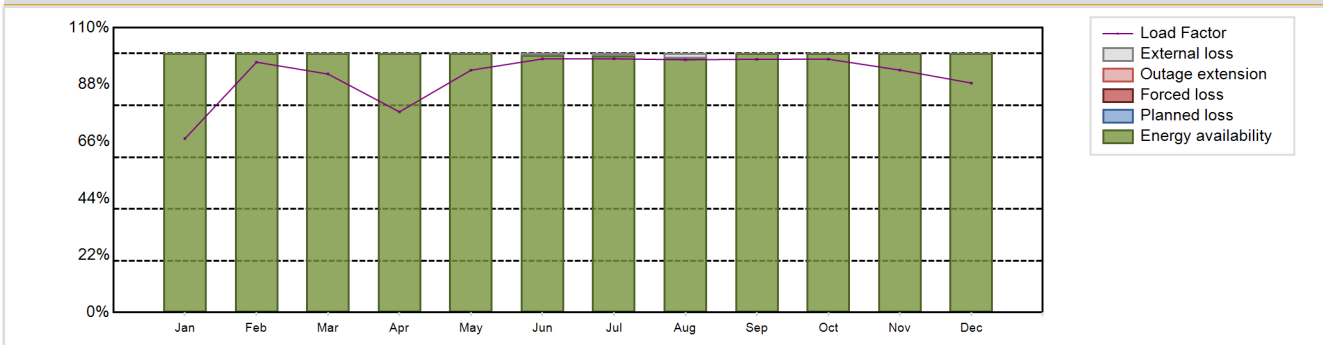
Non-electrical applications

| | |
|--|--------|
| | : none |
|--|--------|

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 8015.09 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.7 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 100 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 91.5 % | Externally cause unavailability (XUF) | : 0.3 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

Annual Summary

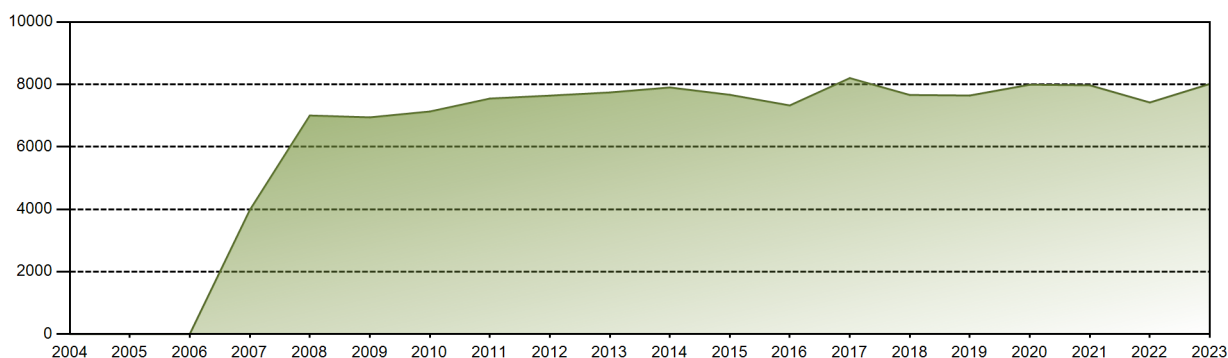


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 499.73 | 649.70 | 685.30 | 557.97 | 696.34 | 705.20 | 729.00 | 726.21 | 704.26 | 727.97 | 674.13 | 659.29 | 8015.09 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.26 | 99.08 | 98.10 | 100.00 | 100.00 | 100.00 | 100.00 | 99.70 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| LF [%] | 67.17 | 96.68 | 92.11 | 77.50 | 93.59 | 97.94 | 97.98 | 97.61 | 97.81 | 97.84 | 93.63 | 88.61 | 91.50 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.74 | 0.92 | 1.90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 125778.72 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.17 % |
| Cumulative Energy Availability Factor (EAF) | : 90.13 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.15 % |
| Cumulative Unit Capability Factor (UCF) | : 90.36 % | Cumulative Planned Unavailability Factor (PUF) | : 9.48 % |
| Cumulative Load Factor (LF) | : 88.83 % | Cumulative Externally cause unavailability (XUF) | : 0.23 % |
| Cumulative Operating Factor (OF) | : 90.04 % | | |

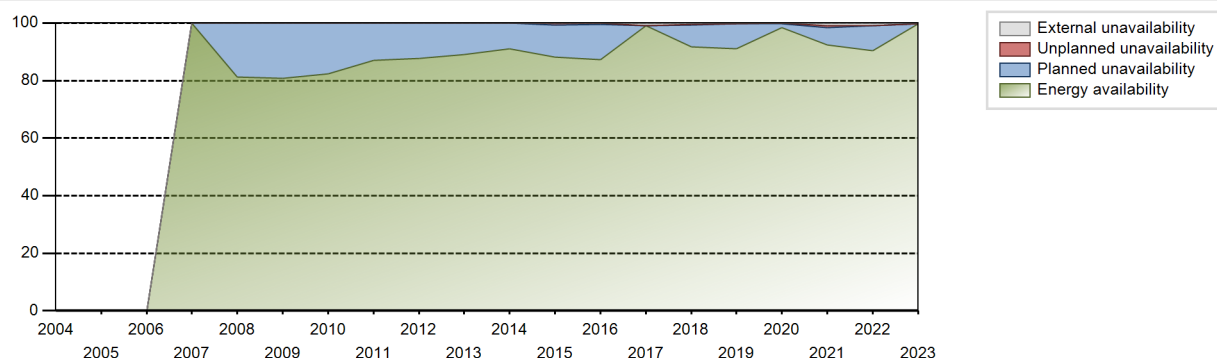
Electricity Production (net) [GWh]



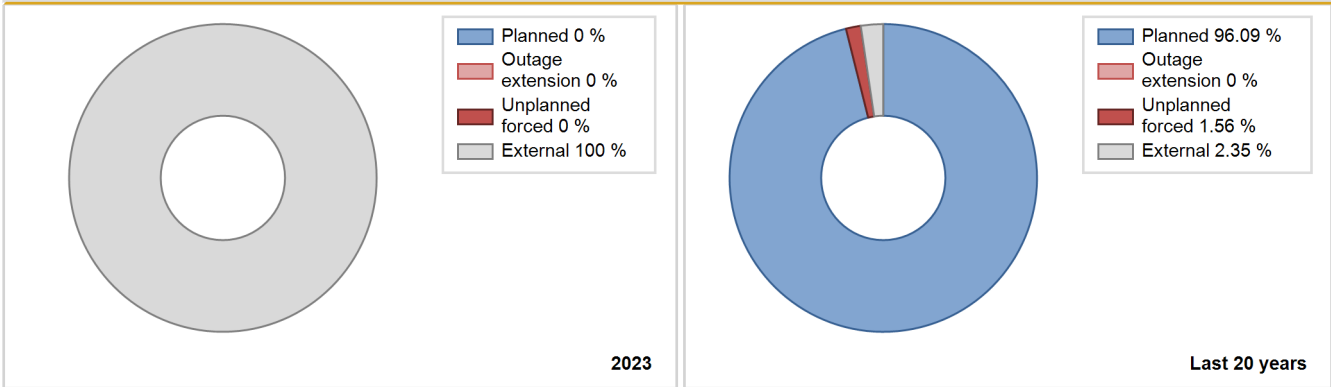
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2007 | 3974.00 | 4471 | 958 | 100.00 | 100.00 | 105.13 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 7003.03 | 7193 | 933 | 81.20 | 81.20 | 85.45 | 81.89 | 0.03 | 0.03 | 18.77 | 0.00 |
| 2009 | 6943.40 | 7054 | 933 | 80.69 | 80.69 | 84.95 | 80.53 | 0.02 | 0.02 | 19.29 | 0.00 |
| 2010 | 7131.13 | 7260 | 933 | 82.28 | 82.28 | 87.25 | 82.88 | 0.09 | 0.08 | 17.65 | 0.00 |
| 2011 | 7546.20 | 7658 | 990 | 87.05 | 87.05 | 87.01 | 87.42 | 0.00 | 0.00 | 12.95 | 0.00 |
| 2012 | 7640.12 | 7722 | 990 | 87.77 | 87.77 | 87.86 | 87.91 | 0.00 | 0.00 | 12.23 | 0.00 |
| 2013 | 7741.45 | 7837 | 990 | 89.14 | 89.14 | 89.27 | 89.46 | 0.00 | 0.00 | 10.86 | 0.00 |
| 2014 | 7901.45 | 7950 | 990 | 91.10 | 91.10 | 91.11 | 90.75 | 0.00 | 0.00 | 8.90 | 0.00 |
| 2015 | 7666.57 | 7790 | 990 | 88.22 | 88.22 | 88.40 | 88.93 | 0.87 | 0.77 | 11.01 | 0.00 |
| 2016 | 7326.45 | 7705 | 990 | 87.36 | 87.36 | 84.25 | 87.72 | 0.50 | 0.44 | 12.20 | 0.00 |
| 2017 | 8201.96 | 8430 | 990 | 98.97 | 99.90 | 94.58 | 96.23 | 0.03 | 0.03 | 0.07 | 0.93 |
| 2018 | 7661.18 | 8007 | 990 | 91.64 | 92.22 | 88.34 | 91.40 | 0.07 | 0.07 | 7.72 | 0.58 |
| 2019 | 7644.10 | 7833 | 990 | 91.13 | 91.30 | 88.14 | 89.42 | 0.09 | 0.09 | 8.62 | 0.17 |
| 2020 | 7991.08 | 8683 | 990 | 98.32 | 98.32 | 91.89 | 98.85 | 0.25 | 0.25 | 1.43 | 0.00 |
| 2021 | 7972.07 | 8253 | 1000 | 92.34 | 93.24 | 91.01 | 94.21 | 0.77 | 0.72 | 6.03 | 0.90 |
| 2022 | 7420.49 | 7861 | 1000 | 90.46 | 91.32 | 84.71 | 89.74 | 0.00 | 0.00 | 8.68 | 0.86 |
| 2023 | 8015.09 | 8760 | 1000 | 99.70 | 100.00 | 91.50 | 100.00 | 0.00 | 0.00 | 0.00 | 0.30 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2007 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 3 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 730 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 105 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 50 |
| L. Human factor related | | | | | 3 | |
| Subtotal | | | | 835 | 6 | 50 |
| Total | | 0 | | | 891 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2007 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 31. Turbine and auxiliaries | | | | 3 |
| 32. Feedwater and Main Steam System | | | | 1 |
| 34. Miscellaneous Systems | | | | 10 |
| 35. All other I&C Systems | | | | 2 |
| Total | | | | 16 |

Highlights (2023)

This year, Unit 2 has cooperated with the power grid multiple times to reduce power, while maintaining power operation at other times without any emergency shutdown incidents.

2023 Operating Experience

CN-45

TIANWAN-3

CHINA

Status at end of year : **Operational**
 Operator : JNPC (Jiangsu Nuclear Power Corporation)
 Owner : JNPC (Jiangsu Nuclear Power Corporation)
 Reactor Supplier : IZ (Izhorskiye Zavody)
 Turbine Supplier : HTC (HARBIN TURBINE COMPANY LIMITED)

| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-428M | Construction Date | : 2012-12-27 |
| Thermal power | : 3000 MWth | Grid Date | : 2017-12-30 |
| Gross electrical power | : 1126 MWe | Commercial Date | : 2018-02-14 |
| Reference unit power (net) | : 1060 MWe | Age at end of year | : 6 years |

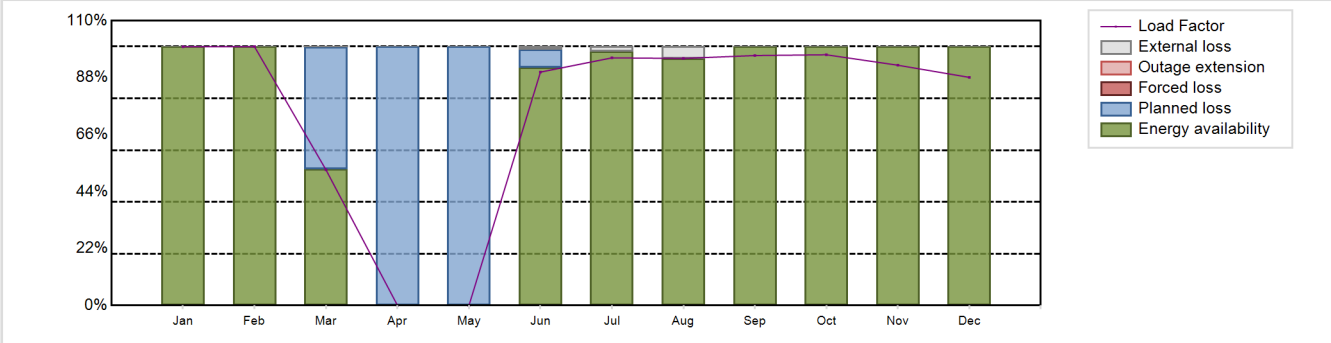
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 321 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : NA | Containment design pressure [MPa] | : 0.49 |
| Refuelling frequency [month] | : 12 | Secondary systems | |
| Part of the core refuelled [%] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : NA | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.16 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : NA | HP cylinder inlet steam pressure [MPa] | : 5.88 |
| Number of fissile fuel assemblies/bundles | : 163 | Output voltage [kV] | : 24 |
| Fuel linear heat generation rate [kW/m] | : NA | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 103 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 4 | Number of FW pumps for full power operation | : 4 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : NA |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 7013.26 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 78.06 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 78.7 % | Planned Unavailability Factor (PUF) | : 21.3 % |
| Load Factor (LF) | : 75.53 % | Externally cause unavailability (XUF) | : 0.64 % |
| Operating Factor (OF) | : 79.02 % | Total off-line time | : 1838 hours |

Annual Summary

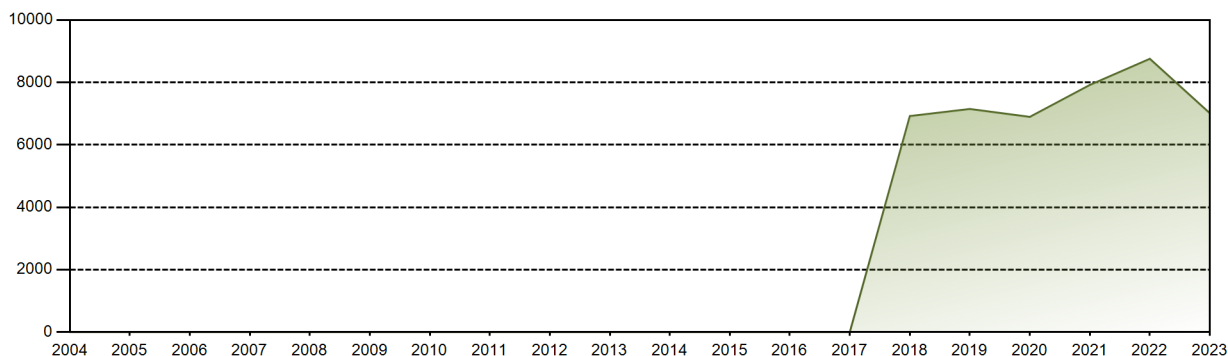


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 788.27 | 712.32 | 413.46 | 0.38 | 0.00 | 687.98 | 754.36 | 752.68 | 736.88 | 763.70 | 708.31 | 694.93 | 7013.26 |
| EAF [%] | 100.00 | 100.00 | 52.74 | 0.05 | 0.00 | 91.90 | 98.02 | 95.45 | 100.00 | 100.00 | 100.00 | 100.00 | 78.06 |
| UCF [%] | 100.00 | 100.00 | 52.75 | 0.05 | 0.00 | 92.96 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 78.70 |
| LF [%] | 99.95 | 100.00 | 52.43 | 0.05 | 0.00 | 90.14 | 95.65 | 95.44 | 96.55 | 96.84 | 92.81 | 88.12 | 75.53 |
| OF [%] | 100.00 | 100.00 | 53.23 | 1.39 | 0.00 | 95.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 79.02 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 47.25 | 99.95 | 100.00 | 7.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.30 |
| XUF [%] | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 1.06 | 1.98 | 4.55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.64 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 44660.01 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.22 % |
| Cumulative Energy Availability Factor (EAF) | : 88.65 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.1 % |
| Cumulative Unit Capability Factor (UCF) | : 89.34 % | Cumulative Planned Unavailability Factor (PUF) | : 9.56 % |
| Cumulative Load Factor (LF) | : 81.26 % | Cumulative Externally cause unavailability (XUF) | : 0.69 % |
| Cumulative Operating Factor (OF) | : 86.9 % | | |

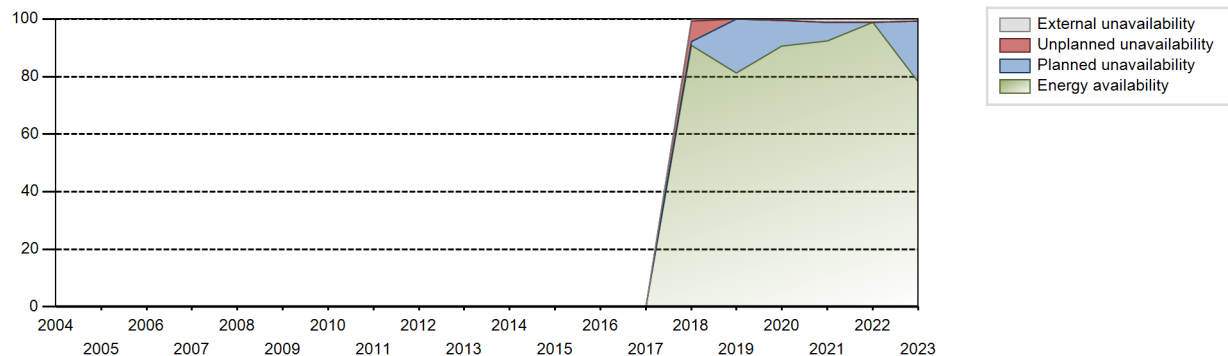
Electricity Production (net) [GWh]



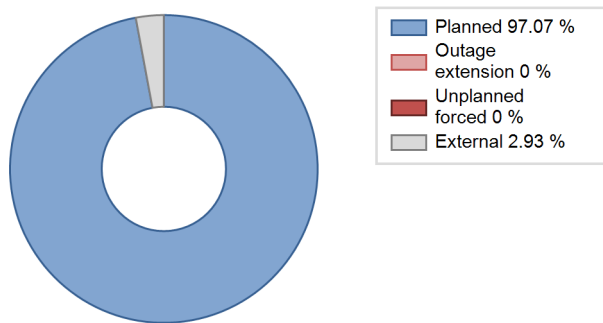
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2018 | 6922.47 | 7704 | 1045 | 90.85 | 91.48 | 78.83 | 86.83 | 7.27 | 7.18 | 1.34 | 0.63 |
| 2019 | 7149.36 | 7055 | 1045 | 81.24 | 81.29 | 78.10 | 80.54 | 0.00 | 0.00 | 18.71 | 0.05 |
| 2020 | 6896.21 | 7611 | 1045 | 90.70 | 91.29 | 75.13 | 86.65 | 0.00 | 0.00 | 8.71 | 0.58 |
| 2021 | 7919.12 | 7790 | 1060 | 92.29 | 93.41 | 85.28 | 88.93 | 0.00 | 0.00 | 6.59 | 1.11 |
| 2022 | 8757.42 | 8709 | 1060 | 98.89 | 100.00 | 94.31 | 99.42 | 0.00 | 0.00 | 0.00 | 1.11 |
| 2023 | 7013.26 | 6922 | 1060 | 78.06 | 78.70 | 75.53 | 79.02 | 0.00 | 0.00 | 21.30 | 0.64 |

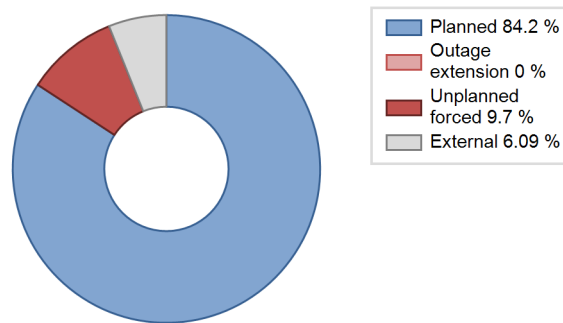
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2018 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 84 | |
| C. Inspection, maintenance or repair combined with refuelling | 581 | | | 588 | | |
| D. Inspection, maintenance or repair without refuelling | 1258 | | | 213 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 265 |
| Subtotal | 1839 | | | 801 | 84 | 265 |
| Total | | 1839 | | | 1150 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2018 to 2023 | |
|-------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 13. Reactor Auxiliary Systems | | | | 61 |
| 16. Steam generation systems | | | | 22 |
| 34. Miscellaneous Systems | | | | 158 |
| Total | | | | 241 |

Highlights (2023)

This year, Unit 3 has cooperated with the power grid multiple times to reduce power, while maintaining power operation at other times; This year, Unit 3 underwent a outage, one minor maintenance shutdown, and multiple power reductions in coordination with the power grid, while maintaining power operation at other times.

On March 17th at 12:05, the steam turbine generator of Unit 3 was disconnected and the OT304 material replacement overhaul began. At 16:10 on April 10th, Unit 1 was reconnected to the grid for operation after completing major repairs.

At 17:55 on April 21st, Unit 3 underwent maintenance and defect elimination of the primary low-pressure safety injection system containment isolation valve, as well as reactor disassembly inspection. It began to shut down for minor repairs and was reconnected to the grid at 12:20 on June 2nd.

2023 Operating Experience

CN-46

TIANWAN-4

CHINA

Status at end of year : **Operational**
 Operator : JNPC (Jiangsu Nuclear Power Corporation)
 Owner : JNPC (Jiangsu Nuclear Power Corporation)
 Reactor Supplier : IZ (Izhorskiye Zavody)
 Turbine Supplier : HTC (HARBIN TURBINE COMPANY LIMITED)

Reactor Unit Details

Reactor type and model : PWR / VVER V-428M
 Thermal power : 3000 MWth
 Gross electrical power : 1126 MWe
 Reference unit power (net) : 1060 MWe

Key Dates

Construction Date : 2013-09-27
 Grid Date : 2018-10-27
 Commercial Date : 2018-12-22
 Age at end of year : 5 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : NA
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : NA
 Average discharge burnup [MWd/t] : NA
 Active core diameter [m] : 3.16
 Active core height/length [m] : NA
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : NA
 Number of control rod assemblies : 103
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 321
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 0.49

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.88
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : NA

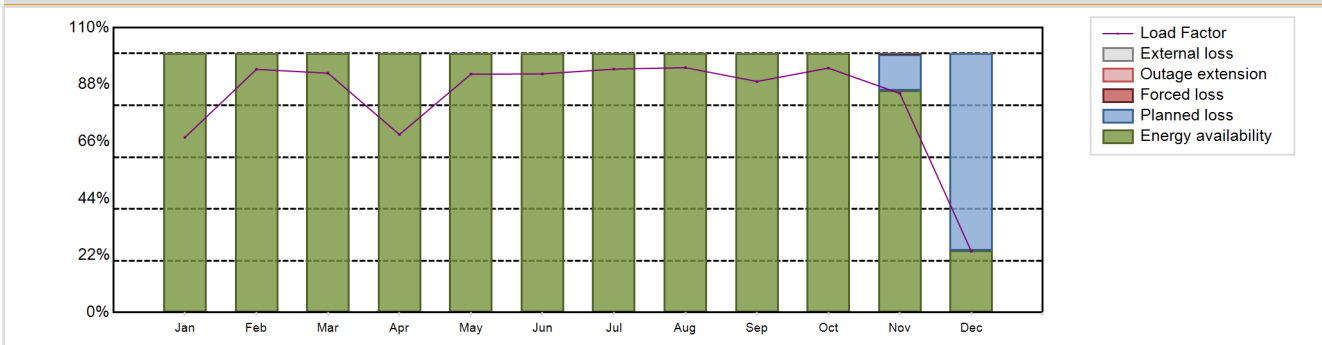
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7630.39 GW(e).h
 Energy Availability Factor (EAF) : 92.35 %
 Unit Capability Factor (UCF) : 92.35 %
 Load Factor (LF) : 82.17 %
 Operating Factor (OF) : 90.55 %
 Forced Loss Rate (FLR) : 0.04 %
 Unplanned Capability Loss Factor (UCL) : 0.04 %
 Planned Unavailability Factor (PUF) : 7.61 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 828 hours

Annual Summary

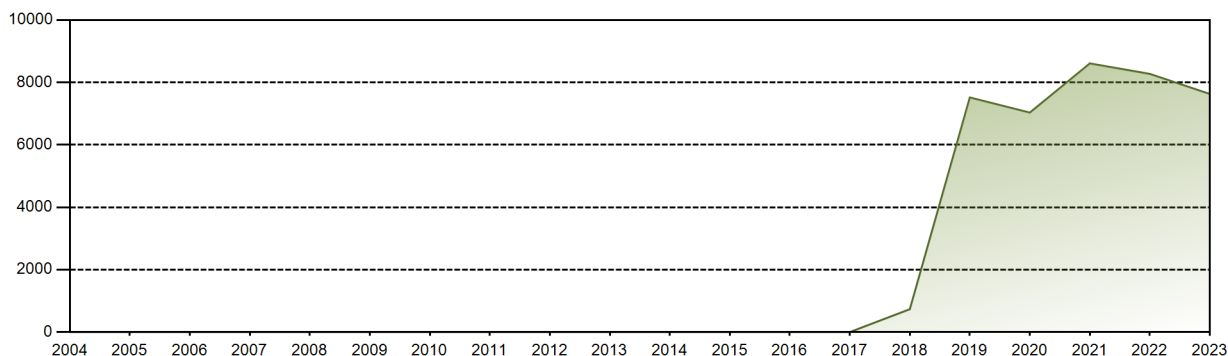


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 533.61 | 668.99 | 729.06 | 524.65 | 725.94 | 703.35 | 741.38 | 745.83 | 681.08 | 744.40 | 645.84 | 186.26 | 7630.39 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.64 | 23.80 | 92.35 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.64 | 23.80 | 92.35 |
| LF [%] | 67.66 | 93.92 | 92.45 | 68.74 | 92.05 | 92.16 | 94.01 | 94.57 | 89.24 | 94.39 | 86.67 | 26.21 | 82.17 |
| OF [%] | 75.40 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.67 | 26.21 | 90.55 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.55 | 0.00 | 0.04 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.47 | 0.00 | 0.04 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.89 | 76.20 | 7.61 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 39799.82 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.05 % |
| Cumulative Energy Availability Factor (EAF) | : 92.25 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.04 % |
| Cumulative Unit Capability Factor (UCF) | : 92.31 % | Cumulative Planned Unavailability Factor (PUF) | : 7.65 % |
| Cumulative Load Factor (LF) | : 84.58 % | Cumulative Externally cause unavailability (XUF) | : 0.05 % |
| Cumulative Operating Factor (OF) | : 89.14 % | | |

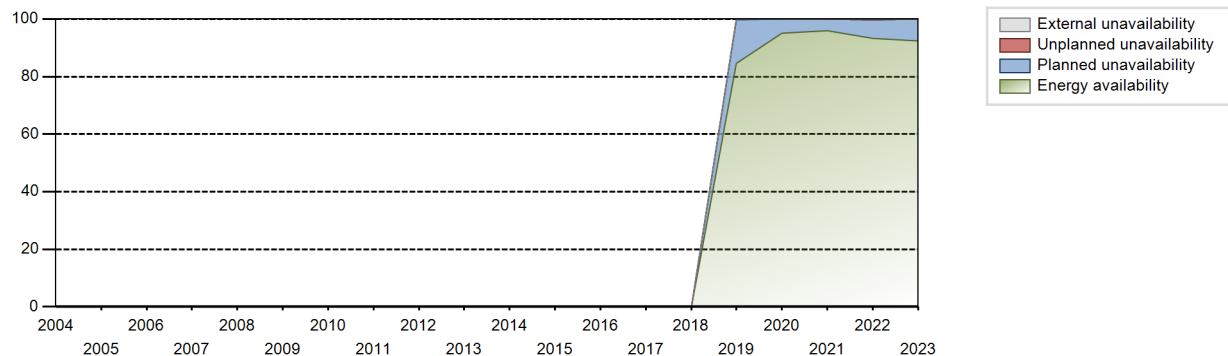
Electricity Production (net) [GWh]



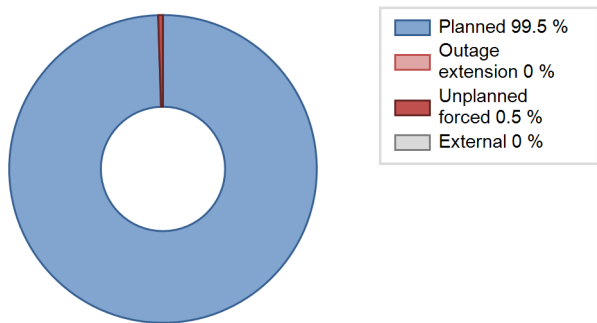
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2018 | 732.62 | 1035 | 1045 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 7519.47 | 7462 | 1045 | 84.63 | 84.71 | 82.14 | 85.18 | 0.19 | 0.16 | 15.13 | 0.09 |
| 2020 | 7033.68 | 7003 | 1045 | 95.17 | 95.17 | 76.63 | 79.72 | 0.03 | 0.02 | 4.80 | 0.00 |
| 2021 | 8610.04 | 8422 | 1060 | 95.87 | 95.87 | 92.72 | 96.14 | 0.00 | 0.00 | 4.13 | 0.00 |
| 2022 | 8273.71 | 8244 | 1060 | 93.18 | 93.35 | 89.10 | 94.11 | 0.00 | 0.00 | 6.65 | 0.17 |
| 2023 | 7630.39 | 7932 | 1060 | 92.35 | 92.35 | 82.17 | 90.55 | 0.04 | 0.04 | 7.61 | 0.00 |

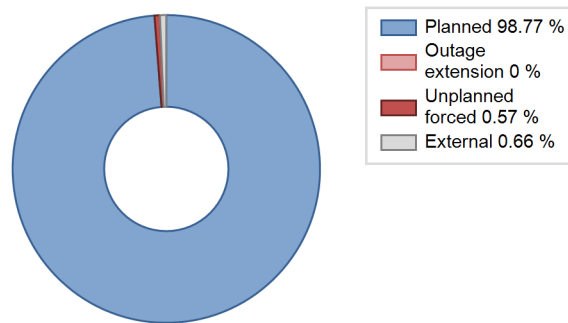
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2018 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 1 | |
| C. Inspection, maintenance or repair combined with refuelling | 645 | | | 637 | | |
| E. Testing of plant systems or components | | | | 106 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 183 | | | 316 |
| Subtotal | 645 | | 183 | 743 | 1 | 316 |
| Total | 828 | | | 1060 | | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2018 to 2023 | |
|---------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 1 |
| 34. Miscellaneous Systems | | | 183 | 301 |
| Total | | | 183 | 302 |

Highlights (2023)

This year, Unit 4 underwent a major overhaul and experienced an unplanned power reduction event (on November 22, during the maintenance process of Unit 4's start-up transformer, backup was used)
 During the power switch transmission test, triggering the logic resulted in a decrease in reactor power. In addition, we have cooperated with the power grid multiple times this year to reduce power, while maintaining power operation for others
 The detailed information is as follows:
 On November 26th at 3:00 PM, Unit 4 began to reduce power, and on the 27th at 00:00 PM, it disconnected from the power grid and began the OT404 refueling overhaul. At 21:28 on December 23rd, the major overhaul was completed and the unit was connected to the grid.

2023 Operating Experience

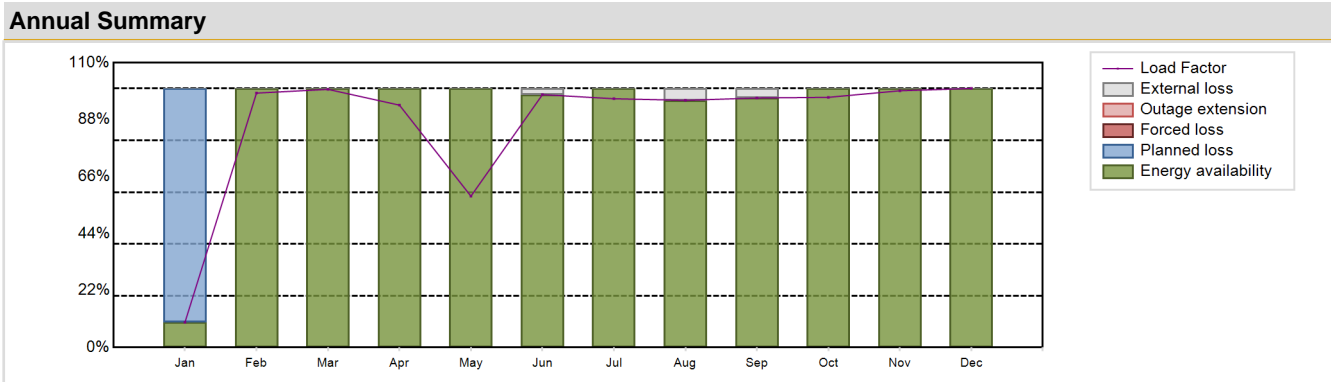
CN-53 **TIANWAN-5** **CHINA**

Status at end of year : **Operational**
 Operator : JNPC (Jiangsu Nuclear Power Corporation)
 Owner : JNPC (Jiangsu Nuclear Power Corporation)
 Reactor Supplier : SHE (Shanghai Electric)
 Turbine Supplier : DEC (Dongfang Electric Corporation)

| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / CNP-1000 | Construction Date | : 2015-12-27 |
| Thermal power | : 2905 MWth | Grid Date | : 2020-08-08 |
| Gross electrical power | : 1118 MWe | Commercial Date | : 2020-09-08 |
| Reference unit power (net) | : 1060 MWe | Age at end of year | : 3 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 329.8 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.52 |
| Average fuel enrichment [% of U235] | : 3.2 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 3.2 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 6.43 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : 24 |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.6 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 8038.07 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 91.46 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 92.34 % | Planned Unavailability Factor (PUF) | : 7.66 % |
| Load Factor (LF) | : 86.56 % | Externally cause unavailability (XUF) | : 0.88 % |
| Operating Factor (OF) | : 89.77 % | Total off-line time | : 896 hours |

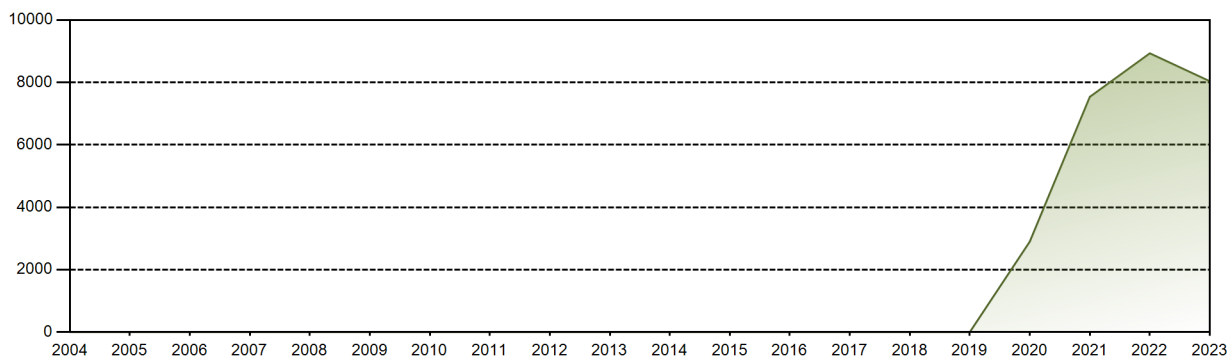


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 77.03 | 699.90 | 786.32 | 714.46 | 460.93 | 745.34 | 757.73 | 752.92 | 735.51 | 762.05 | 756.81 | 789.07 | 8038.07 |
| EAF [%] | 9.77 | 100.00 | 100.00 | 100.00 | 100.00 | 97.66 | 100.00 | 95.47 | 96.37 | 100.00 | 100.00 | 100.00 | 91.46 |
| UCF [%] | 9.77 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.34 |
| LF [%] | 9.77 | 98.26 | 99.71 | 93.61 | 58.45 | 97.66 | 96.08 | 95.47 | 96.37 | 96.63 | 99.16 | 100.05 | 86.56 |
| OF [%] | 21.77 | 100.00 | 100.00 | 94.58 | 63.04 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 89.77 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 90.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.66 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.34 | 0.00 | 4.53 | 3.63 | 0.00 | 0.00 | 0.00 | 0.88 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 27411.54 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0 % |
| Cumulative Energy Availability Factor (EAF) | : 91.59 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0 % |
| Cumulative Unit Capability Factor (UCF) | : 92.66 % | Cumulative Planned Unavailability Factor (PUF) | : 7.34 % |
| Cumulative Load Factor (LF) | : 88.3 % | Cumulative Externally cause unavailability (XUF) | : 1.07 % |
| Cumulative Operating Factor (OF) | : 91.86 % | | |

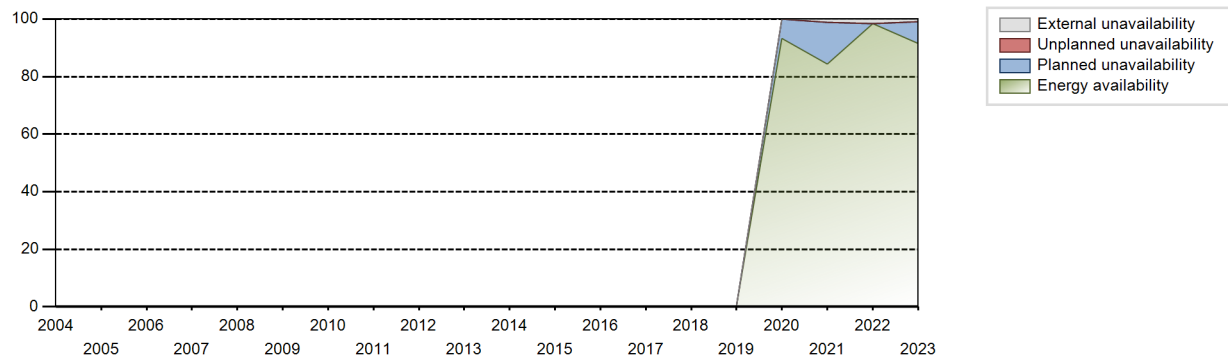
Electricity Production (net) [GWh]



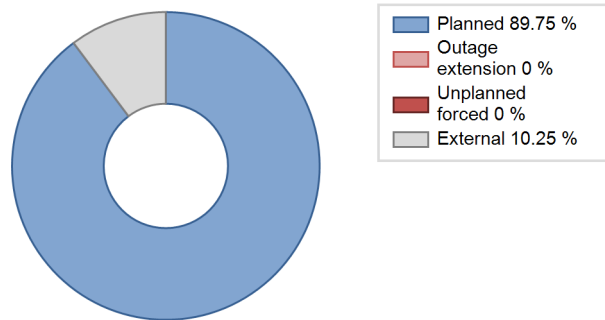
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2020 | 2901.91 | 3383 | 1000 | 93.34 | 93.34 | 91.31 | 95.87 | 0.00 | 0.00 | 6.66 | 0.00 |
| 2021 | 7538.34 | 7400 | 1060 | 84.35 | 85.46 | 81.18 | 84.47 | 0.00 | 0.00 | 14.54 | 1.11 |
| 2022 | 8933.22 | 8760 | 1060 | 98.41 | 99.97 | 96.21 | 100.00 | 0.00 | 0.00 | 0.03 | 1.56 |
| 2023 | 8038.07 | 7864 | 1060 | 91.46 | 92.34 | 86.56 | 89.77 | 0.00 | 0.00 | 7.66 | 0.88 |

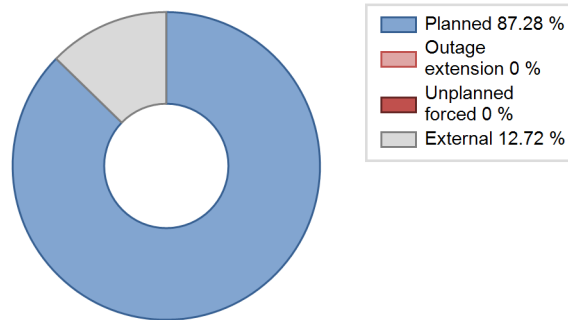
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2020 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| C. Inspection, maintenance or repair combined with refuelling | 582 | | | 532 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 314 | | | 187 |
| Subtotal | 582 | | 314 | 532 | | 187 |
| Total | | 896 | | | 719 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2020 to 2023 | |
|---------------------------|------------|-----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 34. Miscellaneous Systems | | 314 | | 183 |
| Total | | 314 | | 183 |

Highlights (2023)

This year, Unit 5 has cooperated with the power grid multiple times to reduce power, while others have maintained power operation. No manual emergency shutdown events have occurred, and the detailed situation is as follows:
 On January 1, 2023 at 00:09, Unit 5 tripped and shut down, starting the OT502 overhaul. On January 25 at 06:36, the unit was connected to the grid, and the OT502 overhaul was completed.

2023 Operating Experience

CN-54

TIANWAN-6

CHINA

Status at end of year : **Operational**
 Operator : JNPC (Jiangsu Nuclear Power Corporation)
 Owner : JNPC (Jiangsu Nuclear Power Corporation)
 Reactor Supplier : CFHI (China First Heavy Industries)
 Turbine Supplier : DEC (Dongfang Electric Corporation)

Reactor Unit Details

Reactor type and model : PWR / CNP-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1118 MWe
 Reference unit power (net) : 1060 MWe

Key Dates

Construction Date : 2016-09-07
 Grid Date : 2021-05-11
 Commercial Date : 2021-06-02
 Age at end of year : 2 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.2
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 3.2
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 329.8
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

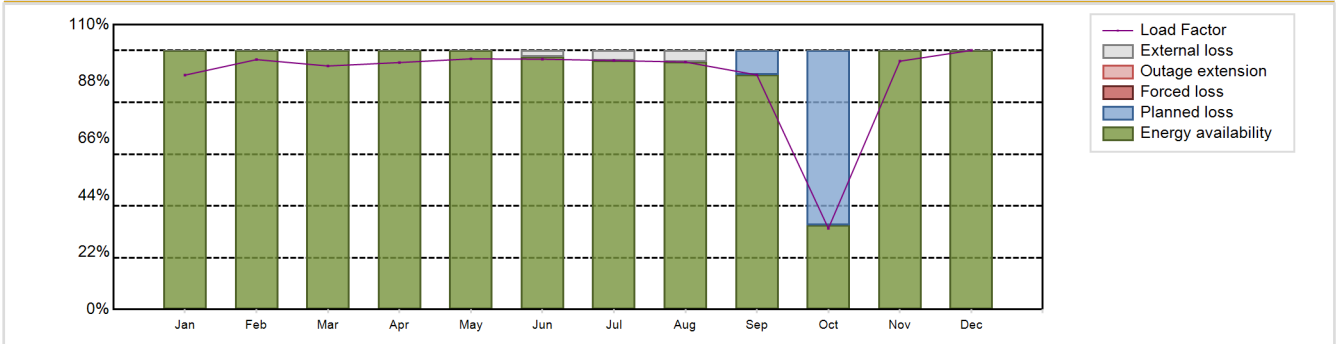
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8344 GW(e).h
 Energy Availability Factor (EAF) : 92.6 %
 Unit Capability Factor (UCF) : 93.49 %
 Load Factor (LF) : 89.86 %
 Operating Factor (OF) : 94.22 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 6.51 %
 Externally cause unavailability (XUF) : 0.89 %
 Total off-line time : 506 hours

Annual Summary

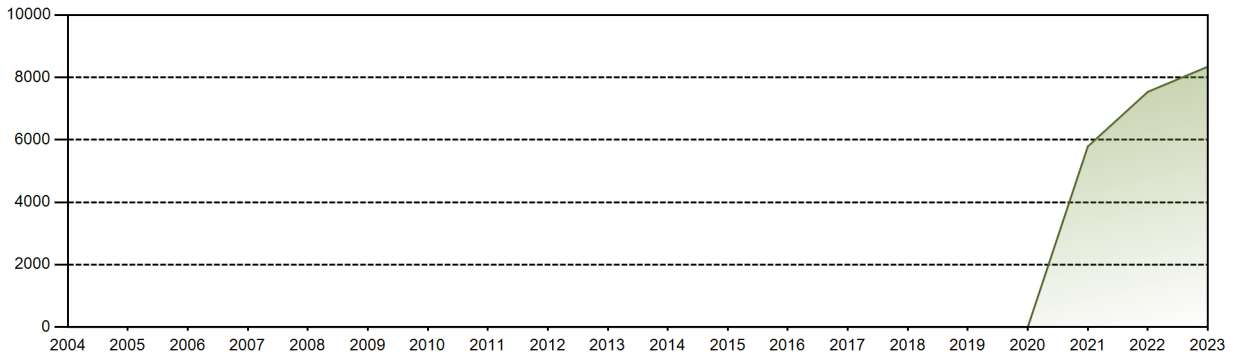


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 713.85 | 687.50 | 741.76 | 727.96 | 763.52 | 737.82 | 758.28 | 753.72 | 691.32 | 247.00 | 731.97 | 789.31 | 8344.00 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.70 | 96.15 | 95.57 | 90.58 | 32.52 | 100.00 | 100.00 | 92.60 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.58 | 32.52 | 100.00 | 100.00 | 93.49 |
| LF [%] | 90.52 | 96.52 | 94.06 | 95.38 | 96.81 | 96.67 | 96.15 | 95.57 | 90.58 | 31.32 | 95.91 | 100.08 | 89.86 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.86 | 36.96 | 100.00 | 100.00 | 94.22 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.42 | 67.48 | 0.00 | 0.00 | 6.51 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.30 | 3.85 | 4.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.89 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 21668.64 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.03 % |
| Cumulative Energy Availability Factor (EAF) | : 91.79 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.03 % |
| Cumulative Unit Capability Factor (UCF) | : 92.38 % | Cumulative Planned Unavailability Factor (PUF) | : 7.59 % |
| Cumulative Load Factor (LF) | : 88 % | Cumulative Externally cause unavailability (XUF) | : 0.59 % |
| Cumulative Operating Factor (OF) | : 92.84 % | | |

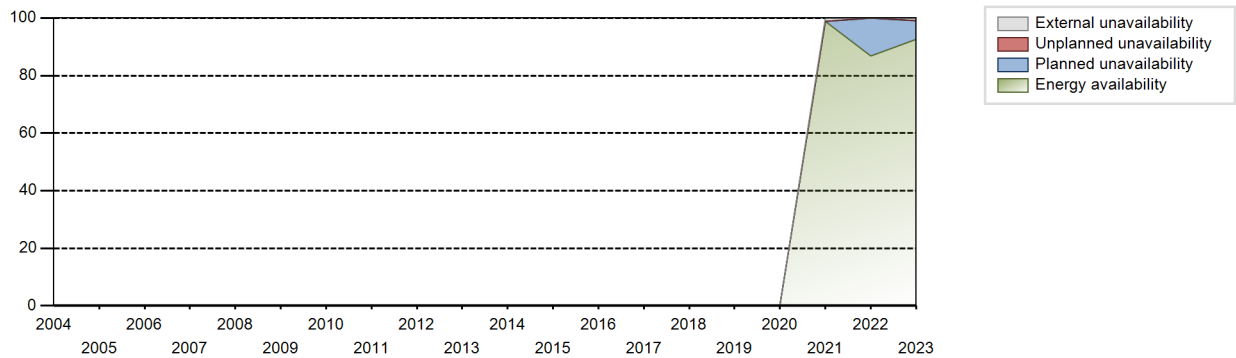
Electricity Production (net) [GWh]



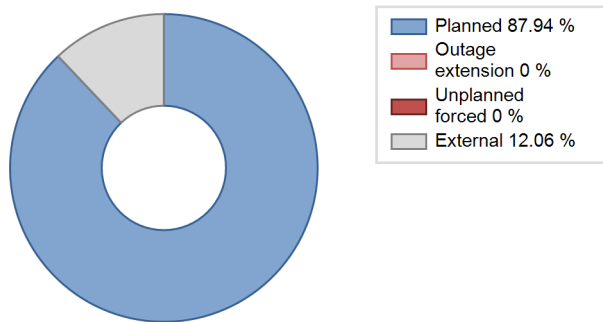
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2021 | 5786.59 | 5636 | 1060 | 98.89 | 99.98 | 96.48 | 100.00 | 0.02 | 0.02 | 0.00 | 1.09 |
| 2022 | 7538.05 | 7643 | 1060 | 86.81 | 86.81 | 81.18 | 87.25 | 0.07 | 0.06 | 13.12 | 0.00 |
| 2023 | 8344.00 | 8254 | 1060 | 92.60 | 93.49 | 89.86 | 94.22 | 0.00 | 0.00 | 6.51 | 0.89 |

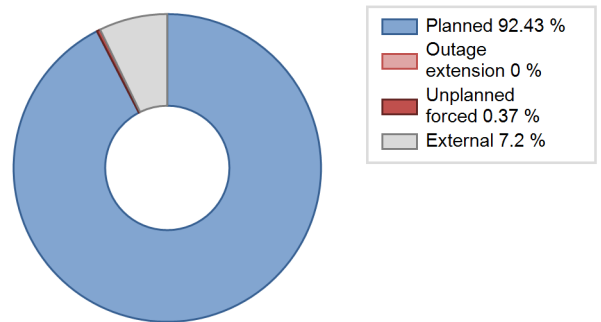
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2021 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| C. Inspection, maintenance or repair combined with refuelling | 498 | | | 617 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 9 | | | 3 |
| Subtotal | 498 | | 9 | 617 | | 3 |
| Total | | 507 | | | 620 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2021 to 2023 | |
|---------------------------|------------|----------|-------------------------------------|----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 34. Miscellaneous Systems | | 9 | | 3 |
| Total | | 9 | | 3 |

Highlights (2023)

This year, Unit 6 has cooperated with the power grid multiple times to reduce power, while others have maintained power operation. No manual emergency shutdown events have occurred, and the detailed situation is as follows:
 Unit 6 began power reduction at 00:00 on September 29th, disconnected from the power grid at 11:02 on September 29th, and began material replacement and overhaul
 On September 29, 2023 at 11:02, Unit 6 tripped and shut down, starting the OT602 overhaul; At 04:52 on October 20th, the grid connection conditions were met, and the OT602 material replacement overhaul was completed. The actual construction period was 20.74 days.
 Due to the large amount of new energy generation and difficulties in balancing the power grid, the unit was actually reconnected to the grid for operation at 13:48 on October 20th, and rose to full power operation at 05:40 on October 23rd

2023 Operating Experience

CN-22

YANGJIANG-1

CHINA

Status at end of year : **Operational**
 Operator : YJNPC (Yangjiang Nuclear Power Company)
 Owner : YJNPC (Yangjiang Nuclear Power Company)
 Reactor Supplier : CFHI (China First Heavy Industries)
 Turbine Supplier : SEG (Shanghai Electric Group)



Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1086 MWe
 Reference unit power (net) : 1000 MWe

Key Dates

Construction Date : 2008-12-16
 Grid Date : 2013-12-31
 Commercial Date : 2014-03-25
 Age at end of year : 10 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.45
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 4.45
 Average discharge burnup [MWd/t] : 44000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 328.4
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

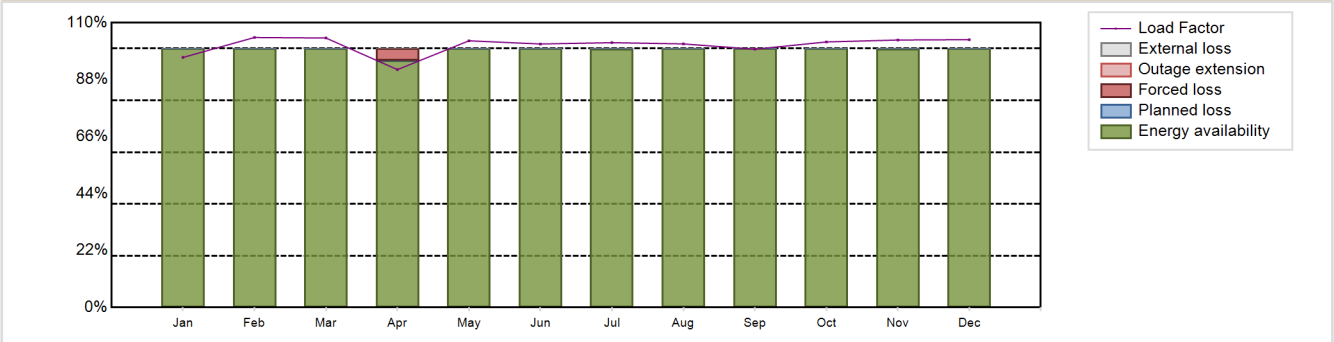
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8868.11 GW(e).h
 Energy Availability Factor (EAF) : 99.61 %
 Unit Capability Factor (UCF) : 99.61 %
 Load Factor (LF) : 101.23 %
 Operating Factor (OF) : 99.67 %

Forced Loss Rate (FLR) : 0.38 %
 Unplanned Capability Loss Factor (UCL) : 0.38 %
 Planned Unavailability Factor (PUF) : 0.01 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 29 hours

Annual Summary

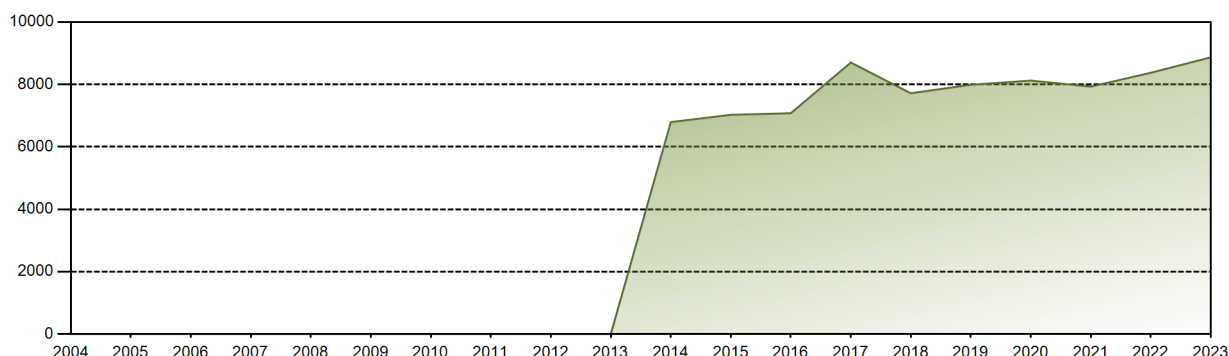


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 718.56 | 700.84 | 774.36 | 661.61 | 766.40 | 732.77 | 761.06 | 757.49 | 718.33 | 763.09 | 743.90 | 769.70 | 8868.11 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 95.36 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 100.00 | 99.95 | 100.00 | 99.61 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 95.36 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 100.00 | 99.95 | 100.00 | 99.61 |
| LF [%] | 96.58 | 104.29 | 104.08 | 91.89 | 103.01 | 101.77 | 102.29 | 101.81 | 99.77 | 102.57 | 103.32 | 103.45 | 101.23 |
| OF [%] | 100.00 | 100.00 | 100.00 | 95.97 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.67 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 4.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.38 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 4.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.38 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 79218.18 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.28 % |
| Cumulative Energy Availability Factor (EAF) | : 91.71 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.26 % |
| Cumulative Unit Capability Factor (UCF) | : 91.78 % | Cumulative Planned Unavailability Factor (PUF) | : 7.97 % |
| Cumulative Load Factor (LF) | : 91.75 % | Cumulative Externally cause unavailability (XUF) | : 0.07 % |
| Cumulative Operating Factor (OF) | : 91.8 % | | |

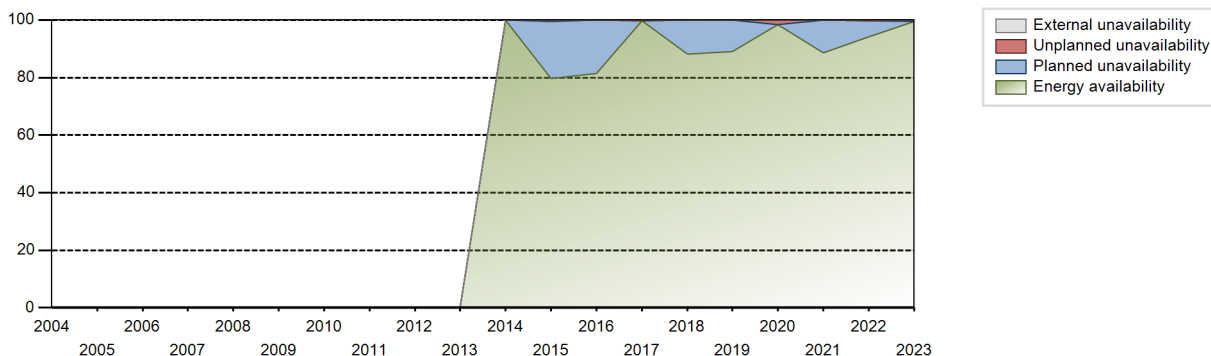
Electricity Production (net) [GWh]



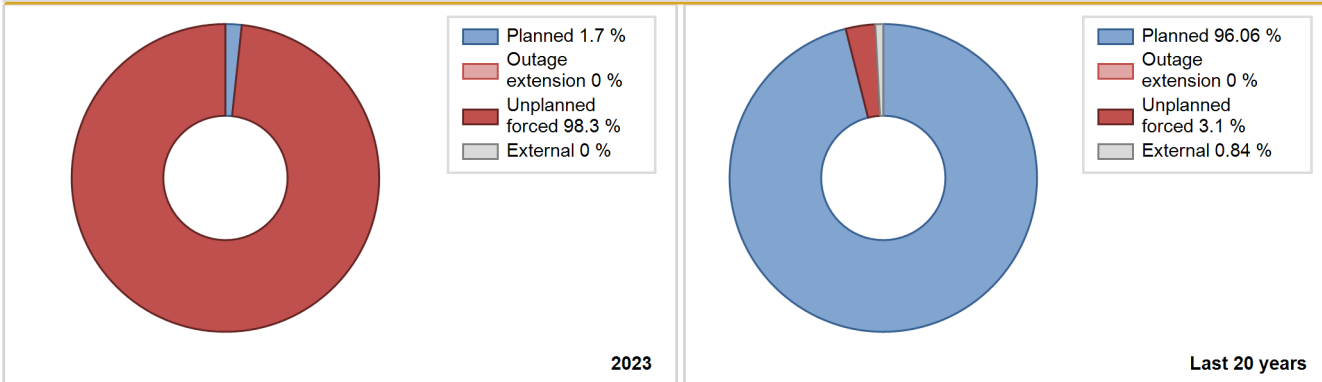
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2014 | 6793.37 | 6753 | 1000 | 99.93 | 99.93 | 100.54 | 100.00 | 0.05 | 0.05 | 0.02 | 0.00 |
| 2015 | 7025.37 | 7021 | 1000 | 79.73 | 79.73 | 80.20 | 80.15 | 0.74 | 0.59 | 19.68 | 0.00 |
| 2016 | 7077.81 | 6989 | 1000 | 81.52 | 81.56 | 80.58 | 79.57 | 0.00 | 0.00 | 18.44 | 0.04 |
| 2017 | 8699.83 | 8677 | 1000 | 99.75 | 99.99 | 99.31 | 99.05 | 0.00 | 0.00 | 0.01 | 0.24 |
| 2018 | 7715.76 | 7789 | 1000 | 88.20 | 88.24 | 88.08 | 88.92 | 0.00 | 0.00 | 11.76 | 0.03 |
| 2019 | 7988.46 | 7861 | 1000 | 89.09 | 89.09 | 91.19 | 89.74 | 0.00 | 0.00 | 10.91 | 0.00 |
| 2020 | 8122.92 | 8665 | 1000 | 98.42 | 98.51 | 92.47 | 98.65 | 1.49 | 1.49 | 0.00 | 0.09 |
| 2021 | 7930.66 | 7834 | 1000 | 88.69 | 88.72 | 90.53 | 89.43 | 0.00 | 0.00 | 11.28 | 0.03 |
| 2022 | 8373.86 | 8312 | 1000 | 94.17 | 94.41 | 95.59 | 94.89 | 0.00 | 0.00 | 5.58 | 0.25 |
| 2023 | 8868.11 | 8731 | 1000 | 99.61 | 99.61 | 101.23 | 99.67 | 0.38 | 0.38 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2014 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 29 | | | 22 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 723 | | |
| E. Testing of plant systems or components | | | | 0 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 34 |
| Subtotal | | 29 | | 723 | 22 | 34 |
| Total | | 29 | | | 779 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2014 to 2023 | |
|------------------------------|------------|----|-------------------------------------|----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 31. Turbine and auxiliaries | | 29 | | 9 |
| 33. Circulating Water System | | | | 13 |
| Total | | 29 | | 22 |

Highlights (2023)

Unit 1 of Yangjiang Nuclear Power Plant had a turbine trip on April 12, 2023, and re-connected to the grid on April 13. The unit operated at full power at all times except during holidays and grid line maintenance in which it operated at reduced power in order to cooperate with peak shaving of the grid. No scrams has occurred throughout the year.

2023 Operating Experience

CN-23

YANGJIANG-2

CHINA

Status at end of year : **Operational**
 Operator : YJNPC (Yangjiang Nuclear Power Company)
 Owner : YJNPC (Yangjiang Nuclear Power Company)
 Reactor Supplier : CFHI (China First Heavy Industries)
 Turbine Supplier : SEG (Shanghai Electric Group)



Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1086 MWe
 Reference unit power (net) : 1000 MWe

Key Dates

Construction Date : 2009-06-04
 Grid Date : 2015-03-10
 Commercial Date : 2015-06-05
 Age at end of year : 8 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.45
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 4.45
 Average discharge burnup [MWd/t] : 44000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 328.4
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

Non-electrical applications

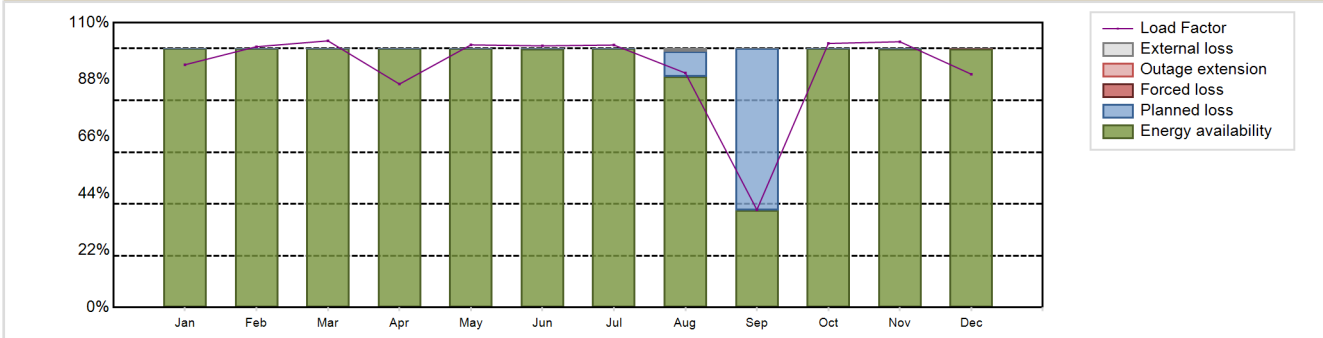
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8111.96 GW(e).h
 Energy Availability Factor (EAF) : 93.94 %
 Unit Capability Factor (UCF) : 94.04 %
 Load Factor (LF) : 92.6 %
 Operating Factor (OF) : 93.89 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 5.95 %
 Externally cause unavailability (XUF) : 0.11 %
 Total off-line time : 535 hours

Annual Summary

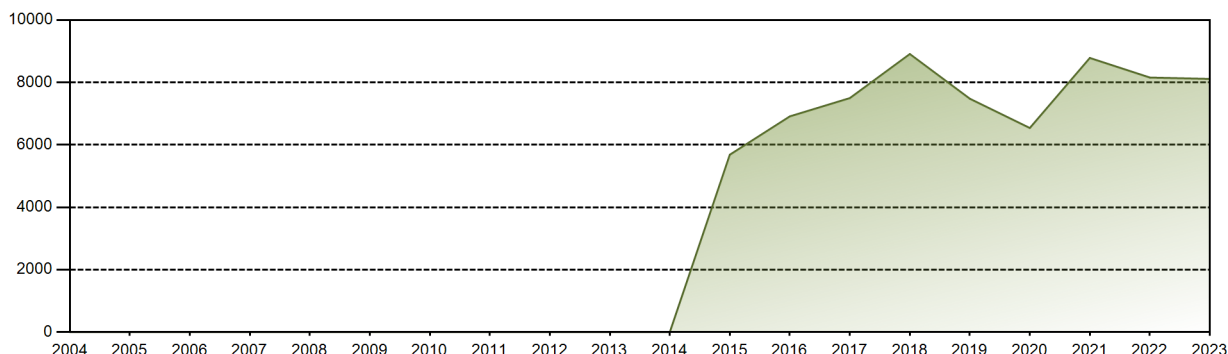


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 697.47 | 676.90 | 766.20 | 621.29 | 754.63 | 727.53 | 754.22 | 673.74 | 271.78 | 758.71 | 739.08 | 670.41 | 8111.96 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 | 100.00 | 89.10 | 37.60 | 100.00 | 99.98 | 99.96 | 93.94 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 | 100.00 | 90.33 | 37.60 | 100.00 | 99.98 | 99.96 | 94.04 |
| LF [%] | 93.75 | 100.73 | 102.98 | 86.29 | 101.43 | 101.05 | 101.37 | 90.56 | 37.75 | 101.98 | 102.65 | 90.11 | 92.60 |
| OF [%] | 100.00 | 100.00 | 100.00 | 92.22 | 100.00 | 100.00 | 100.00 | 90.73 | 43.06 | 100.00 | 100.00 | 100.00 | 93.89 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 9.67 | 62.40 | 0.00 | 0.02 | 0.00 | 5.95 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 |

Historical Summary

| | | | |
|---|-------------------|---|----------|
| Lifetime energy generation | : 68073.1 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.4 % |
| Cumulative Energy Availability Factor (EAF) | : 91.79 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.37 % |
| Cumulative Unit Capability Factor (UCF) | : 91.85 % | Cumulative Planned Unavailability Factor (PUF) | : 7.77 % |
| Cumulative Load Factor (LF) | : 89.87 % | Cumulative Externally cause unavailability (XUF) | : 0.06 % |
| Cumulative Operating Factor (OF) | : 90.49 % | | |

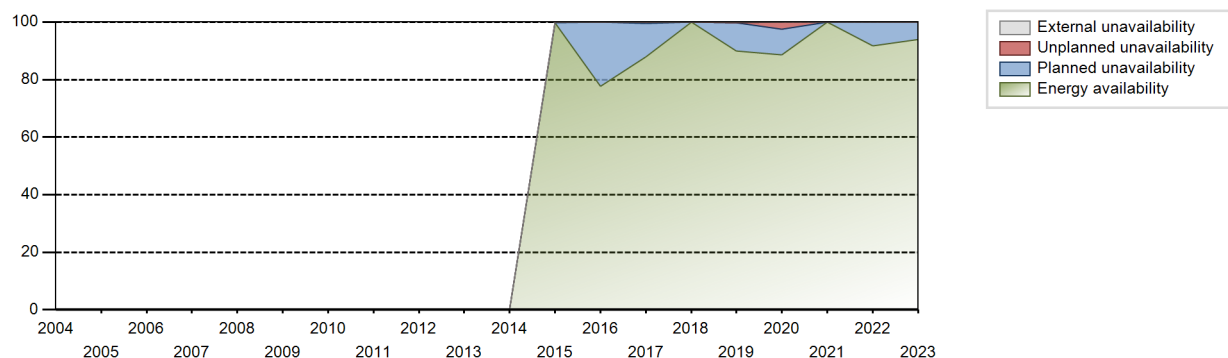
Electricity Production (net) [GWh]



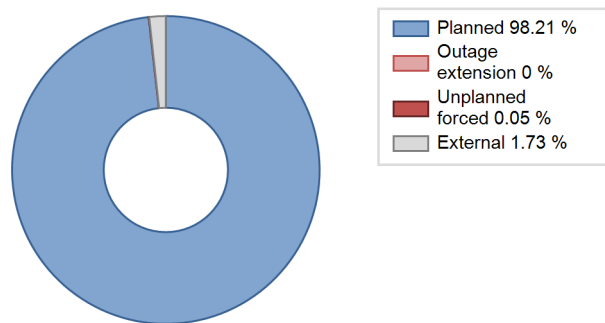
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2015 | 5683.72 | 6017 | 1000 | 99.79 | 99.79 | 102.21 | 100.00 | 0.20 | 0.20 | 0.01 | 0.00 |
| 2016 | 6911.71 | 6874 | 1000 | 77.59 | 77.69 | 78.69 | 78.26 | 0.00 | 0.00 | 22.31 | 0.10 |
| 2017 | 7497.38 | 7476 | 1000 | 87.99 | 87.99 | 85.59 | 85.34 | 0.52 | 0.46 | 11.55 | 0.00 |
| 2018 | 8910.12 | 8760 | 1000 | 99.95 | 99.98 | 101.71 | 100.00 | 0.00 | 0.00 | 0.02 | 0.04 |
| 2019 | 7478.07 | 7943 | 1000 | 89.97 | 90.27 | 85.37 | 90.67 | 0.00 | 0.00 | 9.73 | 0.30 |
| 2020 | 6539.67 | 6854 | 1000 | 88.49 | 88.49 | 74.45 | 78.03 | 2.84 | 2.59 | 8.92 | 0.00 |
| 2021 | 8783.89 | 8760 | 1000 | 99.99 | 99.99 | 100.27 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2022 | 8156.58 | 8077 | 1000 | 91.78 | 91.78 | 93.11 | 92.20 | 0.00 | 0.00 | 8.21 | 0.00 |
| 2023 | 8111.96 | 8225 | 1000 | 93.94 | 94.04 | 92.60 | 93.89 | 0.00 | 0.00 | 5.95 | 0.11 |

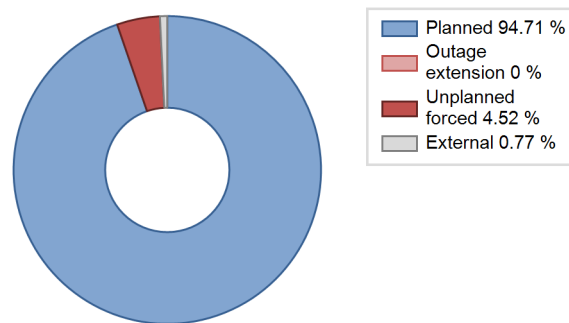
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2015 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 5 | |
| C. Inspection, maintenance or repair combined with refuelling | 479 | | | 645 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 3 | | |
| I. Grid capacity limitation | | | 53 | | | 120 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 34 |
| Z. Other | | | | 1 | 26 | |
| Subtotal | 479 | | 53 | 649 | 31 | 154 |
| Total | | 532 | | | 834 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2015 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 32. Feedwater and Main Steam System | | | | 4 |
| 33. Circulating Water System | | | | 25 |
| 42. Electrical Power Supply Systems | | | 53 | 117 |
| Total | | | 53 | 146 |

Highlights (2023)

Unit 2 of Yangjiang Nuclear Power Plant was disconnected from the grid for Y206 outage on August 29, 2023, and re-connected to the grid on September 18. The unit operated at full power at all times except during holidays and grid line maintenance in which it operated at reduced power in order to cooperate with peak shaving of the grid (including 1 shutdown for standby to cooperate with the grid). No scrams has occurred throughout the year.

2023 Operating Experience

CN-40

YANGJIANG-3

CHINA

Status at end of year : **Operational**
 Operator : YJNPC (Yangjiang Nuclear Power Company)
 Owner : YJNPC (Yangjiang Nuclear Power Company)
 Reactor Supplier : CFHI (China First Heavy Industries)
 Turbine Supplier : SEG (Shanghai Electric Group)



Reactor Unit Details

Reactor type and model : PWR / CPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1086 MWe
 Reference unit power (net) : 1000 MWe

Key Dates

Construction Date : 2010-11-15
 Grid Date : 2015-10-18
 Commercial Date : 2016-01-01
 Age at end of year : 8 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.45
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 4.45
 Average discharge burnup [MWd/t] : 44000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 328.4
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

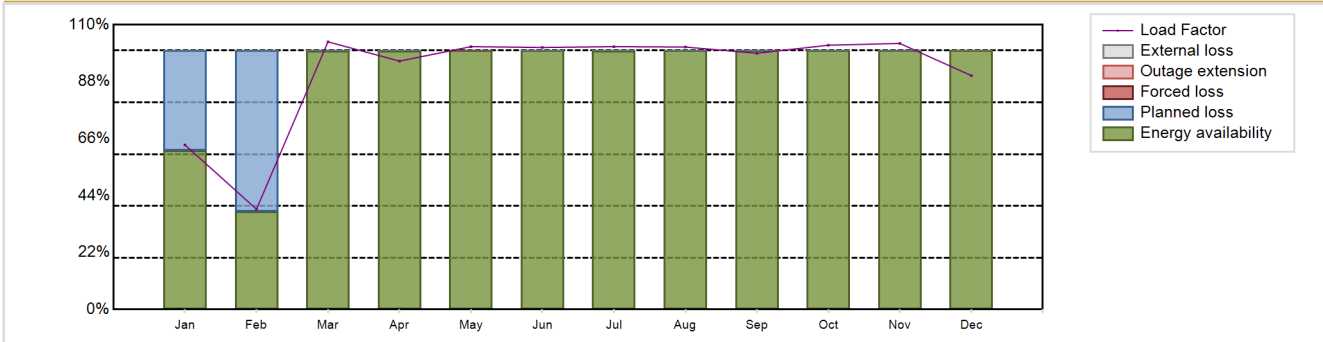
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8071.11 GW(e).h
 Energy Availability Factor (EAF) : 91.93 %
 Unit Capability Factor (UCF) : 91.93 %
 Load Factor (LF) : 92.14 %
 Operating Factor (OF) : 92.32 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 8.06 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 673 hours

Annual Summary

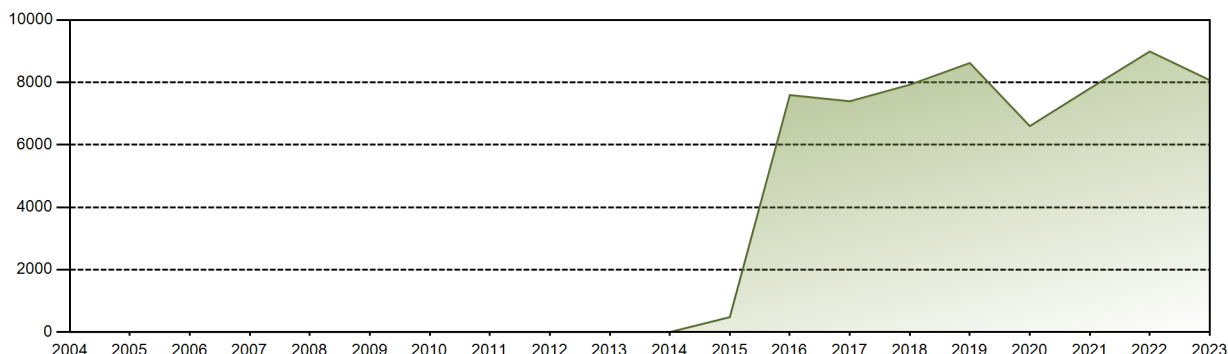


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 472.93 | 260.38 | 769.13 | 690.82 | 755.35 | 728.71 | 755.42 | 754.19 | 712.61 | 759.52 | 739.91 | 672.14 | 8071.11 |
| EAF [%] | 61.39 | 37.73 | 99.98 | 99.95 | 99.99 | 100.00 | 99.98 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.93 |
| UCF [%] | 61.39 | 37.73 | 99.98 | 99.95 | 99.99 | 100.00 | 99.98 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.93 |
| LF [%] | 63.57 | 38.75 | 103.38 | 95.95 | 101.53 | 101.21 | 101.53 | 101.37 | 98.97 | 102.09 | 102.77 | 90.34 | 92.14 |
| OF [%] | 61.69 | 42.26 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.32 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 38.61 | 62.27 | 0.02 | 0.05 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.06 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 63485.22 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.38 % |
| Cumulative Energy Availability Factor (EAF) | : 92.55 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.36 % |
| Cumulative Unit Capability Factor (UCF) | : 92.73 % | Cumulative Planned Unavailability Factor (PUF) | : 6.91 % |
| Cumulative Load Factor (LF) | : 89.85 % | Cumulative Externally cause unavailability (XUF) | : 0.18 % |
| Cumulative Operating Factor (OF) | : 90.76 % | | |

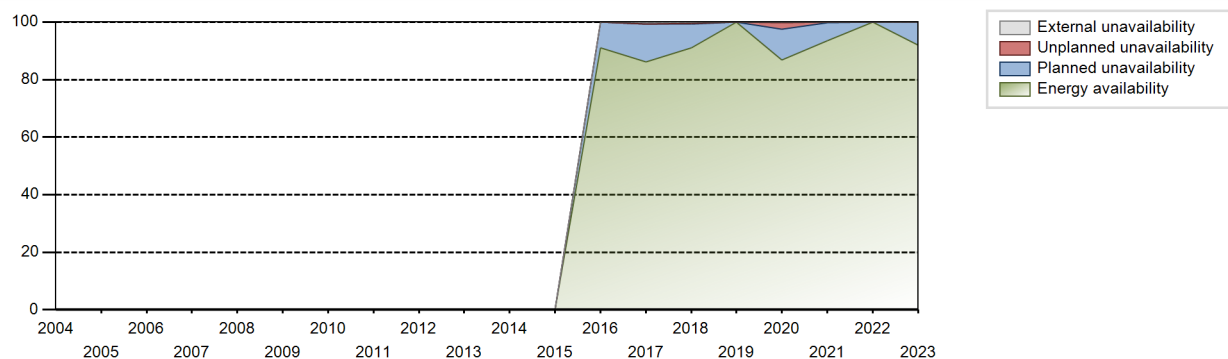
Electricity Production (net) [GWh]



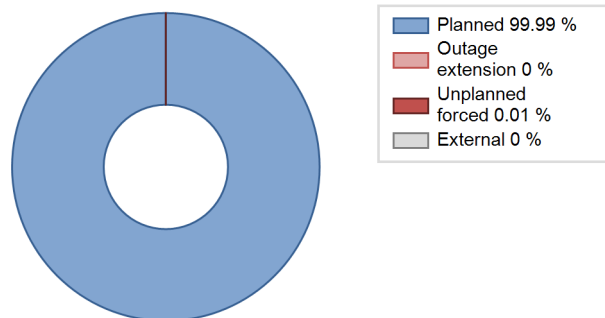
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|--------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 7593.85 | 7559 | 1000 | 91.12 | 91.24 | 86.45 | 86.05 | 0.01 | 0.01 | 8.75 | 0.12 |
| 2017 | 7396.07 | 7435 | 1000 | 86.14 | 86.87 | 84.43 | 84.87 | 0.00 | 0.00 | 13.13 | 0.72 |
| 2018 | 7926.66 | 8028 | 1000 | 91.09 | 91.51 | 90.49 | 91.64 | 0.22 | 0.20 | 8.30 | 0.41 |
| 2019 | 8621.67 | 8760 | 1000 | 99.96 | 99.99 | 98.42 | 100.00 | 0.00 | 0.00 | 0.01 | 0.04 |
| 2020 | 6600.21 | 7039 | 1000 | 86.76 | 86.91 | 75.14 | 80.13 | 2.70 | 2.41 | 10.68 | 0.15 |
| 2021 | 7804.98 | 7978 | 1000 | 93.41 | 93.41 | 89.10 | 91.07 | 0.24 | 0.23 | 6.36 | 0.00 |
| 2022 | 8991.99 | 8760 | 1000 | 100.00 | 100.00 | 102.65 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 8071.11 | 8087 | 1000 | 91.93 | 91.93 | 92.14 | 92.32 | 0.00 | 0.00 | 8.06 | 0.00 |

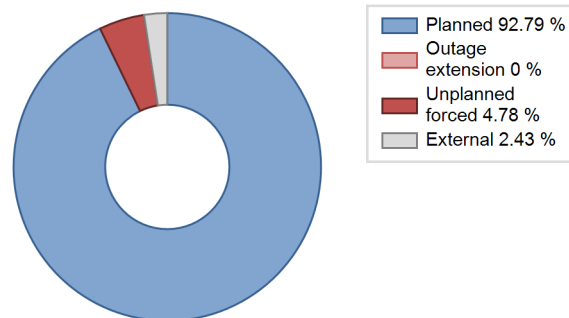
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 2 | |
| C. Inspection, maintenance or repair combined with refuelling | 673 | | | 577 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 3 | | |
| I. Grid capacity limitation | | | | | | 113 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 85 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| Z. Other | | | | | 26 | |
| Subtotal | 673 | | | 580 | 28 | 202 |
| Total | | 673 | | | 810 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 31. Turbine and auxiliaries | | | | 2 |
| 33. Circulating Water System | | | | 26 |
| 42. Electrical Power Supply Systems | | | | 113 |
| Total | | | | 141 |

Highlights (2023)

Unit 3 of Yangjiang Nuclear Power Plant was disconnected from the grid for Y305 outage on January 20, 2023, and re-connected to the grid on February 17. The unit operated at full power at all times except during holidays and grid line maintenance in which it operated at reduced power in order to cooperate with peak shaving of the grid. No scrams has occurred throughout the year.

2023 Operating Experience

CN-41

YANGJIANG-4

CHINA

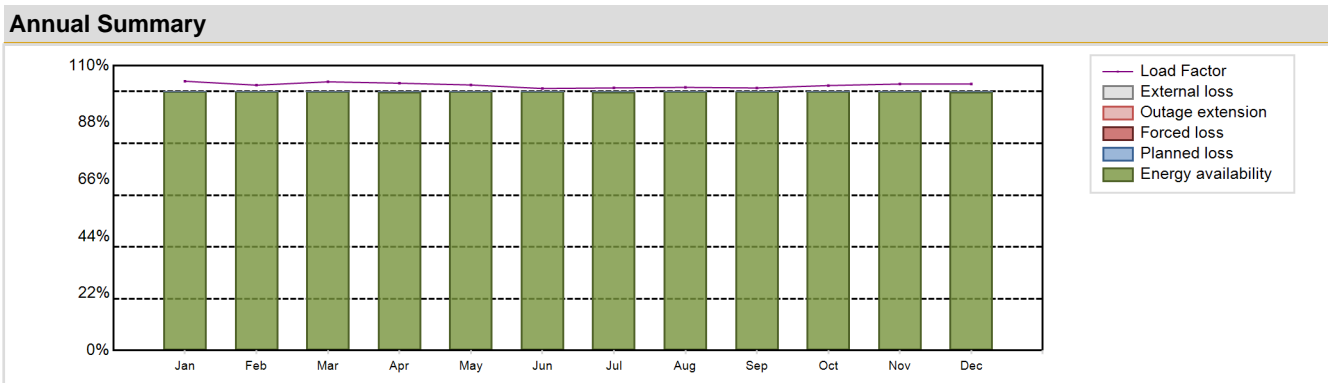
Status at end of year : **Operational**
 Operator : YJNPC (Yangjiang Nuclear Power Company)
 Owner : YJNPC (Yangjiang Nuclear Power Company)
 Reactor Supplier : CFHI (China First Heavy Industries)
 Turbine Supplier : SEG (Shanghai Electric Group)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / CPR-1000 | Construction Date | : 2012-11-17 |
| Thermal power | : 2905 MWth | Grid Date | : 2017-01-08 |
| Gross electrical power | : 1086 MWe | Commercial Date | : 2017-03-15 |
| Reference unit power (net) | : 1000 MWe | Age at end of year | : 6 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 328.4 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.52 |
| Average fuel enrichment [% of U235] | : 4.45 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 4.45 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 44000 | Number of LP cylinders per turbine | : 2 |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 6.43 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : 24 |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.6 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 8978.18 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.99 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 99.99 % | Planned Unavailability Factor (PUF) | : 0.01 % |
| Load Factor (LF) | : 102.49 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

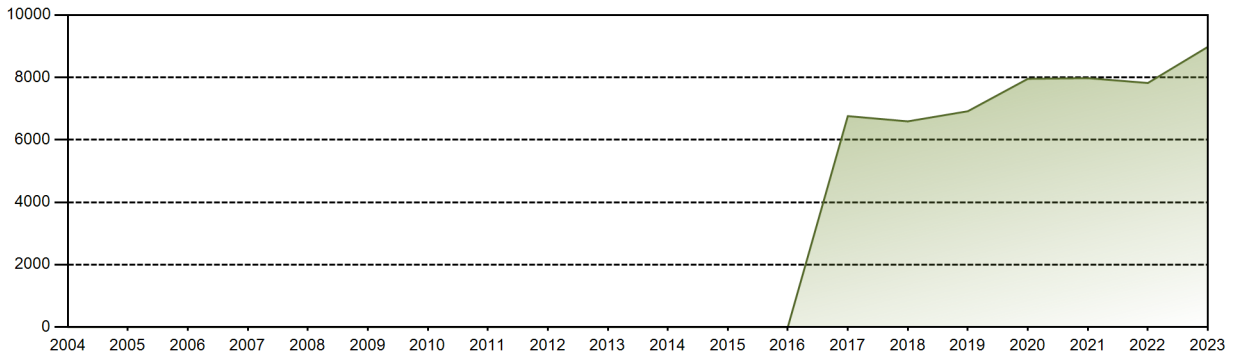


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 773.76 | 688.64 | 772.11 | 743.27 | 762.95 | 728.53 | 754.59 | 756.21 | 729.97 | 761.34 | 741.04 | 765.77 | 8978.18 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 99.93 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 100.00 | 100.00 | 99.98 | 99.99 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 99.93 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 100.00 | 100.00 | 99.98 | 99.99 |
| LF [%] | 104.00 | 102.48 | 103.78 | 103.23 | 102.55 | 101.18 | 101.42 | 101.64 | 101.38 | 102.33 | 102.92 | 102.93 | 102.49 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 53001.67 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.81 % |
| Cumulative Energy Availability Factor (EAF) | : 92.22 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.7 % |
| Cumulative Unit Capability Factor (UCF) | : 92.31 % | Cumulative Planned Unavailability Factor (PUF) | : 5.99 % |
| Cumulative Load Factor (LF) | : 88.22 % | Cumulative Externally cause unavailability (XUF) | : 0.09 % |
| Cumulative Operating Factor (OF) | : 88.43 % | | |

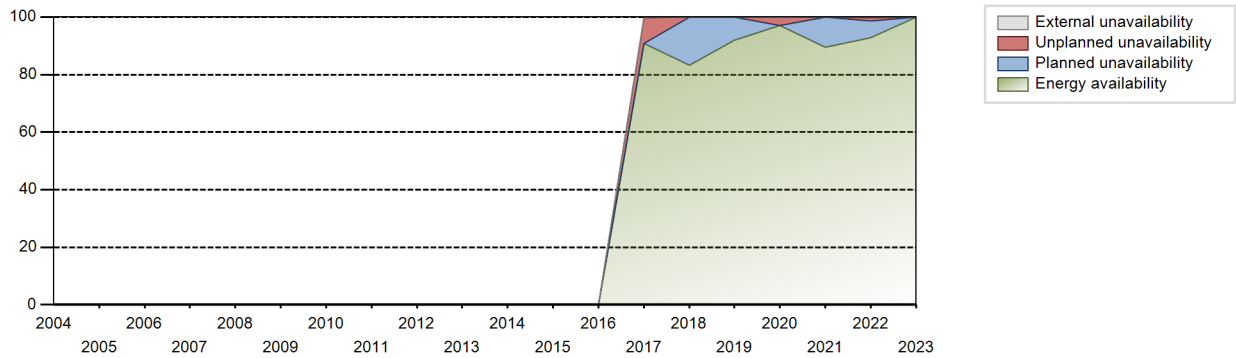
Electricity Production (net) [GWh]



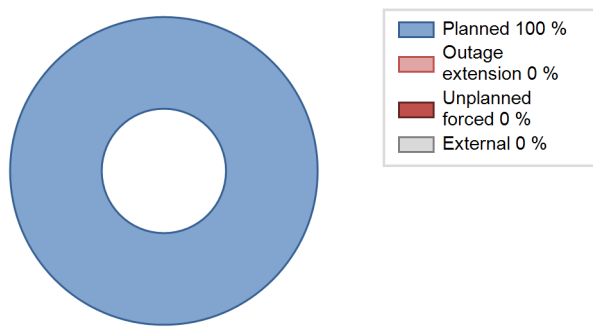
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2017 | 6759.71 | 6353 | 1000 | 90.72 | 91.02 | 90.26 | 86.51 | 8.98 | 8.98 | 0.01 | 0.30 |
| 2018 | 6591.93 | 6695 | 1000 | 83.35 | 83.43 | 75.25 | 76.43 | 0.01 | 0.01 | 16.57 | 0.07 |
| 2019 | 6915.91 | 7164 | 1000 | 91.88 | 91.88 | 78.95 | 81.78 | 0.01 | 0.01 | 8.11 | 0.00 |
| 2020 | 7954.62 | 8216 | 1000 | 97.02 | 97.11 | 90.56 | 93.53 | 2.88 | 2.88 | 0.00 | 0.09 |
| 2021 | 7977.13 | 7880 | 1000 | 89.45 | 89.45 | 91.06 | 89.95 | 0.08 | 0.08 | 10.48 | 0.00 |
| 2022 | 7820.95 | 7927 | 1000 | 92.87 | 93.08 | 89.28 | 90.49 | 1.18 | 1.11 | 5.81 | 0.21 |
| 2023 | 8978.18 | 8760 | 1000 | 99.99 | 99.99 | 102.49 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |

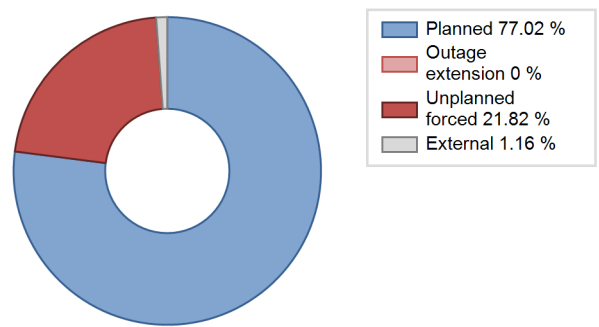
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2017 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 96 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 501 | | |
| I. Grid capacity limitation | | | | | | 101 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 231 |
| Z. Other | | | | | 36 | |
| Subtotal | | | | 501 | 132 | 332 |
| Total | | 0 | | | 965 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2017 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 33. Circulating Water System | | 36 |
| 42. Electrical Power Supply Systems | | 192 |
| Total | | 228 |

Highlights (2023)

Unit 4 of Yangjiang Nuclear Power operated at full power at all times except during holidays and grid line maintenance in which it operated at reduced power in order to cooperate with peak shaving of the grid. No scrams has occurred throughout the year.

2023 Operating Experience

CN-47

YANGJIANG-5

CHINA

Status at end of year : **Operational**
 Operator : YJNPC (Yangjiang Nuclear Power Company)
 Owner : YJNPC (Yangjiang Nuclear Power Company)
 Reactor Supplier : CFHI (China First Heavy Industries)
 Turbine Supplier : SEG (Shanghai Electric Group)



Reactor Unit Details

Reactor type and model : PWR / ACPR-1000
 Thermal power : 2905 MWth
 Gross electrical power : 1086 MWe
 Reference unit power (net) : 1000 MWe

Key Dates

Construction Date : 2013-09-18
 Grid Date : 2018-05-23
 Commercial Date : 2018-07-12
 Age at end of year : 5 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 44000
 Active core diameter [m] : -
 Active core height/length [m] : -
 Number of fissile fuel assemblies/bundles : -
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : -
 Reactor outlet temperature [°C] : -
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : -
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : 3

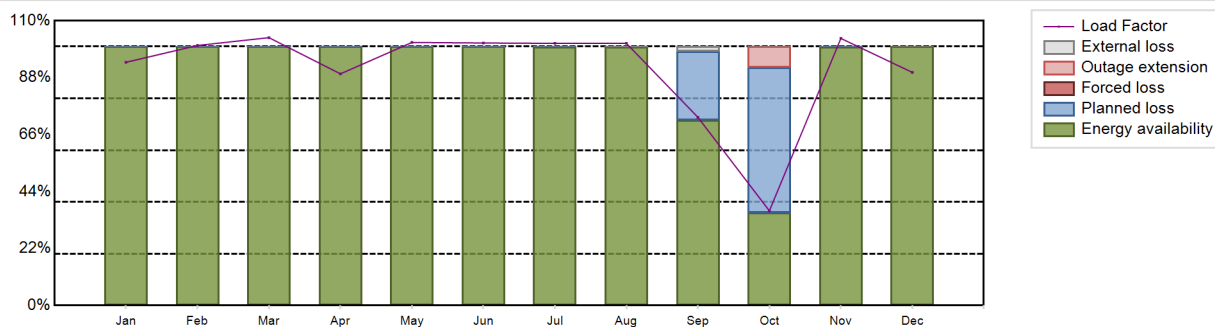
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7988.19 GW(e).h
 Energy Availability Factor (EAF) : 92.19 %
 Unit Capability Factor (UCF) : 92.34 %
 Load Factor (LF) : 91.19 %
 Operating Factor (OF) : 92.33 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0.68 %
 Planned Unavailability Factor (PUF) : 6.98 %
 Externally cause unavailability (XUF) : 0.15 %
 Total off-line time : 672 hours

Annual Summary

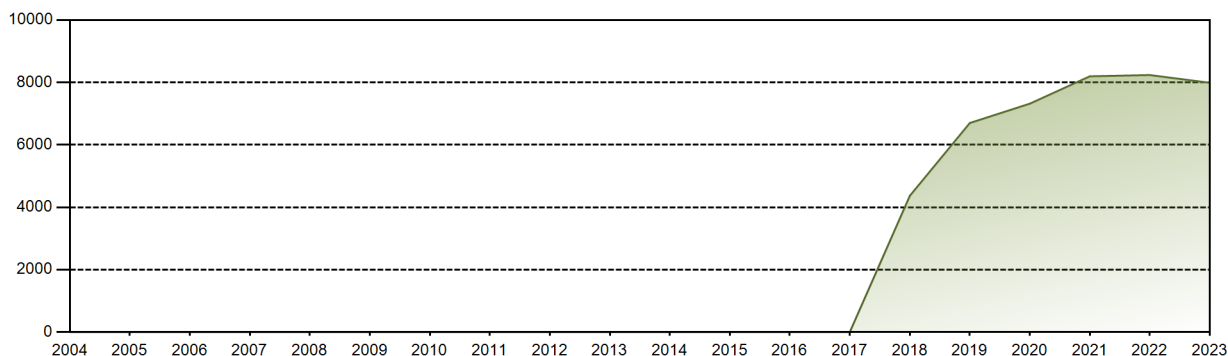


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 698.84 | 674.92 | 769.69 | 644.19 | 755.96 | 729.96 | 753.34 | 753.17 | 523.48 | 272.10 | 742.75 | 669.79 | 7988.19 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.98 | 99.99 | 71.46 | 35.73 | 99.97 | 100.00 | 92.19 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.98 | 100.00 | 73.29 | 35.73 | 99.97 | 100.00 | 92.34 |
| LF [%] | 93.93 | 100.43 | 103.45 | 89.47 | 101.61 | 101.38 | 101.26 | 101.23 | 72.71 | 36.57 | 103.16 | 90.03 | 91.19 |
| OF [%] | 100.00 | 100.00 | 100.00 | 95.00 | 100.00 | 100.00 | 100.00 | 100.00 | 73.75 | 39.92 | 100.00 | 100.00 | 92.33 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.04 | 0.00 | 0.00 | 0.68 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 26.71 | 56.23 | 0.03 | 0.00 | 6.98 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 1.83 | 0.00 | 0.00 | 0.00 | 0.15 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 42803.68 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.7 % |
| Cumulative Energy Availability Factor (EAF) | : 91.98 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.77 % |
| Cumulative Unit Capability Factor (UCF) | : 92.11 % | Cumulative Planned Unavailability Factor (PUF) | : 7.11 % |
| Cumulative Load Factor (LF) | : 88.32 % | Cumulative Externally cause unavailability (XUF) | : 0.13 % |
| Cumulative Operating Factor (OF) | : 90.19 % | | |

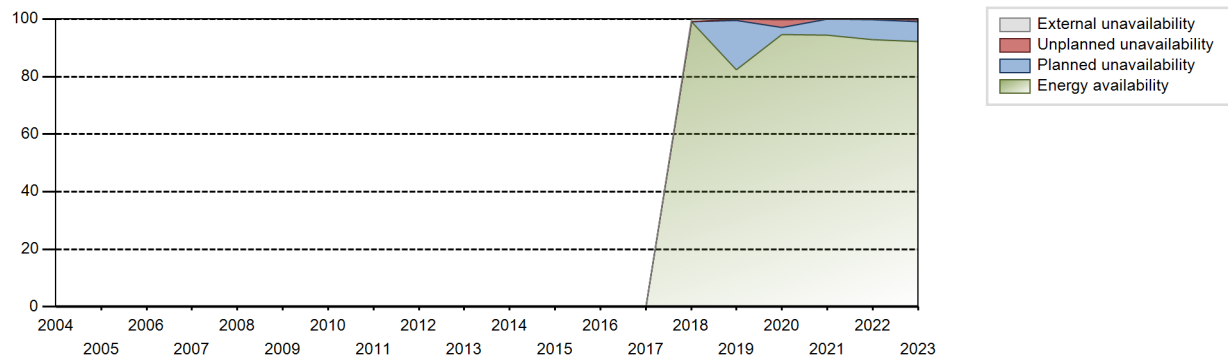
Electricity Production (net) [GWh]



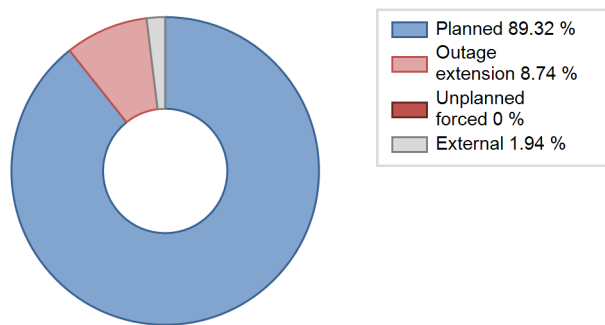
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2018 | 4365.35 | 4847 | 1000 | 99.11 | 99.94 | 94.36 | 97.26 | 0.06 | 0.06 | 0.00 | 0.83 |
| 2019 | 6699.42 | 6927 | 1000 | 82.36 | 82.36 | 76.48 | 79.08 | 0.68 | 0.56 | 17.08 | 0.00 |
| 2020 | 7318.68 | 7706 | 1000 | 94.64 | 94.79 | 83.32 | 87.73 | 2.83 | 2.76 | 2.45 | 0.15 |
| 2021 | 8195.95 | 8314 | 1000 | 94.39 | 94.40 | 93.56 | 94.91 | 0.00 | 0.00 | 5.60 | 0.01 |
| 2022 | 8236.09 | 8177 | 1000 | 92.72 | 92.72 | 94.02 | 93.34 | 0.24 | 0.22 | 7.06 | 0.00 |
| 2023 | 7988.19 | 8088 | 1000 | 92.19 | 92.34 | 91.19 | 92.33 | 0.00 | 0.68 | 6.98 | 0.15 |

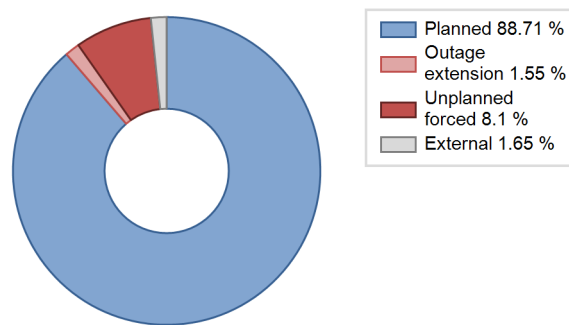
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2018 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 60 | | | 22 | |
| C. Inspection, maintenance or repair combined with refuelling | 576 | | | 593 | | |
| I. Grid capacity limitation | | | 33 | | | 121 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 61 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 6 |
| Z. Other | | | | | 43 | |
| Subtotal | 576 | 60 | 33 | 593 | 65 | 188 |
| Total | | 669 | | | 846 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2018 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 14. Safety Systems | | | | 8 |
| 31. Turbine and auxiliaries | | | | 3 |
| 33. Circulating Water System | | | | 42 |
| 34. Miscellaneous Systems | | 60 | | 11 |
| 42. Electrical Power Supply Systems | | | 33 | 117 |
| Total | | 93 | | 181 |

Highlights (2023)

Unit 5 of Yangjiang Nuclear Power Plant was disconnected from the grid for Y504 outage on September 23, 2023, and re-connected to the grid on October 19, 2023. The unit operated at full power at all times except during holidays and grid line maintenance in which it operated at reduced power in order to cooperate with peak shaving of the grid (including 1 shutdown for standby to cooperate with the grid). No scrams has occurred throughout the year.

2023 Operating Experience

CN-48

YANGJIANG-6

CHINA

Status at end of year : **Operational**
 Operator : YJNPC (Yangjiang Nuclear Power Company)
 Owner : YJNPC (Yangjiang Nuclear Power Company)
 Reactor Supplier : CFHI (China First Heavy Industries)
 Turbine Supplier : SEG (Shanghai Electric Group)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------|--------------------|--------------|
| Reactor type and model | : PWR / ACPR-1000 | Construction Date | : 2013-12-23 |
| Thermal power | : 2905 MWth | Grid Date | : 2019-06-29 |
| Gross electrical power | : 1086 MWe | Commercial Date | : 2019-07-24 |
| Reference unit power (net) | : 1000 MWe | Age at end of year | : 4 years |

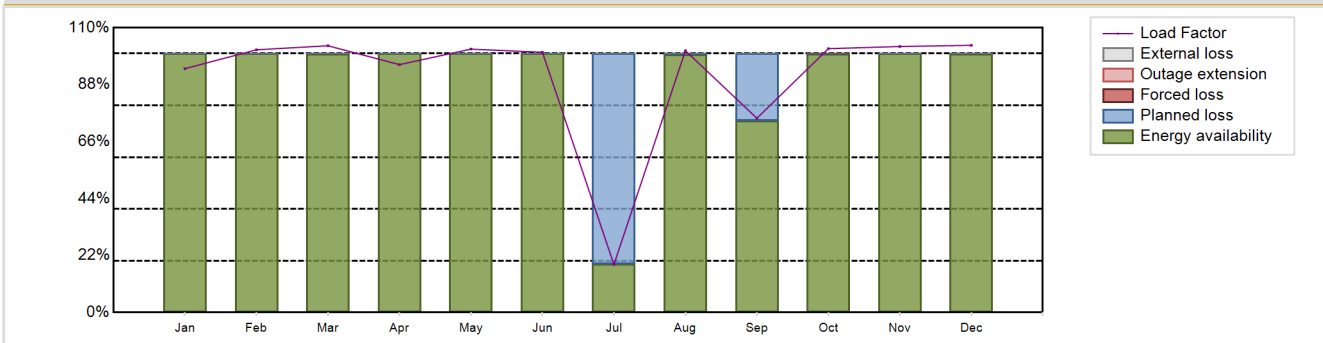
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.5 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 328.4 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 4.45 | Containment design pressure [MPa] | : 0.52 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 4.45 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 44000 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : 2 |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 6.43 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : 24 |
| Fuel linear heat generation rate [kW/m] | : 18.6 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 61 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 3 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 8015.33 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 90.92 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 90.92 % | Planned Unavailability Factor (PUF) | : 9.08 % |
| Load Factor (LF) | : 91.5 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 91.21 % | Total off-line time | : 770 hours |

Annual Summary

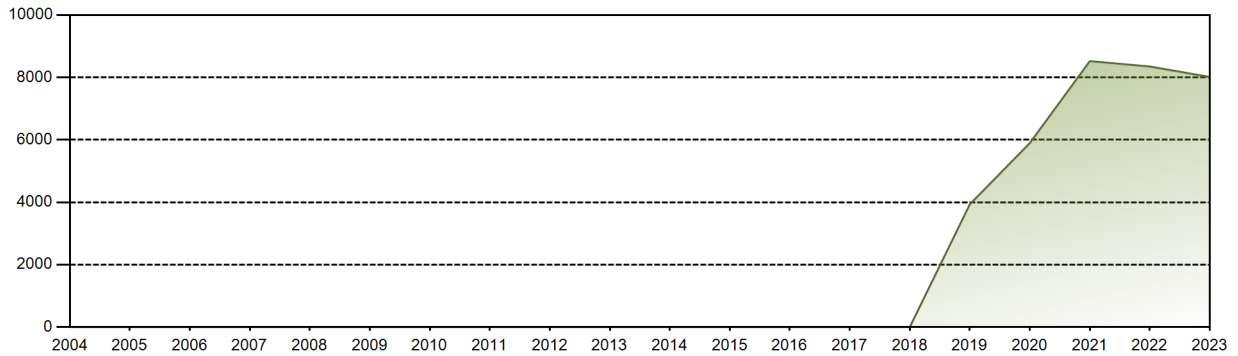


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 700.89 | 681.82 | 766.54 | 689.28 | 756.93 | 723.69 | 137.87 | 752.31 | 540.26 | 758.19 | 739.68 | 767.87 | 8015.33 |
| EAF [%] | 100.00 | 100.00 | 99.98 | 100.00 | 100.00 | 100.00 | 18.69 | 99.60 | 74.03 | 99.98 | 100.00 | 99.97 | 90.92 |
| UCF [%] | 100.00 | 100.00 | 99.98 | 100.00 | 100.00 | 100.00 | 18.69 | 99.60 | 74.03 | 99.98 | 100.00 | 99.97 | 90.92 |
| LF [%] | 94.21 | 101.46 | 103.03 | 95.73 | 101.74 | 100.51 | 18.53 | 101.12 | 75.04 | 101.91 | 102.73 | 103.21 | 91.50 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 22.85 | 100.00 | 72.78 | 100.00 | 100.00 | 100.00 | 91.21 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 81.31 | 0.40 | 25.97 | 0.00 | 0.00 | 0.03 | 9.08 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 34778.15 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.87 % |
| Cumulative Energy Availability Factor (EAF) | : 92.34 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.81 % |
| Cumulative Unit Capability Factor (UCF) | : 92.35 % | Cumulative Planned Unavailability Factor (PUF) | : 6.84 % |
| Cumulative Load Factor (LF) | : 88.27 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 89.7 % | | |

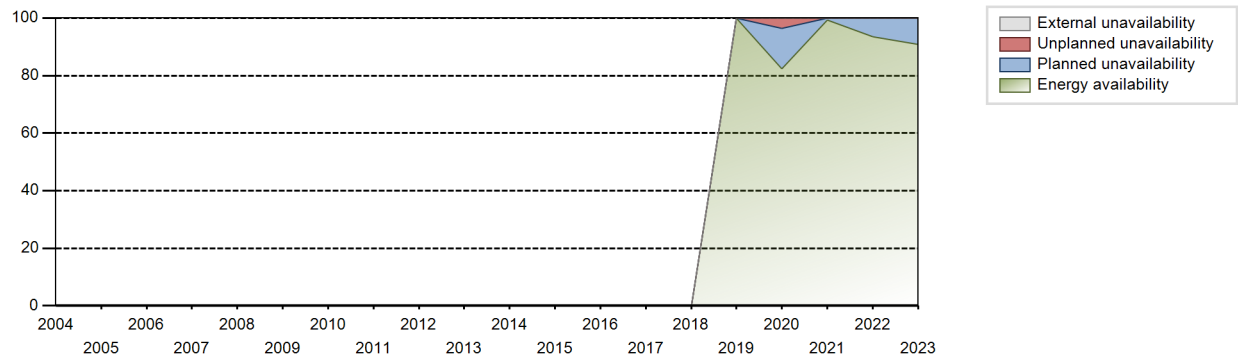
Electricity Production (net) [GWh]



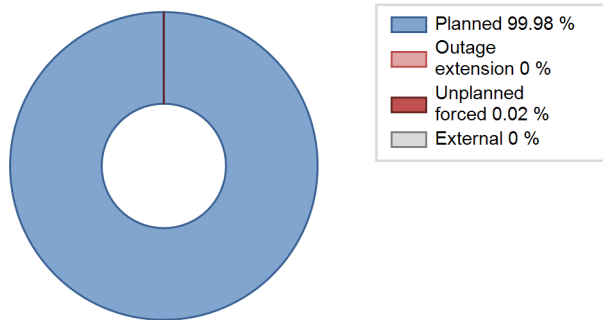
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2019 | 3934.18 | 3915 | 1000 | 100.00 | 100.00 | 92.83 | 93.25 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 5896.66 | 6526 | 1000 | 82.41 | 82.41 | 67.13 | 74.29 | 4.15 | 3.57 | 14.02 | 0.00 |
| 2021 | 8522.45 | 8571 | 1000 | 99.31 | 99.31 | 97.29 | 97.84 | 0.00 | 0.00 | 0.69 | 0.00 |
| 2022 | 8349.54 | 8234 | 1000 | 93.56 | 93.56 | 95.31 | 94.00 | 0.00 | 0.00 | 6.44 | 0.00 |
| 2023 | 8015.33 | 7990 | 1000 | 90.92 | 90.92 | 91.50 | 91.21 | 0.00 | 0.00 | 9.08 | 0.00 |

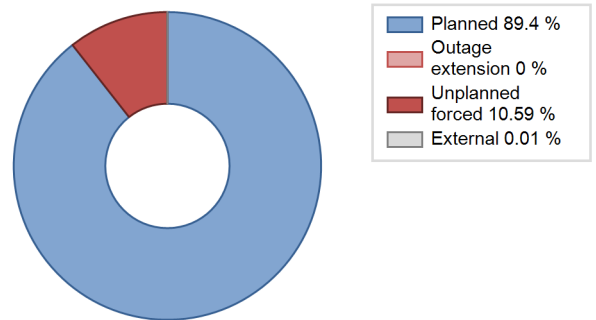
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2019 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| C. Inspection, maintenance or repair combined with refuelling | 574 | | | 519 | | |
| D. Inspection, maintenance or repair without refuelling | 182 | | | 54 | | |
| I. Grid capacity limitation | | | | | | 223 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 56 |
| Z. Other | | | | | 49 | |
| Subtotal | 756 | | | 573 | 49 | 279 |
| Total | | 756 | | | 901 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2019 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 33. Circulating Water System | | | | 47 |
| 42. Electrical Power Supply Systems | | | | 215 |
| Total | | | | 262 |

Highlights (2023)

Unit 6 of Yangjiang Nuclear Power Plant was disconnected from the grid for Y603 outage on July 6, 2023, and re-connected to the grid on July 30. Unit 6 shut down for maintenance from September 6 to September 14. The unit operated at full power at all times except during holidays and grid line maintenance in which it operated at reduced power in order to cooperate with peak shaving of the grid. No scrams has occurred throughout the year.

2023 Operating Experience

CZ-4

DUKOVANY-1

CZECH REPUBLIC

Status at end of year : **Operational**
 Operator : CEZ (CZECH POWER Co., CEZ a.s.)
 Owner : CEZ (CZECH POWER Co., CEZ a.s.)
 Reactor Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1444 MWth
 Gross electrical power : 500 MWe
 Reference unit power (net) : 468 MWe

Key Dates

Construction Date : 1979-01-01
 Grid Date : 1985-02-24
 Commercial Date : 1985-05-03
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.3
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 20
 Average discharge burnup [MWd/t] : 44000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.26
 Reactor outlet temperature [°C] : 297
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.15

Secondary systems

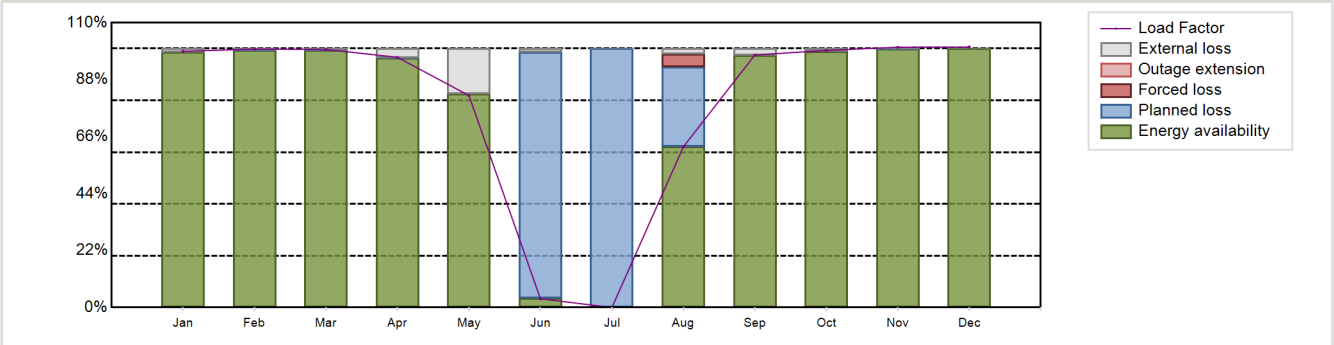
Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.3
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3207.28 GW(e).h
 Energy Availability Factor (EAF) : 78.03 %
 Unit Capability Factor (UCF) : 80.64 %
 Load Factor (LF) : 78.23 %
 Operating Factor (OF) : 81.11 %
 Forced Loss Rate (FLR) : 0.52 %
 Unplanned Capability Loss Factor (UCL) : 0.42 %
 Planned Unavailability Factor (PUF) : 18.94 %
 Externally cause unavailability (XUF) : 2.62 %
 Total off-line time : 1655 hours

Annual Summary

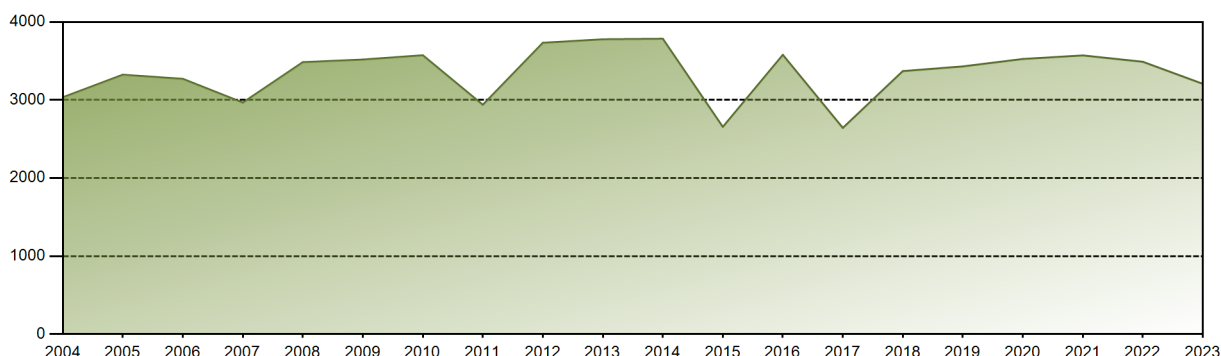


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 344.60 | 313.91 | 347.03 | 325.61 | 285.07 | 11.41 | 0.00 | 216.15 | 328.70 | 345.68 | 338.79 | 350.33 | 3207.28 |
| EAF [%] | 98.53 | 99.36 | 99.35 | 96.31 | 82.38 | 3.48 | 0.00 | 62.25 | 97.47 | 98.89 | 99.87 | 100.00 | 78.03 |
| UCF [%] | 100.00 | 99.97 | 99.97 | 99.83 | 100.00 | 4.77 | 0.00 | 64.49 | 100.00 | 100.00 | 99.99 | 100.00 | 80.64 |
| LF [%] | 98.97 | 99.81 | 99.67 | 96.63 | 81.87 | 3.39 | 0.00 | 62.08 | 97.55 | 99.28 | 100.54 | 100.62 | 78.23 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 5.42 | 0.00 | 69.09 | 100.00 | 100.00 | 100.00 | 100.00 | 81.11 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.52 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.95 | 0.00 | 0.00 | 0.00 | 0.00 | 0.42 |
| PUF [%] | 0.00 | 0.03 | 0.03 | 0.17 | 0.00 | 95.23 | 100.00 | 30.56 | 0.00 | 0.00 | 0.01 | 0.00 | 18.94 |
| XUF [%] | 1.47 | 0.61 | 0.62 | 3.52 | 17.62 | 1.29 | 0.00 | 2.24 | 2.53 | 1.11 | 0.12 | 0.00 | 2.62 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 122229.56 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.25 % |
| Cumulative Energy Availability Factor (EAF) | : 83.05 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.28 % |
| Cumulative Unit Capability Factor (UCF) | : 83.98 % | Cumulative Planned Unavailability Factor (PUF) | : 13.74 % |
| Cumulative Load Factor (LF) | : 83.85 % | Cumulative Externally cause unavailability (XUF) | : 0.93 % |
| Cumulative Operating Factor (OF) | : 85.38 % | | |

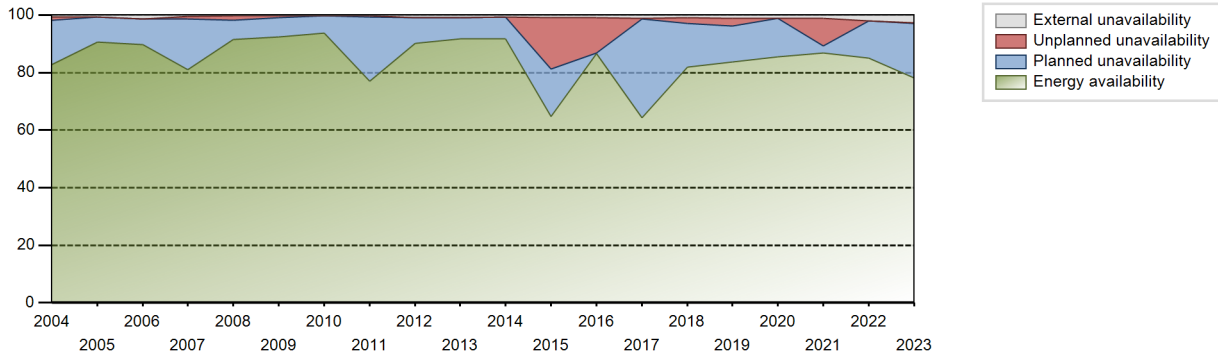
Electricity Production (net) [GWh]



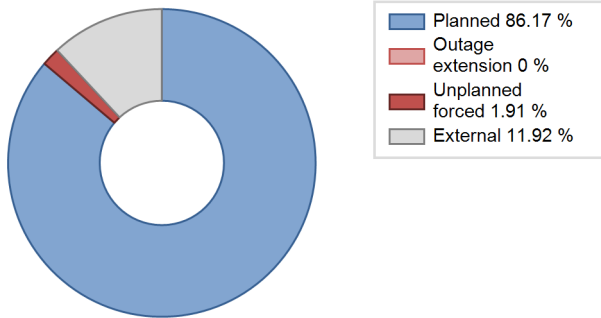
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 1993.92 | 5418 | 396 | 88.11 | 88.11 | 86.73 | 88.06 | 2.36 | 2.13 | 9.77 | 0.00 |
| 1986 | 2658.35 | 7094 | 403 | 76.12 | 76.15 | 75.30 | 80.98 | 1.22 | 0.94 | 22.91 | 0.03 |
| 1987 | 2575.95 | 6867 | 408 | 70.74 | 74.73 | 72.07 | 78.39 | 0.79 | 0.60 | 24.68 | 3.99 |
| 1988 | 2523.99 | 6996 | 408 | 71.53 | 74.17 | 70.43 | 79.64 | 1.48 | 1.11 | 24.72 | 2.64 |
| 1989 | 2940.57 | 7579 | 408 | 82.01 | 82.60 | 82.27 | 86.52 | 2.05 | 1.72 | 15.68 | 0.59 |
| 1990 | 2965.55 | 7658 | 408 | 82.49 | 84.34 | 82.97 | 87.42 | 3.02 | 2.62 | 13.04 | 1.85 |
| 1991 | 2581.09 | 6751 | 408 | 70.50 | 70.68 | 72.22 | 77.07 | 9.25 | 7.20 | 22.12 | 0.18 |
| 1992 | 3172.77 | 7537 | 408 | 80.45 | 80.90 | 88.53 | 85.80 | 3.16 | 2.64 | 16.46 | 0.44 |
| 1993 | 3239.65 | 7649 | 442 | 83.67 | 83.67 | 83.67 | 87.32 | 2.87 | 2.47 | 13.86 | 0.00 |
| 1994 | 3278.54 | 7656 | 442 | 84.64 | 84.64 | 84.67 | 87.40 | 3.15 | 2.76 | 12.60 | 0.00 |
| 1995 | 2966.06 | 7022 | 442 | 76.78 | 76.78 | 76.60 | 80.16 | 4.40 | 3.53 | 19.69 | 0.00 |
| 1996 | 3144.62 | 7592 | 412 | 85.36 | 86.01 | 86.89 | 86.43 | 2.73 | 2.42 | 11.57 | 0.65 |
| 1997 | 3295.57 | 7678 | 440 | 85.26 | 86.76 | 85.50 | 87.65 | 1.01 | 0.88 | 12.36 | 1.50 |
| 1998 | 2973.35 | 7518 | 412 | 82.62 | 85.44 | 82.38 | 85.82 | 3.29 | 2.91 | 11.65 | 2.82 |
| 1999 | 2901.08 | 7034 | 412 | 79.23 | 79.75 | 80.38 | 80.30 | 0.46 | 0.37 | 19.88 | 0.52 |
| 2000 | 3327.93 | 7934 | 412 | 89.73 | 89.84 | 91.96 | 90.32 | 0.48 | 0.44 | 9.72 | 0.11 |
| 2001 | 3328.90 | 7996 | 412 | 90.16 | 90.57 | 92.24 | 91.28 | 0.77 | 0.70 | 8.73 | 0.42 |
| 2002 | 3267.45 | 7926 | 412 | 88.92 | 89.63 | 90.53 | 90.48 | 1.03 | 0.94 | 9.43 | 0.71 |
| 2003 | 3032.00 | 7261 | 412 | 82.63 | 82.89 | 84.01 | 82.89 | 0.06 | 0.05 | 17.06 | 0.25 |
| 2004 | 3035.50 | 7349 | 412 | 82.91 | 83.65 | 83.88 | 83.66 | 0.01 | 1.17 | 15.18 | 0.73 |
| 2005 | 3324.55 | 8015 | 412 | 90.62 | 91.26 | 92.12 | 91.50 | 0.00 | 0.00 | 8.74 | 0.64 |
| 2006 | 3271.63 | 8014 | 412 | 89.73 | 91.20 | 90.65 | 91.48 | 0.01 | 0.01 | 8.79 | 1.46 |
| 2007 | 2967.32 | 7198 | 427 | 80.92 | 81.36 | 81.72 | 82.17 | 1.23 | 1.01 | 17.63 | 0.45 |
| 2008 | 3485.30 | 8090 | 427 | 91.59 | 91.80 | 92.92 | 92.10 | 1.66 | 1.55 | 6.65 | 0.21 |
| 2009 | 3518.64 | 8186 | 427 | 92.48 | 92.68 | 94.07 | 93.45 | 0.49 | 0.68 | 6.65 | 0.20 |
| 2010 | 3573.83 | 8256 | 427 | 93.76 | 93.98 | 95.54 | 94.25 | 0.06 | 0.06 | 5.96 | 0.21 |
| 2011 | 2939.01 | 6877 | 468 | 76.93 | 77.28 | 77.94 | 78.50 | 0.43 | 0.33 | 22.39 | 0.35 |
| 2012 | 3733.44 | 8049 | 468 | 90.24 | 91.13 | 90.82 | 91.63 | 0.06 | 0.06 | 8.82 | 0.89 |
| 2013 | 3778.58 | 8142 | 468 | 91.72 | 92.63 | 92.17 | 92.95 | 0.12 | 0.11 | 7.27 | 0.91 |
| 2014 | 3785.47 | 8141 | 468 | 91.74 | 92.55 | 92.34 | 92.93 | 0.00 | 0.00 | 7.45 | 0.80 |
| 2015 | 2655.64 | 5753 | 468 | 64.66 | 65.63 | 64.78 | 65.67 | 0.00 | 17.81 | 16.56 | 0.97 |
| 2016 | 3579.05 | 7721 | 468 | 86.69 | 87.58 | 87.07 | 87.91 | 0.00 | 12.35 | 0.07 | 0.89 |
| 2017 | 2642.46 | 5780 | 468 | 64.32 | 65.46 | 64.46 | 65.98 | 0.30 | 0.19 | 34.35 | 1.13 |
| 2018 | 3370.83 | 7305 | 468 | 81.91 | 82.82 | 82.22 | 83.39 | 2.36 | 2.00 | 15.18 | 0.91 |
| 2019 | 3430.94 | 7462 | 468 | 83.62 | 84.83 | 83.69 | 85.18 | 0.18 | 2.68 | 12.50 | 1.21 |
| 2020 | 3526.21 | 7620 | 468 | 85.48 | 86.67 | 85.78 | 86.75 | 0.00 | 0.00 | 13.33 | 1.19 |
| 2021 | 3571.79 | 7761 | 468 | 86.90 | 88.15 | 87.12 | 88.60 | 0.10 | 9.57 | 2.28 | 1.25 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 3490.34 | 7673 | 468 | 85.11 | 87.12 | 85.14 | 87.59 | 0.15 | 0.13 | 12.75 | 2.01 |
| 2023 | 3207.28 | 7105 | 468 | 78.03 | 80.64 | 78.23 | 81.11 | 0.52 | 0.42 | 18.94 | 2.62 |

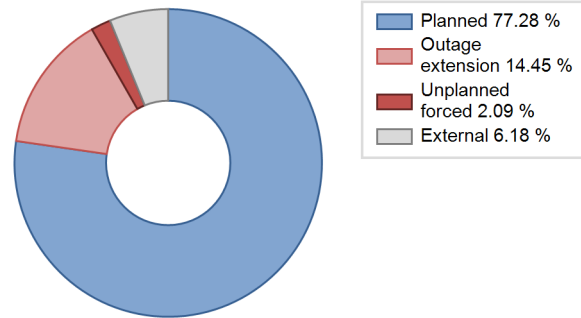
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 36 | | | 72 | |
| C. Inspection, maintenance or repair combined with refuelling | 1619 | | | 1103 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 71 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| L. Human factor related | | | | | 68 | |
| Subtotal | 1619 | 36 | | 1174 | 140 | 4 |
| Total | | 1655 | | | 1318 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1985 to 2023 | |
|--|------------|----|-------------------------------------|----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 0 |
| 12. Reactor I&C Systems | | | | 3 |
| 13. Reactor Auxiliary Systems | | 36 | | 1 |
| 14. Safety Systems | | | | 5 |
| 15. Reactor Cooling Systems | | | | 12 |
| 16. Steam generation systems | | | | 34 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 0 |
| 31. Turbine and auxiliaries | | | | 2 |
| 32. Feedwater and Main Steam System | | | | 0 |
| 41. Main Generator Systems | | | | 0 |
| 42. Electrical Power Supply Systems | | | | 12 |
| Total | | 36 | | 69 |

2023 Operating Experience

CZ-5

DUKOVANY-2

CZECH REPUBLIC

Status at end of year : **Operational**
 Operator : CEZ (CZECH POWER Co., CEZ a.s.)
 Owner : CEZ (CZECH POWER Co., CEZ a.s.)
 Reactor Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1444 MWth
 Gross electrical power : 500 MWe
 Reference unit power (net) : 471 MWe

Key Dates

Construction Date : 1979-01-01
 Grid Date : 1986-01-30
 Commercial Date : 1986-03-21
 Age at end of year : 37 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.3
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 20
 Average discharge burnup [MWd/t] : 44000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.26
 Reactor outlet temperature [°C] : 297
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.15

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.3
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

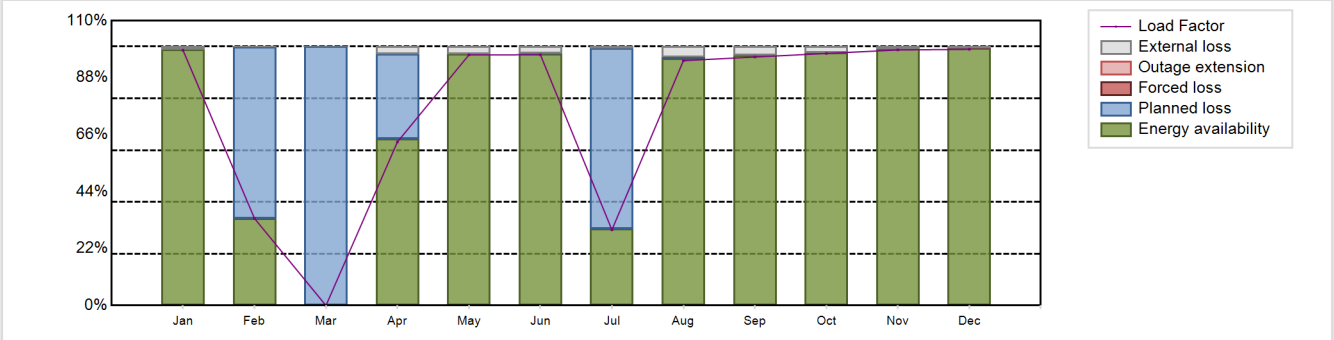
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3115.8 GW(e).h
 Energy Availability Factor (EAF) : 75.91 %
 Unit Capability Factor (UCF) : 77.75 %
 Load Factor (LF) : 75.52 %
 Operating Factor (OF) : 78.36 %

Forced Loss Rate (FLR) : 0.01 %
 Unplanned Capability Loss Factor (UCL) : 0.01 %
 Planned Unavailability Factor (PUF) : 22.24 %
 Externally cause unavailability (XUF) : 1.84 %
 Total off-line time : 1896 hours

Annual Summary

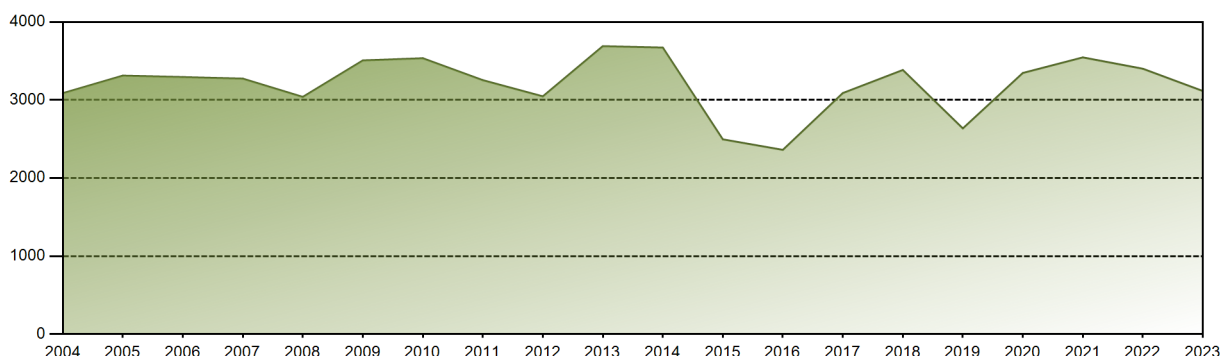


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 345.55 | 106.48 | 0.00 | 214.29 | 339.20 | 328.41 | 102.41 | 331.37 | 325.50 | 341.15 | 334.68 | 346.75 | 3115.80 |
| EAF [%] | 98.87 | 33.72 | 0.00 | 64.44 | 97.09 | 97.08 | 29.60 | 95.29 | 96.54 | 97.64 | 99.02 | 99.26 | 75.91 |
| UCF [%] | 100.00 | 33.85 | 0.00 | 67.41 | 100.00 | 99.66 | 30.30 | 99.43 | 100.00 | 100.00 | 100.00 | 99.94 | 77.75 |
| LF [%] | 98.61 | 33.64 | 0.00 | 63.19 | 96.80 | 96.84 | 29.22 | 94.56 | 95.98 | 97.35 | 98.69 | 98.95 | 75.52 |
| OF [%] | 100.00 | 34.67 | 0.00 | 70.69 | 100.00 | 100.00 | 32.53 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 78.36 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 |
| PUF [%] | 0.00 | 66.15 | 100.00 | 32.59 | 0.00 | 0.34 | 69.70 | 0.51 | 0.00 | 0.00 | 0.00 | 0.03 | 22.24 |
| XUF [%] | 1.13 | 0.13 | 0.00 | 2.97 | 2.91 | 2.58 | 0.70 | 4.14 | 3.46 | 2.36 | 0.98 | 0.68 | 1.84 |

Historical Summary

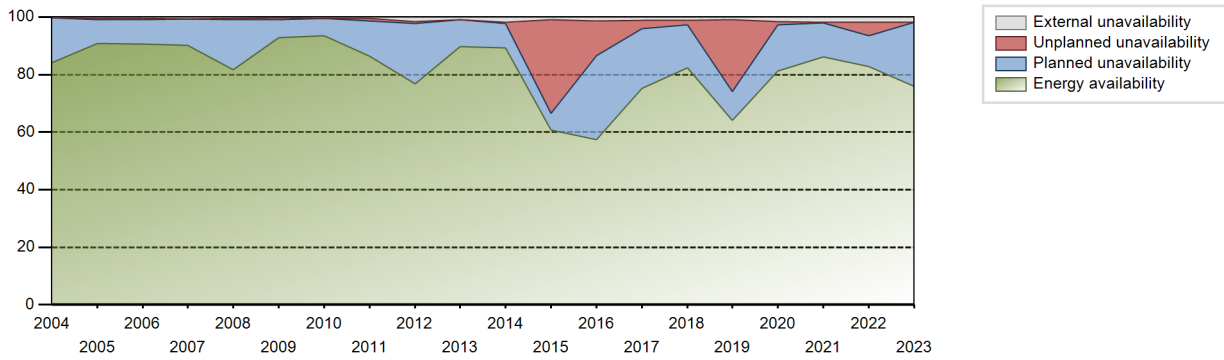
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 117421.22 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.54 % |
| Cumulative Energy Availability Factor (EAF) | : 81.57 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.2 % |
| Cumulative Unit Capability Factor (UCF) | : 82.57 % | Cumulative Planned Unavailability Factor (PUF) | : 14.23 % |
| Cumulative Load Factor (LF) | : 82.23 % | Cumulative Externally cause unavailability (XUF) | : 1 % |
| Cumulative Operating Factor (OF) | : 84.08 % | | |

Electricity Production (net) [GWh]

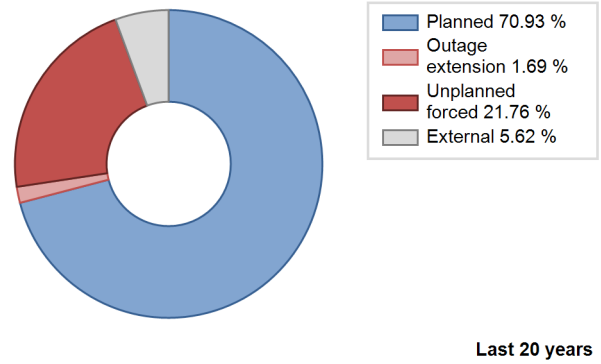
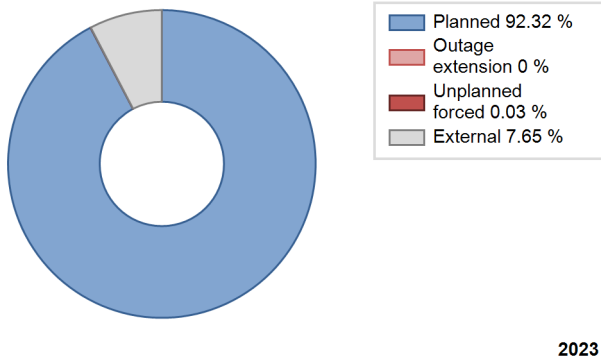


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 2792.72 | 7615 | 408 | 93.71 | 93.71 | 93.32 | 96.65 | 0.83 | 0.78 | 5.50 | 0.00 |
| 1987 | 2668.61 | 6997 | 408 | 71.57 | 76.57 | 74.67 | 79.87 | 0.21 | 0.16 | 23.28 | 5.00 |
| 1988 | 2771.27 | 6963 | 408 | 74.59 | 74.89 | 77.33 | 79.27 | 5.14 | 4.06 | 21.06 | 0.30 |
| 1989 | 3011.03 | 7713 | 408 | 82.23 | 82.68 | 84.25 | 88.05 | 1.71 | 1.43 | 15.89 | 0.45 |
| 1990 | 2822.65 | 7566 | 408 | 76.46 | 80.06 | 78.98 | 86.37 | 5.38 | 4.55 | 15.39 | 3.60 |
| 1991 | 2901.44 | 7600 | 408 | 81.18 | 81.60 | 81.18 | 86.76 | 3.41 | 2.88 | 15.52 | 0.42 |
| 1992 | 2830.61 | 6551 | 408 | 71.42 | 71.59 | 78.98 | 74.58 | 0.74 | 0.53 | 27.88 | 0.16 |
| 1993 | 3256.93 | 7496 | 440 | 84.16 | 84.16 | 84.50 | 85.57 | 1.34 | 1.14 | 14.70 | 0.00 |
| 1994 | 3094.32 | 7315 | 440 | 79.64 | 80.75 | 80.28 | 83.50 | 6.29 | 5.42 | 13.82 | 1.11 |
| 1995 | 3263.35 | 7720 | 440 | 84.35 | 85.52 | 84.67 | 88.13 | 3.54 | 3.13 | 11.34 | 1.17 |
| 1996 | 2831.01 | 6917 | 412 | 77.31 | 78.32 | 78.23 | 78.75 | 1.82 | 1.45 | 20.22 | 1.02 |
| 1997 | 3144.83 | 7179 | 440 | 81.11 | 81.11 | 81.59 | 81.95 | 0.89 | 0.73 | 18.16 | 0.00 |
| 1998 | 3209.23 | 7803 | 412 | 87.73 | 88.24 | 88.92 | 89.08 | 0.63 | 0.56 | 11.20 | 0.51 |
| 1999 | 3198.15 | 7812 | 412 | 87.81 | 88.44 | 88.61 | 89.18 | 2.04 | 1.84 | 9.71 | 0.63 |
| 2000 | 2954.10 | 7223 | 412 | 81.18 | 81.80 | 81.63 | 82.23 | 0.78 | 0.64 | 17.56 | 0.62 |
| 2001 | 3121.12 | 7646 | 412 | 86.35 | 86.92 | 86.48 | 87.28 | 0.71 | 0.62 | 12.46 | 0.56 |
| 2002 | 3159.64 | 7716 | 412 | 87.83 | 88.30 | 87.55 | 88.08 | 0.40 | 0.35 | 11.35 | 0.47 |
| 2003 | 3252.55 | 7939 | 412 | 89.20 | 89.85 | 90.12 | 90.63 | 1.01 | 0.92 | 9.23 | 0.65 |
| 2004 | 3087.75 | 7439 | 412 | 84.19 | 84.36 | 85.31 | 84.68 | 0.19 | 0.16 | 15.48 | 0.16 |
| 2005 | 3313.22 | 8048 | 412 | 90.75 | 91.25 | 91.80 | 91.87 | 0.49 | 0.45 | 8.30 | 0.50 |
| 2006 | 3294.69 | 8017 | 412 | 90.59 | 91.15 | 91.29 | 91.52 | 0.29 | 0.27 | 8.58 | 0.56 |
| 2007 | 3274.74 | 7983 | 412 | 90.12 | 90.88 | 90.74 | 91.13 | 0.06 | 0.05 | 9.07 | 0.77 |
| 2008 | 3040.36 | 7228 | 427 | 81.60 | 82.08 | 82.01 | 82.29 | 0.49 | 0.40 | 17.52 | 0.48 |
| 2009 | 3507.86 | 8209 | 427 | 92.78 | 93.15 | 93.78 | 93.71 | 0.41 | 0.61 | 6.24 | 0.38 |
| 2010 | 3535.93 | 8250 | 427 | 93.39 | 93.81 | 94.53 | 94.18 | 0.00 | 0.06 | 6.14 | 0.42 |
| 2011 | 3254.83 | 7676 | 427 | 86.33 | 86.73 | 87.04 | 87.65 | 0.66 | 1.04 | 12.23 | 0.40 |
| 2012 | 3047.28 | 6918 | 471 | 76.80 | 78.31 | 76.63 | 78.76 | 0.82 | 0.65 | 21.04 | 1.51 |
| 2013 | 3690.57 | 7984 | 471 | 89.75 | 90.61 | 89.45 | 91.14 | 0.12 | 0.11 | 9.28 | 0.85 |
| 2014 | 3672.64 | 8033 | 471 | 89.25 | 91.15 | 89.01 | 91.70 | 0.34 | 0.32 | 8.54 | 1.90 |
| 2015 | 2495.87 | 5426 | 471 | 60.74 | 61.63 | 60.49 | 61.94 | 31.80 | 32.58 | 5.79 | 0.89 |
| 2016 | 2361.31 | 5194 | 471 | 57.39 | 58.80 | 57.07 | 59.13 | 17.04 | 12.08 | 29.12 | 1.41 |
| 2017 | 3089.36 | 6782 | 471 | 75.20 | 76.32 | 74.88 | 77.42 | 3.04 | 2.90 | 20.78 | 1.12 |
| 2018 | 3384.99 | 7359 | 471 | 82.35 | 83.55 | 82.04 | 84.01 | 1.80 | 1.53 | 14.92 | 1.20 |
| 2019 | 2636.32 | 5751 | 471 | 64.14 | 65.15 | 63.90 | 65.65 | 27.32 | 24.94 | 9.91 | 1.01 |
| 2020 | 3346.78 | 7359 | 471 | 81.25 | 82.83 | 80.89 | 83.78 | 0.80 | 1.21 | 15.95 | 1.58 |
| 2021 | 3546.52 | 7744 | 471 | 86.20 | 88.05 | 85.96 | 88.40 | 0.15 | 0.14 | 11.81 | 1.85 |
| 2022 | 3401.12 | 7448 | 471 | 82.83 | 84.55 | 82.43 | 85.02 | 5.28 | 4.71 | 10.74 | 1.73 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 92 | |
| C. Inspection, maintenance or repair combined with refuelling | 1394 | | | 1007 | | |
| D. Inspection, maintenance or repair without refuelling | 502 | | | 76 | | |
| E. Testing of plant systems or components | | | | | 2 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 115 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| L. Human factor related | | | | | 122 | |
| Subtotal | 1896 | | | 1198 | 216 | 4 |
| Total | | 1896 | | | 1418 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 1 |
| 12. Reactor I&C Systems | | 9 |
| 13. Reactor Auxiliary Systems | | 2 |
| 15. Reactor Cooling Systems | | 18 |
| 16. Steam generation systems | | 62 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 1 |
| 32. Feedwater and Main Steam System | | 10 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 1 |
| 42. Electrical Power Supply Systems | | 5 |
| Total | | 112 |

2023 Operating Experience

CZ-8

DUKOVANY-3

CZECH REPUBLIC

Status at end of year : **Operational**
 Operator : CEZ (CZECH POWER Co., CEZ a.s.)
 Owner : CEZ (CZECH POWER Co., CEZ a.s.)
 Reactor Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1444 MWth
 Gross electrical power : 500 MWe
 Reference unit power (net) : 468 MWe

Key Dates

Construction Date : 1979-03-01
 Grid Date : 1986-11-14
 Commercial Date : 1986-12-20
 Age at end of year : 37 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.3
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 20
 Average discharge burnup [MWd/t] : 44000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.26
 Reactor outlet temperature [°C] : 297
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.15

Secondary systems

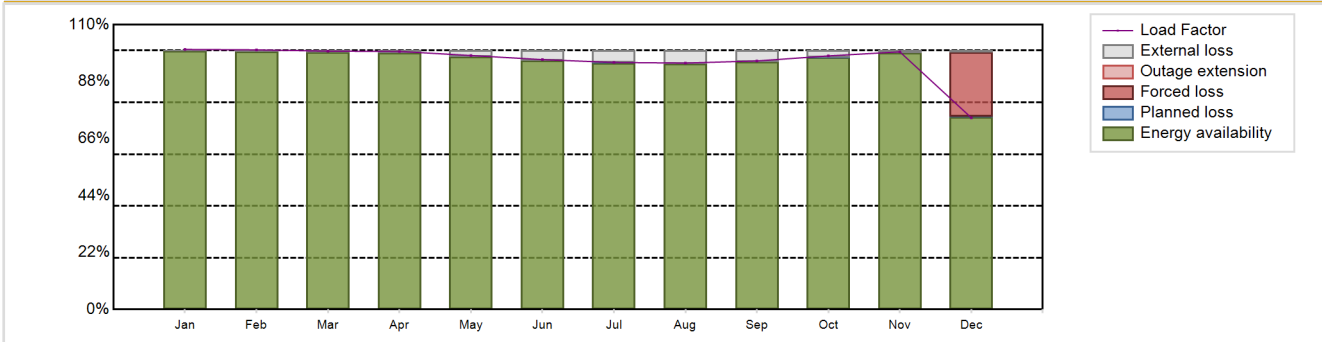
Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.3
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3936.58 GW(e).h
 Energy Availability Factor (EAF) : 95.62 %
 Unit Capability Factor (UCF) : 97.85 %
 Load Factor (LF) : 96.02 %
 Operating Factor (OF) : 98.6 %
 Forced Loss Rate (FLR) : 2.09 %
 Unplanned Capability Loss Factor (UCL) : 2.09 %
 Planned Unavailability Factor (PUF) : 0.06 %
 Externally cause unavailability (XUF) : 2.23 %
 Total off-line time : 123 hours

Annual Summary

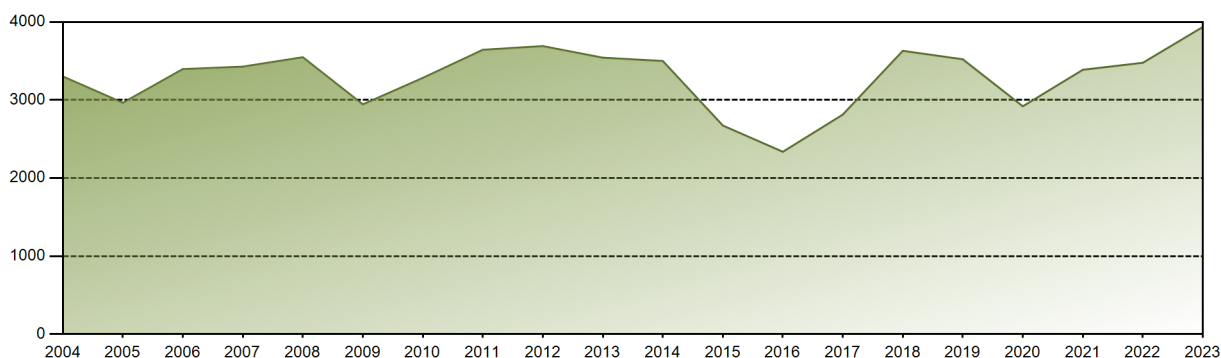


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 349.72 | 315.38 | 347.48 | 335.82 | 341.60 | 325.24 | 332.22 | 331.41 | 323.52 | 341.06 | 335.30 | 257.82 | 3936.58 |
| EAF [%] | 99.77 | 99.64 | 99.30 | 99.08 | 97.70 | 96.15 | 95.13 | 94.99 | 95.60 | 97.37 | 99.03 | 74.26 | 95.62 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.81 | 100.00 | 100.00 | 99.89 | 100.00 | 74.96 | 97.85 |
| LF [%] | 100.44 | 100.28 | 99.80 | 99.66 | 98.11 | 96.52 | 95.41 | 95.18 | 96.01 | 97.95 | 99.51 | 74.04 | 96.02 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 83.47 | 98.60 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.74 | 2.09 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.64 | 2.09 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.11 | 0.00 | 0.40 | 0.06 |
| XUF [%] | 0.23 | 0.36 | 0.70 | 0.92 | 2.30 | 3.85 | 4.68 | 5.01 | 4.40 | 2.52 | 0.97 | 0.70 | 2.23 |

Historical Summary

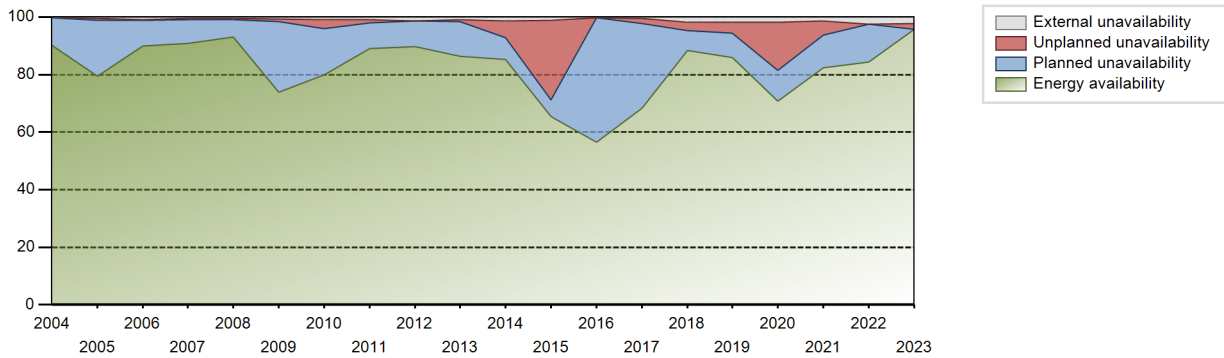
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 116999.07 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.99 % |
| Cumulative Energy Availability Factor (EAF) | : 81.72 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.22 % |
| Cumulative Unit Capability Factor (UCF) | : 83.25 % | Cumulative Planned Unavailability Factor (PUF) | : 13.53 % |
| Cumulative Load Factor (LF) | : 82.62 % | Cumulative Externally cause unavailability (XUF) | : 1.53 % |
| Cumulative Operating Factor (OF) | : 84.66 % | | |

Electricity Production (net) [GWh]

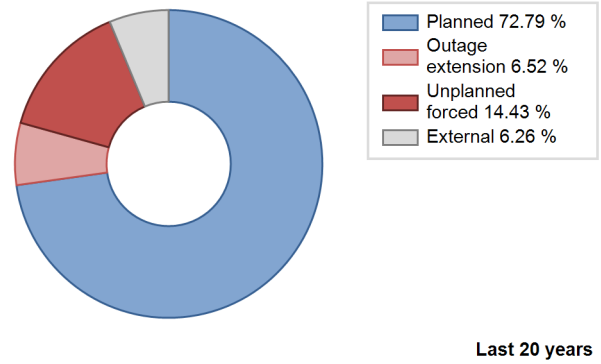
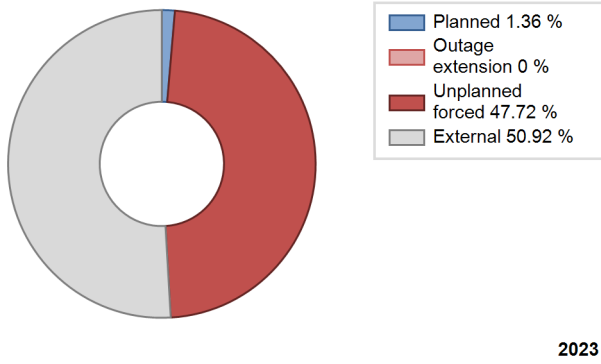


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 280.19 | 1356 | 408 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1987 | 3109.91 | 7644 | 408 | 84.32 | 86.35 | 87.01 | 87.26 | 0.46 | 0.40 | 13.25 | 2.03 |
| 1988 | 2988.88 | 7672 | 408 | 79.96 | 81.44 | 83.40 | 87.34 | 0.40 | 0.33 | 18.22 | 1.48 |
| 1989 | 2685.66 | 6678 | 408 | 71.04 | 71.39 | 75.14 | 76.23 | 1.53 | 1.11 | 27.50 | 0.35 |
| 1990 | 2981.97 | 7763 | 408 | 80.32 | 84.97 | 83.43 | 88.62 | 2.80 | 2.44 | 12.58 | 4.65 |
| 1991 | 2987.03 | 7784 | 408 | 81.28 | 81.59 | 83.57 | 88.86 | 6.94 | 6.09 | 12.33 | 0.31 |
| 1992 | 2917.94 | 6678 | 408 | 72.27 | 72.59 | 81.42 | 76.02 | 8.86 | 7.06 | 20.36 | 0.32 |
| 1993 | 3190.49 | 7259 | 452 | 80.51 | 80.51 | 80.58 | 82.87 | 3.63 | 3.03 | 16.46 | 0.00 |
| 1994 | 3343.93 | 7870 | 452 | 84.45 | 84.45 | 84.45 | 89.84 | 13.39 | 13.05 | 2.49 | 0.00 |
| 1995 | 2689.63 | 7788 | 452 | 70.02 | 87.40 | 67.93 | 88.90 | 1.70 | 1.51 | 11.08 | 17.38 |
| 1996 | 2871.23 | 7114 | 412 | 78.29 | 80.39 | 79.34 | 80.99 | 2.57 | 2.12 | 17.48 | 2.10 |
| 1997 | 2904.58 | 6774 | 440 | 74.88 | 75.46 | 75.36 | 77.33 | 2.29 | 1.77 | 22.77 | 0.57 |
| 1998 | 3090.14 | 7564 | 412 | 85.02 | 85.70 | 85.62 | 86.35 | 3.01 | 2.66 | 11.64 | 0.67 |
| 1999 | 3246.18 | 7849 | 412 | 89.28 | 89.86 | 89.94 | 89.60 | 0.39 | 0.35 | 9.79 | 0.58 |
| 2000 | 3187.89 | 7776 | 412 | 87.40 | 88.75 | 88.09 | 88.52 | 0.42 | 0.37 | 10.88 | 1.35 |
| 2001 | 3005.99 | 7309 | 412 | 82.67 | 83.78 | 83.29 | 83.44 | 0.06 | 0.05 | 16.16 | 1.12 |
| 2002 | 3259.39 | 7880 | 412 | 89.56 | 89.89 | 90.31 | 89.95 | 0.00 | 0.00 | 10.11 | 0.33 |
| 2003 | 3280.09 | 7934 | 412 | 89.83 | 90.50 | 90.88 | 90.57 | 0.03 | 0.02 | 9.47 | 0.68 |
| 2004 | 3302.47 | 7957 | 412 | 90.17 | 90.27 | 91.24 | 90.57 | 0.10 | 0.09 | 9.64 | 0.10 |
| 2005 | 2964.87 | 7034 | 427 | 79.55 | 80.00 | 80.19 | 80.30 | 0.85 | 0.68 | 19.32 | 0.45 |
| 2006 | 3396.20 | 8004 | 427 | 90.01 | 90.83 | 90.79 | 91.37 | 0.41 | 0.38 | 8.79 | 0.82 |
| 2007 | 3427.86 | 8068 | 427 | 90.90 | 91.41 | 91.64 | 92.10 | 0.49 | 0.45 | 8.13 | 0.51 |
| 2008 | 3548.84 | 8273 | 427 | 93.15 | 93.66 | 94.62 | 94.18 | 0.02 | 0.37 | 5.97 | 0.50 |
| 2009 | 2944.75 | 6688 | 468 | 73.96 | 74.69 | 73.96 | 76.35 | 0.99 | 0.80 | 24.51 | 0.74 |
| 2010 | 3283.52 | 7146 | 468 | 79.93 | 80.87 | 80.09 | 81.58 | 1.99 | 3.01 | 16.13 | 0.94 |
| 2011 | 3643.88 | 7940 | 468 | 89.03 | 89.93 | 88.88 | 90.64 | 0.60 | 1.10 | 8.97 | 0.90 |
| 2012 | 3691.31 | 8040 | 468 | 89.82 | 91.09 | 89.79 | 91.53 | 0.07 | 0.06 | 8.84 | 1.28 |
| 2013 | 3542.84 | 7714 | 468 | 86.36 | 87.37 | 86.42 | 88.06 | 0.31 | 0.68 | 11.95 | 1.01 |
| 2014 | 3500.03 | 7639 | 468 | 85.15 | 86.61 | 85.37 | 87.20 | 5.52 | 5.81 | 7.59 | 1.46 |
| 2015 | 2673.32 | 5870 | 468 | 65.48 | 66.71 | 65.21 | 67.01 | 29.23 | 27.65 | 5.64 | 1.23 |
| 2016 | 2336.18 | 5021 | 468 | 56.57 | 56.75 | 56.83 | 57.16 | 0.01 | 0.01 | 43.24 | 0.18 |
| 2017 | 2813.49 | 6072 | 468 | 68.37 | 68.86 | 68.63 | 69.32 | 0.07 | 1.68 | 29.47 | 0.48 |
| 2018 | 3630.68 | 7947 | 468 | 88.45 | 90.37 | 88.56 | 90.72 | 3.09 | 2.88 | 6.75 | 1.92 |
| 2019 | 3521.99 | 7691 | 468 | 85.94 | 87.65 | 85.91 | 87.80 | 0.04 | 3.86 | 8.49 | 1.71 |
| 2020 | 2919.55 | 6452 | 468 | 70.76 | 72.50 | 71.02 | 73.45 | 5.75 | 16.72 | 10.78 | 1.74 |
| 2021 | 3387.51 | 7412 | 468 | 82.32 | 83.75 | 82.63 | 84.61 | 3.91 | 4.76 | 11.49 | 1.43 |
| 2022 | 3477.43 | 7638 | 468 | 84.35 | 86.76 | 84.83 | 87.20 | 0.00 | 0.00 | 13.24 | 2.41 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 123 | | | 114 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1007 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 33 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 102 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 97 | |
| Z. Other | | | | | 5 | |
| Subtotal | | 123 | | 1142 | 216 | 3 |
| Total | | 123 | | | 1361 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1986 to 2023 | |
|--|------------|--|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 1 |
| 12. Reactor I&C Systems | | | | 7 |
| 13. Reactor Auxiliary Systems | | | | 1 |
| 14. Safety Systems | | | | 10 |
| 15. Reactor Cooling Systems | | | | 44 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 0 |
| 31. Turbine and auxiliaries | | | | 2 |
| 32. Feedwater and Main Steam System | | | | 14 |
| 33. Circulating Water System | | | | 8 |
| 35. All other I&C Systems | | | | 0 |
| 41. Main Generator Systems | | | 123 | 25 |
| 42. Electrical Power Supply Systems | | | | 3 |
| Total | | | 123 | 115 |

2023 Operating Experience

CZ-9

DUKOVANY-4

CZECH REPUBLIC

Status at end of year : **Operational**
 Operator : CEZ (CZECH POWER Co., CEZ a.s.)
 Owner : CEZ (CZECH POWER Co., CEZ a.s.)
 Reactor Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1444 MWth
 Gross electrical power : 500 MWe
 Reference unit power (net) : 471 MWe

Key Dates

Construction Date : 1979-03-01
 Grid Date : 1987-06-11
 Commercial Date : 1987-07-19
 Age at end of year : 36 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.3
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 20
 Average discharge burnup [MWd/t] : 44000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.26
 Reactor outlet temperature [°C] : 297
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.15

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.3
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

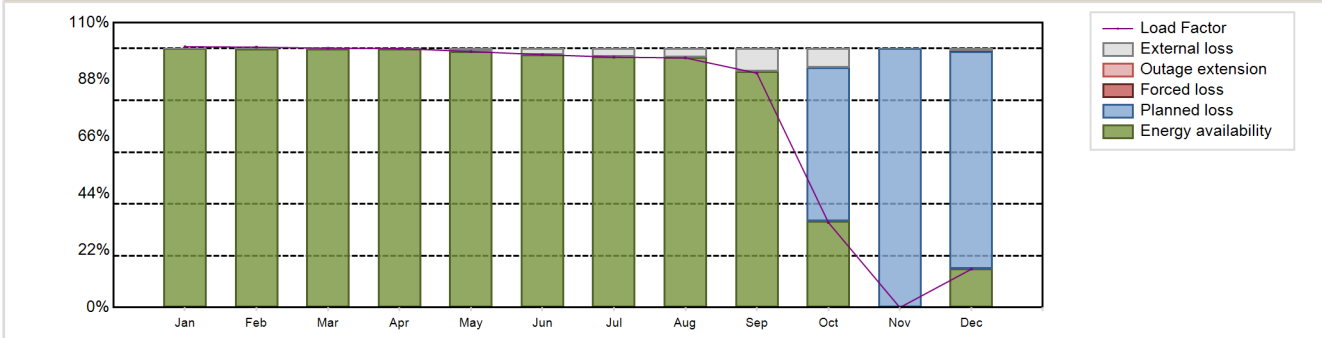
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3189.39 GW(e).h
 Energy Availability Factor (EAF) : 77.31 %
 Unit Capability Factor (UCF) : 79.59 %
 Load Factor (LF) : 77.3 %
 Operating Factor (OF) : 79.91 %
 Forced Loss Rate (FLR) : 0.01 %
 Unplanned Capability Loss Factor (UCL) : 0.01 %
 Planned Unavailability Factor (PUF) : 20.4 %
 Externally cause unavailability (XUF) : 2.28 %
 Total off-line time : 1760 hours

Annual Summary

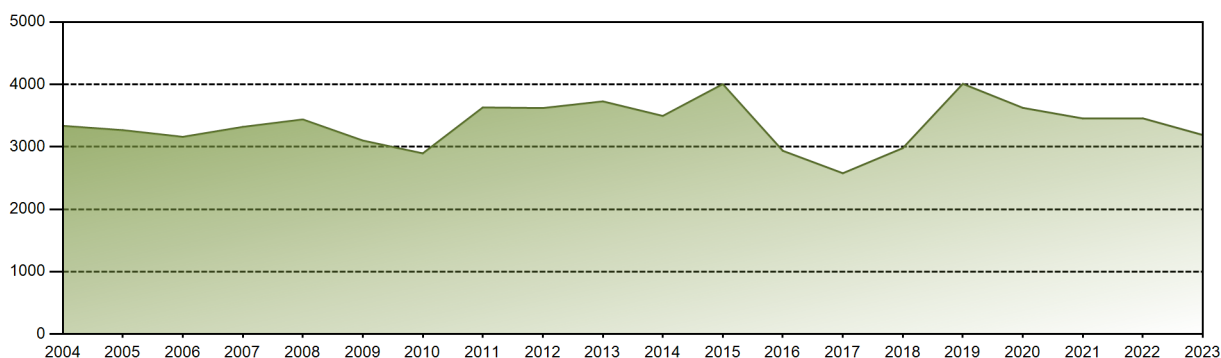


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|---------|
| GW(e)-h | 352.94 | 318.28 | 350.90 | 339.25 | 346.37 | 331.14 | 338.77 | 337.83 | 306.96 | 115.07 | 0.00 | 51.88 | 3189.39 |
| EAF [%] | 100.00 | 99.95 | 99.83 | 99.77 | 98.85 | 97.70 | 96.80 | 96.75 | 91.26 | 33.24 | 0.00 | 15.09 | 77.31 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 40.48 | 0.00 | 16.01 | 79.59 |
| LF [%] | 100.72 | 100.56 | 100.14 | 100.04 | 98.84 | 97.65 | 96.67 | 96.41 | 90.52 | 32.84 | 0.00 | 14.80 | 77.30 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 41.13 | 0.00 | 19.09 | 79.91 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.57 | 0.01 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.01 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 59.52 | 100.00 | 83.90 | 20.40 |
| XUF [%] | 0.00 | 0.05 | 0.17 | 0.23 | 1.15 | 2.30 | 3.20 | 3.25 | 8.74 | 7.24 | 0.00 | 0.92 | 2.28 |

Historical Summary

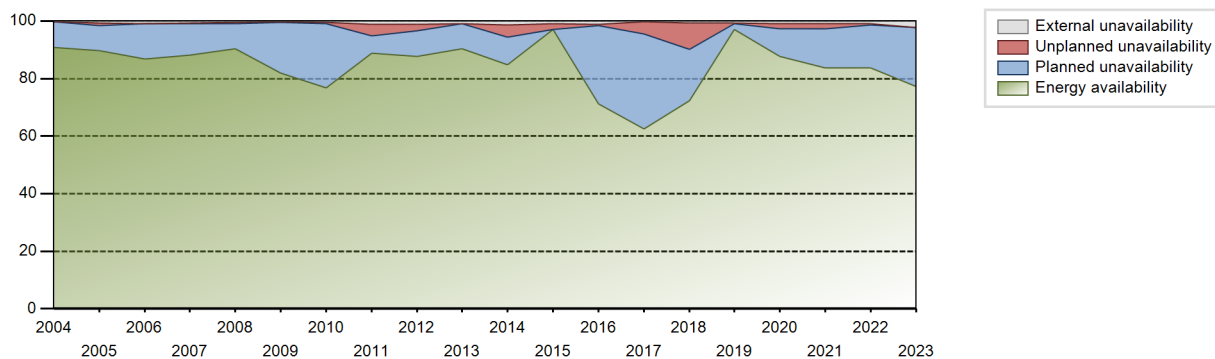
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 117499.32 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.01 % |
| Cumulative Energy Availability Factor (EAF) | : 83.37 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.91 % |
| Cumulative Unit Capability Factor (UCF) | : 84.3 % | Cumulative Planned Unavailability Factor (PUF) | : 13.79 % |
| Cumulative Load Factor (LF) | : 84.41 % | Cumulative Externally cause unavailability (XUF) | : 0.93 % |
| Cumulative Operating Factor (OF) | : 85.85 % | | |

Electricity Production (net) [GWh]

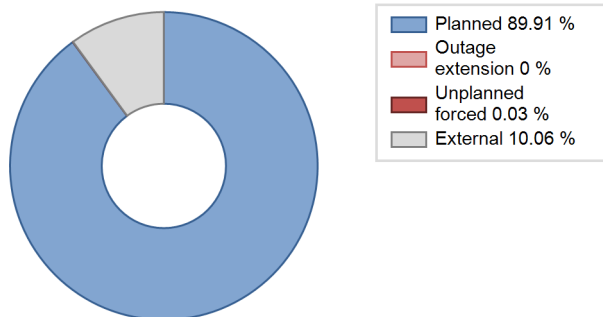


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 1624.94 | 4643 | 408 | 97.85 | 99.92 | 90.09 | 94.34 | 0.08 | 0.08 | 0.00 | 2.08 |
| 1988 | 2764.01 | 7092 | 408 | 73.78 | 74.45 | 77.12 | 80.74 | 3.05 | 2.34 | 23.20 | 0.67 |
| 1989 | 2984.55 | 7314 | 408 | 80.41 | 80.81 | 83.51 | 83.49 | 0.54 | 0.44 | 18.74 | 0.41 |
| 1990 | 2995.30 | 7836 | 408 | 79.96 | 82.75 | 83.81 | 89.45 | 2.21 | 1.87 | 15.38 | 2.79 |
| 1991 | 2671.99 | 7301 | 408 | 77.93 | 78.03 | 74.76 | 83.34 | 4.57 | 3.74 | 18.23 | 0.10 |
| 1992 | 3328.41 | 7614 | 408 | 83.66 | 84.48 | 92.87 | 86.68 | 2.81 | 2.45 | 13.07 | 0.82 |
| 1993 | 2939.81 | 6859 | 448 | 62.05 | 62.05 | 74.91 | 78.30 | 21.40 | 16.90 | 21.05 | 0.00 |
| 1994 | 3259.81 | 7538 | 448 | 83.06 | 84.51 | 83.06 | 86.05 | 2.85 | 2.48 | 13.01 | 1.45 |
| 1995 | 3311.14 | 7712 | 448 | 85.35 | 85.46 | 84.37 | 88.04 | 3.74 | 3.32 | 11.23 | 0.11 |
| 1996 | 3202.13 | 7762 | 412 | 87.13 | 88.19 | 88.48 | 88.37 | 0.18 | 0.16 | 11.64 | 1.06 |
| 1997 | 3149.15 | 7202 | 440 | 80.89 | 80.89 | 81.70 | 82.21 | 0.50 | 0.41 | 18.70 | 0.00 |
| 1998 | 3078.56 | 7536 | 412 | 83.85 | 85.66 | 85.30 | 86.03 | 0.28 | 0.24 | 14.09 | 1.81 |
| 1999 | 3179.42 | 7792 | 412 | 86.60 | 88.64 | 88.09 | 88.95 | 0.18 | 0.16 | 11.20 | 2.04 |
| 2000 | 3234.52 | 7839 | 412 | 88.12 | 89.46 | 89.38 | 89.24 | 0.10 | 0.09 | 10.45 | 1.34 |
| 2001 | 3258.06 | 7946 | 412 | 89.25 | 90.40 | 90.27 | 90.71 | 0.24 | 0.21 | 9.39 | 1.15 |
| 2002 | 2748.24 | 6745 | 412 | 75.57 | 77.29 | 76.15 | 77.00 | 0.04 | 0.03 | 22.68 | 1.72 |
| 2003 | 3309.80 | 8009 | 412 | 90.66 | 91.35 | 91.71 | 91.43 | 0.02 | 0.02 | 8.63 | 0.70 |
| 2004 | 3335.38 | 8029 | 412 | 90.87 | 91.09 | 92.16 | 91.40 | 0.06 | 0.06 | 8.85 | 0.23 |
| 2005 | 3267.00 | 8008 | 412 | 89.62 | 90.27 | 90.52 | 91.42 | 0.98 | 0.89 | 8.83 | 0.66 |
| 2006 | 3159.49 | 7704 | 412 | 86.92 | 87.79 | 87.54 | 87.95 | 0.16 | 0.14 | 12.07 | 0.88 |
| 2007 | 3318.99 | 7854 | 427 | 88.05 | 88.70 | 88.73 | 89.66 | 0.37 | 0.33 | 10.96 | 0.65 |
| 2008 | 3438.67 | 8010 | 427 | 90.35 | 90.74 | 91.68 | 91.19 | 0.62 | 0.56 | 8.70 | 0.39 |
| 2009 | 3100.50 | 7247 | 427 | 81.82 | 81.99 | 82.89 | 82.73 | 0.31 | 0.25 | 17.75 | 0.18 |
| 2010 | 2895.11 | 6846 | 427 | 76.74 | 77.31 | 77.40 | 78.15 | 0.32 | 0.24 | 22.44 | 0.57 |
| 2011 | 3630.71 | 8001 | 471 | 88.78 | 89.87 | 88.00 | 91.34 | 4.28 | 4.02 | 6.11 | 1.09 |
| 2012 | 3620.96 | 7850 | 471 | 87.65 | 88.75 | 87.52 | 89.37 | 0.14 | 2.37 | 8.87 | 1.11 |
| 2013 | 3727.91 | 8009 | 471 | 90.45 | 91.36 | 90.35 | 91.43 | 0.00 | 0.00 | 8.63 | 0.91 |
| 2014 | 3494.80 | 7591 | 471 | 84.79 | 86.06 | 84.70 | 86.66 | 4.68 | 4.23 | 9.71 | 1.27 |
| 2015 | 4004.79 | 8623 | 471 | 97.05 | 98.00 | 97.06 | 98.44 | 1.89 | 1.89 | 0.11 | 0.96 |
| 2016 | 2936.27 | 6423 | 471 | 71.26 | 72.43 | 70.97 | 73.12 | 0.44 | 0.32 | 27.25 | 1.17 |
| 2017 | 2576.88 | 5542 | 471 | 62.47 | 62.75 | 62.46 | 63.26 | 6.37 | 4.27 | 32.98 | 0.28 |
| 2018 | 2979.28 | 6498 | 471 | 72.22 | 72.99 | 72.22 | 74.19 | 10.97 | 8.99 | 18.01 | 0.77 |
| 2019 | 4009.33 | 8576 | 471 | 96.97 | 97.73 | 97.17 | 97.90 | 0.21 | 0.20 | 2.07 | 0.76 |
| 2020 | 3624.27 | 7800 | 471 | 87.66 | 88.53 | 87.60 | 88.80 | 0.00 | 1.73 | 9.73 | 0.88 |
| 2021 | 3454.30 | 7452 | 471 | 83.80 | 84.65 | 83.72 | 85.07 | 0.02 | 1.93 | 13.42 | 0.85 |
| 2022 | 3456.36 | 7454 | 471 | 83.78 | 84.76 | 83.77 | 85.09 | 0.00 | 0.32 | 14.92 | 0.99 |
| 2023 | 3189.39 | 7000 | 471 | 77.31 | 79.59 | 77.30 | 79.91 | 0.01 | 0.01 | 20.40 | 2.28 |

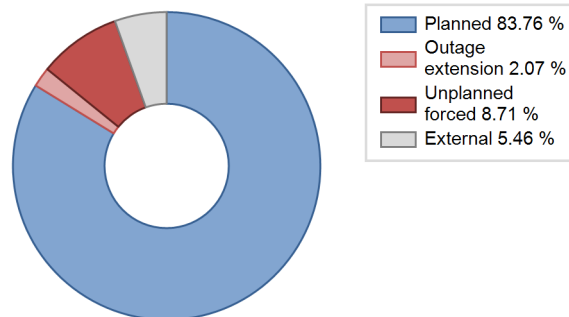
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 71 | |
| C. Inspection, maintenance or repair combined with refuelling | 1760 | | | 1006 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 51 | | |
| E. Testing of plant systems or components | | | | | 4 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 65 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 3 |
| L. Human factor related | | | | | 7 | |
| Subtotal | 1760 | | | 1122 | 82 | 6 |
| Total | | 1760 | | | 1210 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 4 |
| 14. Safety Systems | | 5 |
| 15. Reactor Cooling Systems | | 11 |
| 16. Steam generation systems | | 18 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 10 |
| 32. Feedwater and Main Steam System | | 16 |
| 33. Circulating Water System | | 10 |
| 35. All other I&C Systems | | 1 |
| 42. Electrical Power Supply Systems | | 1 |
| Total | | 76 |

2023 Operating Experience

CZ-23

TEMELIN-1

CZECH REPUBLIC

Status at end of year : **Operational**
 Operator : CEZ (CZECH POWER Co., CEZ a.s.)
 Owner : CEZ (CZECH POWER Co., CEZ a.s.)
 Reactor Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : PWR / VVER V-320
 Thermal power : 3120 MWth
 Gross electrical power : 1082 MWe
 Reference unit power (net) : 1027 MWe

Key Dates

Construction Date : 1987-02-01
 Grid Date : 2000-12-21
 Commercial Date : 2002-06-10
 Age at end of year : 23 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.6
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 25.7
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 3.16
 Active core height/length [m] : 3.63
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : 16.3
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 318
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 0.46

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.2
 Output voltage [kV] : 24
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

Non-electrical applications

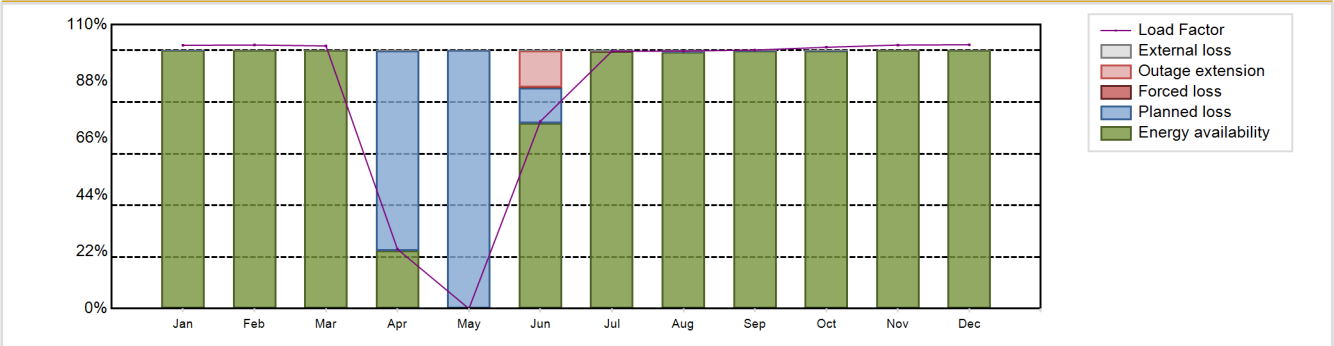
Non-electrical applications : DH

Annual Production Results (2023)

Net Energy Production : 7542.49 GW(e).h
 Energy Availability Factor (EAF) : 82.71 %
 Unit Capability Factor (UCF) : 82.82 %
 Load Factor (LF) : 83.84 %
 Operating Factor (OF) : 83.14 %
 Equivalent non-electrical energy generated (NEG) : 4.72 GW(e).h

Forced Loss Rate (FLR) : 0.02 %
 Unplanned Capability Loss Factor (UCL) : 1.18 %
 Planned Unavailability Factor (PUF) : 16 %
 Externally cause unavailability (XUF) : 0.11 %
 Total off-line time : 1477 hours

Annual Summary

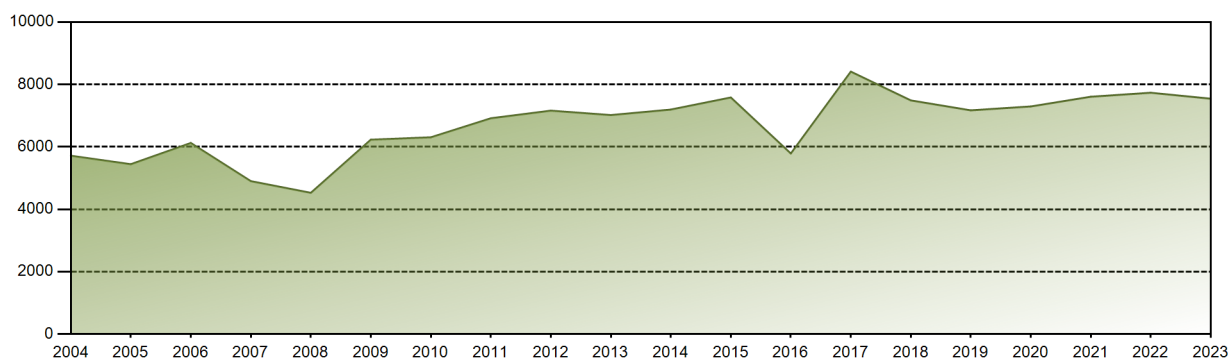


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 779.32 | 704.62 | 777.43 | 170.31 | 0.00 | 536.56 | 761.93 | 762.27 | 740.56 | 773.58 | 754.93 | 780.98 | 7542.49 |
| EAF [%] | 99.99 | 100.00 | 100.00 | 22.52 | 0.00 | 71.79 | 99.54 | 99.41 | 99.82 | 99.93 | 100.00 | 100.00 | 82.71 |
| UCF [%] | 99.99 | 100.00 | 100.00 | 22.54 | 0.00 | 71.96 | 99.94 | 99.96 | 99.98 | 99.96 | 100.00 | 100.00 | 82.82 |
| LF [%] | 101.99 | 102.10 | 101.75 | 23.03 | 0.00 | 72.56 | 99.72 | 99.76 | 100.15 | 101.24 | 102.09 | 102.21 | 83.84 |
| OF [%] | 100.00 | 100.00 | 100.00 | 23.33 | 0.00 | 74.86 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 83.14 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.18 |
| PUF [%] | 0.01 | 0.00 | 0.00 | 77.46 | 100.00 | 13.71 | 0.06 | 0.04 | 0.02 | 0.04 | 0.00 | 0.00 | 16.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.17 | 0.40 | 0.56 | 0.15 | 0.03 | 0.00 | 0.00 | 0.11 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 146131.16 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.05 % |
| Cumulative Energy Availability Factor (EAF) | : 76.55 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.77 % |
| Cumulative Unit Capability Factor (UCF) | : 76.8 % | Cumulative Planned Unavailability Factor (PUF) | : 18.43 % |
| Cumulative Load Factor (LF) | : 76.91 % | Cumulative Externally cause unavailability (XUF) | : 0.26 % |
| Cumulative Operating Factor (OF) | : 77.22 % | | |

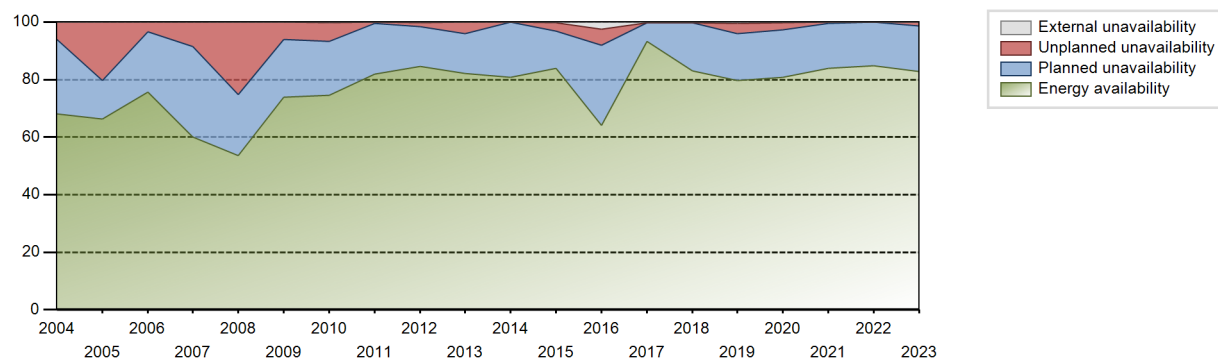
Electricity Production (net) [GWh]



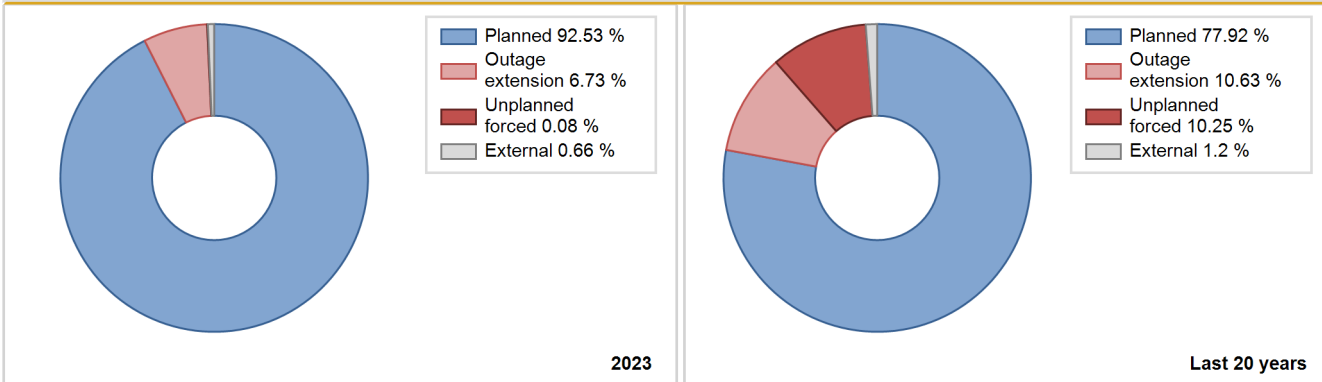
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2002 | 5147.87 | 5961 | 930 | 76.06 | 76.06 | 76.96 | 82.42 | 5.17 | 4.15 | 19.80 | 0.00 |
| 2003 | 5455.32 | 5861 | 912 | 65.30 | 65.30 | 68.28 | 66.91 | 4.15 | 4.71 | 29.99 | 0.00 |
| 2004 | 5715.82 | 6029 | 950 | 68.01 | 68.09 | 68.50 | 68.64 | 7.98 | 6.07 | 25.84 | 0.08 |
| 2005 | 5443.97 | 5846 | 950 | 66.30 | 66.33 | 66.35 | 66.74 | 16.34 | 20.25 | 13.42 | 0.03 |
| 2006 | 6124.86 | 6731 | 930 | 75.68 | 75.69 | 75.18 | 76.84 | 4.39 | 3.48 | 20.83 | 0.01 |
| 2007 | 4901.35 | 5282 | 963 | 60.02 | 60.02 | 59.63 | 60.30 | 4.05 | 8.54 | 31.44 | 0.01 |
| 2008 | 4526.45 | 4745 | 963 | 53.50 | 53.57 | 53.51 | 54.02 | 11.75 | 25.06 | 21.36 | 0.07 |
| 2009 | 6229.78 | 6527 | 963 | 73.81 | 73.88 | 73.85 | 74.51 | 4.22 | 6.00 | 20.12 | 0.07 |
| 2010 | 6305.63 | 6594 | 963 | 74.50 | 74.83 | 74.75 | 75.27 | 0.65 | 6.49 | 18.68 | 0.33 |
| 2011 | 6915.59 | 7205 | 963 | 81.80 | 81.82 | 81.98 | 82.25 | 0.53 | 0.44 | 17.75 | 0.02 |
| 2012 | 7159.77 | 7515 | 963 | 84.68 | 84.99 | 84.64 | 85.55 | 1.59 | 1.38 | 13.63 | 0.31 |
| 2013 | 7018.65 | 7252 | 1003 | 82.22 | 82.26 | 82.06 | 82.79 | 1.18 | 4.07 | 13.68 | 0.04 |
| 2014 | 7194.59 | 7092 | 1023 | 80.85 | 80.85 | 81.34 | 80.96 | 0.02 | 0.10 | 19.04 | 0.01 |
| 2015 | 7581.24 | 7400 | 1026 | 83.88 | 84.22 | 84.35 | 84.47 | 3.28 | 2.86 | 12.92 | 0.34 |
| 2016 | 5786.94 | 5868 | 1026 | 64.07 | 66.48 | 64.21 | 66.80 | 0.59 | 5.72 | 27.79 | 2.42 |
| 2017 | 8410.14 | 8205 | 1026 | 93.27 | 93.60 | 93.57 | 93.66 | 0.03 | 0.02 | 6.37 | 0.33 |
| 2018 | 7487.60 | 7321 | 1027 | 83.11 | 83.34 | 83.24 | 83.57 | 0.11 | 0.09 | 16.57 | 0.23 |
| 2019 | 7169.40 | 7088 | 1027 | 79.65 | 80.21 | 79.69 | 80.91 | 4.17 | 3.49 | 16.30 | 0.56 |
| 2020 | 7294.10 | 7178 | 1027 | 80.89 | 81.08 | 80.86 | 81.72 | 3.08 | 2.58 | 16.34 | 0.19 |
| 2021 | 7605.99 | 7403 | 1027 | 83.92 | 84.02 | 84.54 | 84.51 | 0.25 | 0.33 | 15.65 | 0.10 |
| 2022 | 7733.58 | 7459 | 1027 | 84.84 | 84.93 | 85.96 | 85.15 | 0.04 | 0.04 | 15.03 | 0.10 |
| 2023 | 7542.49 | 7283 | 1027 | 82.71 | 82.82 | 83.84 | 83.14 | 0.02 | 1.18 | 16.00 | 0.11 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2002 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 102 | | | 401 | |
| C. Inspection, maintenance or repair combined with refuelling | 1375 | | | 1378 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 49 | | |
| E. Testing of plant systems or components | | | | 29 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 112 | | |
| L. Human factor related | | | | | 71 | |
| M. Governmental requirements or court decisions | | | | | 31 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 62 | | |
| Subtotal | 1375 | 102 | | 1630 | 504 | |
| Total | | 1477 | | | 2134 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2002 to 2023 | |
|-------------------------------------|------------|-----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 59 |
| 12. Reactor I&C Systems | | | | 14 |
| 15. Reactor Cooling Systems | | 102 | | 72 |
| 16. Steam generation systems | | | | 10 |
| 31. Turbine and auxiliaries | | | | 165 |
| 32. Feedwater and Main Steam System | | | | 28 |
| 33. Circulating Water System | | | | 2 |
| 41. Main Generator Systems | | | | 49 |
| 42. Electrical Power Supply Systems | | | | 1 |
| Total | | 102 | | 400 |

Highlights (2023)

The Temelín Nuclear Power Plant will enter the final phase of approval of an extension of the outage cycle to 18 months. CEZ put into trial operation the third longest hot water piping in Czechia, connecting the Temelín Nuclear Power Plant and the regional city of České Budějovice; the expected annual supply of 750 TJ of emission-free heat corresponds to approximately one-third of the city's heat consumption and should be available for at least 20 years.

2023 Operating Experience

CZ-24

TEMELIN-2

CZECH REPUBLIC

Status at end of year : **Operational**
 Operator : CEZ (CZECH POWER Co., CEZ a.s.)
 Owner : CEZ (CZECH POWER Co., CEZ a.s.)
 Reactor Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : PWR / VVER V-320
 Thermal power : 3120 MWth
 Gross electrical power : 1082 MWe
 Reference unit power (net) : 1029 MWe

Key Dates

Construction Date : 1987-02-01
 Grid Date : 2002-12-29
 Commercial Date : 2003-04-18
 Age at end of year : 21 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.6
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 25.7
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 3.16
 Active core height/length [m] : 3.63
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : 16.3
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 318
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 0.46

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.2
 Output voltage [kV] : 24
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

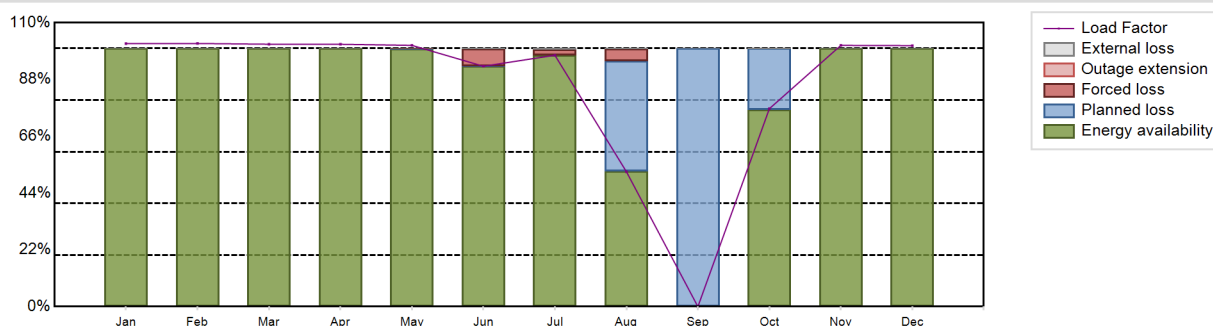
Non-electrical applications : DH

Annual Production Results (2023)

Net Energy Production : 7736.61 GW(e).h
 Energy Availability Factor (EAF) : 84.93 %
 Unit Capability Factor (UCF) : 84.98 %
 Load Factor (LF) : 85.83 %
 Operating Factor (OF) : 85.32 %
 Equivalent non-electrical energy generated (NEG) : 58.27 GW(e).h

Forced Loss Rate (FLR) : 1.36 %
 Unplanned Capability Loss Factor (UCL) : 1.17 %
 Planned Unavailability Factor (PUF) : 13.84 %
 Externally cause unavailability (XUF) : 0.05 %
 Total off-line time : 1286 hours

Annual Summary

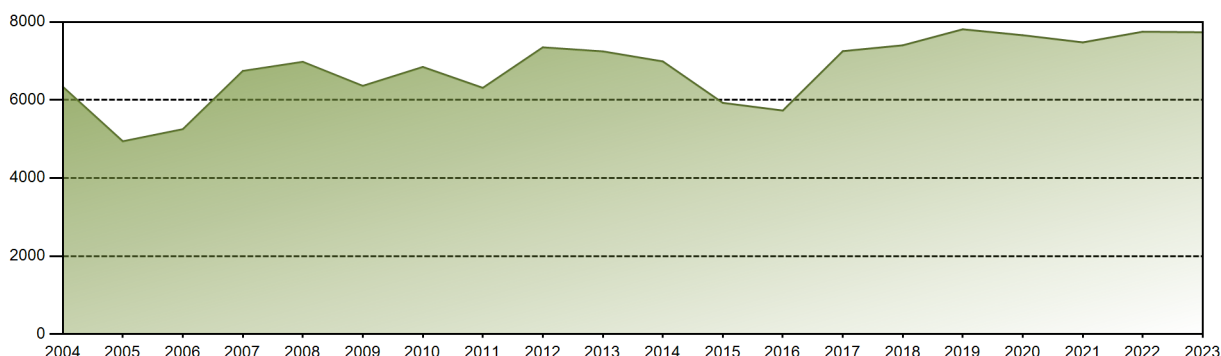


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 779.81 | 704.76 | 778.22 | 752.91 | 774.75 | 689.80 | 745.43 | 400.20 | 0.00 | 587.04 | 749.70 | 773.99 | 7736.61 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.95 | 93.05 | 97.26 | 52.55 | 0.00 | 76.33 | 100.00 | 100.00 | 84.93 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.95 | 93.21 | 97.57 | 52.70 | 0.00 | 76.33 | 100.00 | 100.00 | 84.98 |
| LF [%] | 101.86 | 101.92 | 101.65 | 101.62 | 101.20 | 93.11 | 97.37 | 52.27 | 0.00 | 76.68 | 101.19 | 101.10 | 85.83 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.17 | 98.25 | 53.49 | 0.00 | 77.82 | 100.00 | 100.00 | 85.32 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 6.76 | 2.43 | 8.31 | 0.00 | 0.00 | 0.00 | 0.00 | 1.36 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 6.76 | 2.43 | 4.78 | 0.00 | 0.00 | 0.00 | 0.00 | 1.17 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | 0.00 | 42.52 | 100.00 | 23.67 | 0.00 | 0.00 | 13.84 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.30 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 142140.68 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.44 % |
| Cumulative Energy Availability Factor (EAF) | : 78.55 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.72 % |
| Cumulative Unit Capability Factor (UCF) | : 78.74 % | Cumulative Planned Unavailability Factor (PUF) | : 16.54 % |
| Cumulative Load Factor (LF) | : 78.99 % | Cumulative Externally cause unavailability (XUF) | : 0.19 % |
| Cumulative Operating Factor (OF) | : 79.16 % | | |

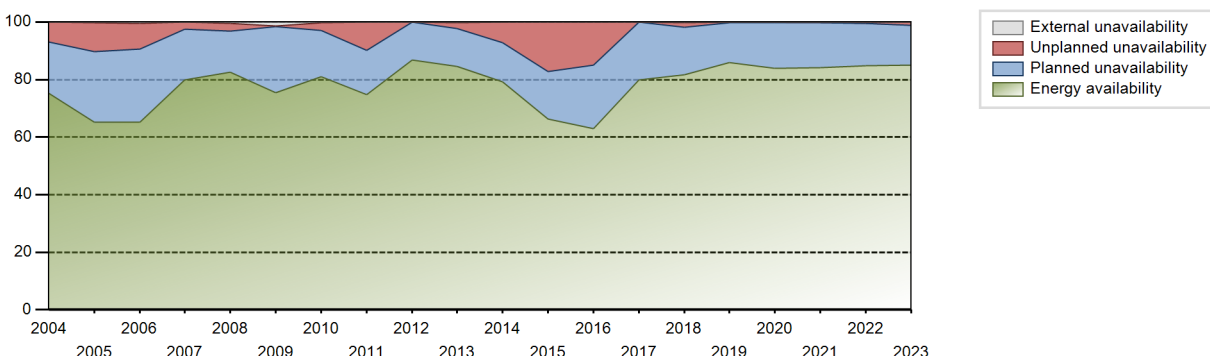
Electricity Production (net) [GWh]



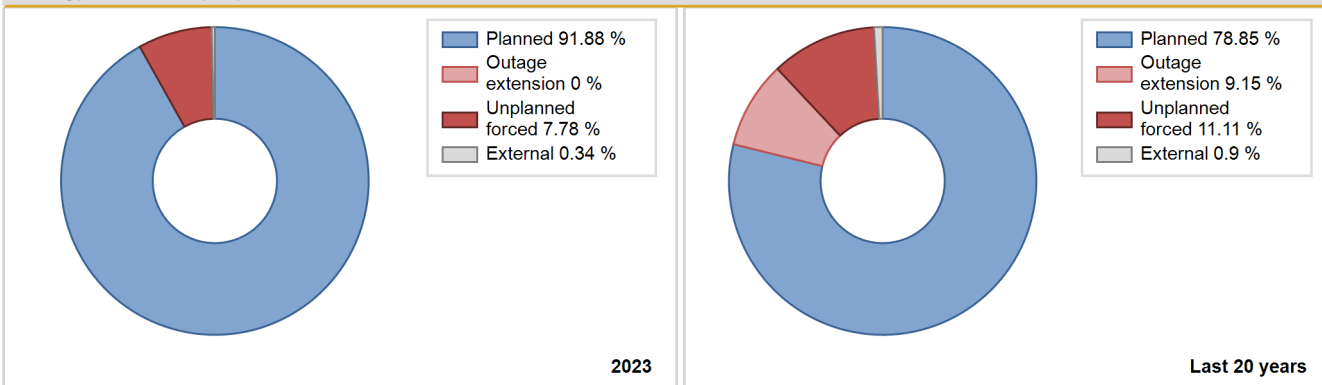
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2003 | 6033.03 | 6934 | 930 | 84.23 | 84.23 | 86.59 | 86.52 | 15.60 | 15.57 | 0.21 | 0.00 |
| 2004 | 6340.09 | 6678 | 950 | 75.22 | 75.22 | 75.98 | 76.02 | 8.49 | 6.98 | 17.80 | 0.00 |
| 2005 | 4941.36 | 6135 | 780 | 65.10 | 65.25 | 65.27 | 70.03 | 6.34 | 10.21 | 24.54 | 0.15 |
| 2006 | 5251.85 | 5765 | 930 | 65.28 | 65.82 | 65.36 | 65.81 | 3.01 | 8.85 | 25.33 | 0.54 |
| 2007 | 6745.10 | 7051 | 963 | 79.93 | 80.05 | 80.50 | 80.49 | 0.85 | 2.44 | 17.50 | 0.12 |
| 2008 | 6978.75 | 7420 | 963 | 82.65 | 83.23 | 82.50 | 84.47 | 3.05 | 2.62 | 14.15 | 0.58 |
| 2009 | 6363.18 | 6756 | 963 | 75.39 | 76.80 | 75.43 | 77.12 | 0.25 | 0.19 | 23.00 | 1.41 |
| 2010 | 6847.34 | 7135 | 963 | 80.95 | 81.10 | 81.18 | 81.46 | 1.55 | 2.78 | 16.12 | 0.15 |
| 2011 | 6311.62 | 6589 | 963 | 74.77 | 74.85 | 74.82 | 75.22 | 3.32 | 9.69 | 15.46 | 0.08 |
| 2012 | 7349.91 | 7656 | 963 | 86.84 | 86.91 | 86.89 | 87.16 | 0.05 | 0.05 | 13.05 | 0.06 |
| 2013 | 7246.82 | 7448 | 1003 | 84.48 | 84.79 | 84.43 | 85.02 | 1.06 | 1.92 | 13.29 | 0.31 |
| 2014 | 6989.25 | 6980 | 1003 | 79.32 | 79.33 | 79.55 | 79.68 | 8.27 | 7.15 | 13.52 | 0.01 |
| 2015 | 5926.47 | 5813 | 1026 | 66.23 | 66.24 | 66.84 | 66.36 | 7.35 | 17.25 | 16.51 | 0.00 |
| 2016 | 5730.12 | 5617 | 1026 | 62.87 | 62.87 | 63.58 | 63.95 | 14.72 | 14.93 | 22.20 | 0.00 |
| 2017 | 7252.35 | 7024 | 1026 | 79.85 | 79.87 | 80.69 | 80.18 | 0.08 | 0.06 | 20.07 | 0.01 |
| 2018 | 7402.41 | 7208 | 1027 | 81.65 | 82.00 | 82.34 | 82.29 | 1.30 | 1.37 | 16.63 | 0.35 |
| 2019 | 7813.14 | 7555 | 1027 | 85.98 | 86.04 | 86.85 | 86.24 | 0.16 | 0.13 | 13.82 | 0.06 |
| 2020 | 7660.96 | 7398 | 1029 | 83.98 | 84.03 | 84.89 | 84.22 | 0.02 | 0.19 | 15.78 | 0.05 |
| 2021 | 7477.64 | 7198 | 1029 | 84.18 | 84.19 | 82.96 | 82.17 | 0.34 | 0.29 | 15.52 | 0.02 |
| 2022 | 7751.47 | 7455 | 1029 | 84.84 | 84.86 | 85.99 | 85.10 | 0.63 | 0.54 | 14.60 | 0.03 |
| 2023 | 7736.61 | 7474 | 1029 | 84.93 | 84.98 | 85.83 | 85.32 | 1.36 | 1.17 | 13.84 | 0.05 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2003 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 86 | | | 378 | |
| C. Inspection, maintenance or repair combined with refuelling | 1200 | | | 1287 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 44 | | |
| E. Testing of plant systems or components | | | | 19 | 3 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 93 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 11 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 45 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Subtotal | 1200 | 86 | | 1443 | 426 | 12 |
| Total | | 1286 | | | 1881 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2003 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 80 |
| 12. Reactor I&C Systems | | 9 |
| 13. Reactor Auxiliary Systems | | 14 |
| 15. Reactor Cooling Systems | | 17 |
| 16. Steam generation systems | | 66 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | 86 | 98 |
| 32. Feedwater and Main Steam System | | 21 |
| 33. Circulating Water System | | 7 |
| 35. All other I&C Systems | | 28 |
| 41. Main Generator Systems | | 30 |
| 42. Electrical Power Supply Systems | | 25 |
| Total | 86 | 397 |

2023 Operating Experience

FI-1

LOVIISA-1

FINLAND

Status at end of year : **Operational**
 Operator : FORTUMPH (FORTUM POWER AND HEAT OY (former IVO))
 Owner : FORTUMPH (FORTUM POWER AND HEAT OY (former IVO))
 Reactor Supplier : AEE (ATOMENERGOEXPORT)
 Turbine Supplier : AEE (ATOMENERGOEXPORT)



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1500 MWth
 Gross electrical power : 531 MWe
 Reference unit power (net) : 507 MWe

Key Dates

Construction Date : 1971-05-01
 Grid Date : 1977-02-08
 Commercial Date : 1977-05-09
 Age at end of year : 46 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.3
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 2.73
 Active core height/length [m] : 2.42
 Number of fissile fuel assemblies/bundles : 313
 Fuel linear heat generation rate [kW/m] : 15.6
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.25
 Reactor outlet temperature [°C] : 301
 Number of SG : 6
 Containment type : Single
 Containment design pressure [MPa] : 0.07

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.4
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 4

Non-electrical applications

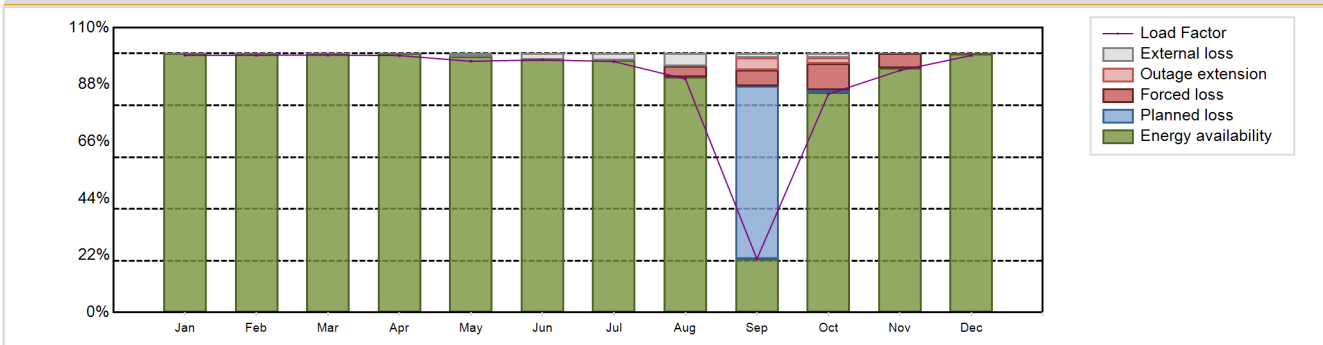
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3987.98 GW(e).h
 Energy Availability Factor (EAF) : 90.47 %
 Unit Capability Factor (UCF) : 91.65 %
 Load Factor (LF) : 89.79 %
 Operating Factor (OF) : 93.61 %

Forced Loss Rate (FLR) : 2.34 %
 Unplanned Capability Loss Factor (UCL) : 2.79 %
 Planned Unavailability Factor (PUF) : 5.56 %
 Externally cause unavailability (XUF) : 1.18 %
 Total off-line time : 560 hours

Annual Summary

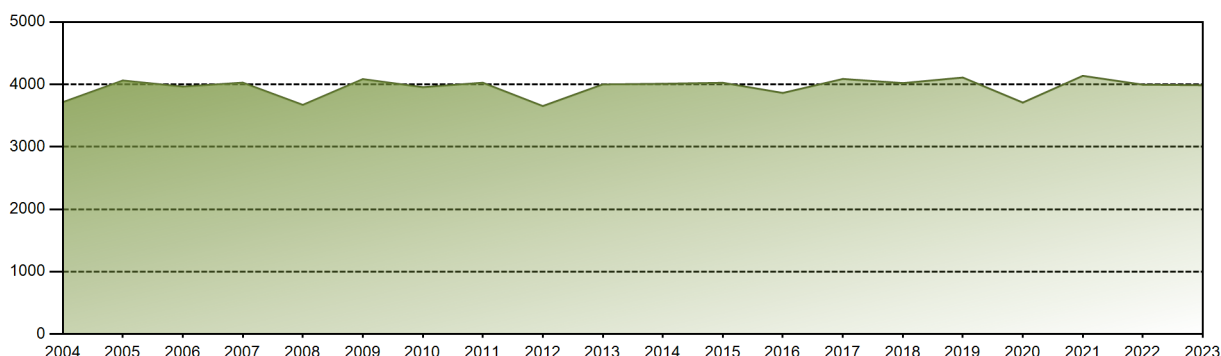


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|---------|
| GW(e)-h | 374.87 | 338.54 | 374.50 | 362.24 | 365.97 | 356.32 | 365.57 | 340.27 | 75.40 | 318.62 | 341.23 | 374.45 | 3987.99 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 98.81 | 97.61 | 97.50 | 91.04 | 20.65 | 85.01 | 94.43 | 99.92 | 90.47 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.86 | 22.17 | 86.57 | 94.43 | 99.92 | 91.65 |
| LF [%] | 99.38 | 99.36 | 99.42 | 99.23 | 97.02 | 97.61 | 96.91 | 90.21 | 20.65 | 84.35 | 93.48 | 99.27 | 89.79 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 28.47 | 97.72 | 96.11 | 100.00 | 93.61 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.14 | 21.67 | 10.64 | 5.57 | 0.08 | 2.34 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.14 | 10.99 | 12.59 | 5.57 | 0.08 | 2.79 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 66.83 | 0.85 | 0.00 | 0.00 | 5.56 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.19 | 2.39 | 2.50 | 4.82 | 1.52 | 1.56 | 0.00 | 0.00 | 1.18 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 169621.16 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.39 % |
| Cumulative Energy Availability Factor (EAF) | : 88.12 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.62 % |
| Cumulative Unit Capability Factor (UCF) | : 88.76 % | Cumulative Planned Unavailability Factor (PUF) | : 8.62 % |
| Cumulative Load Factor (LF) | : 87.87 % | Cumulative Externally cause unavailability (XUF) | : 0.64 % |
| Cumulative Operating Factor (OF) | : 89.92 % | | |

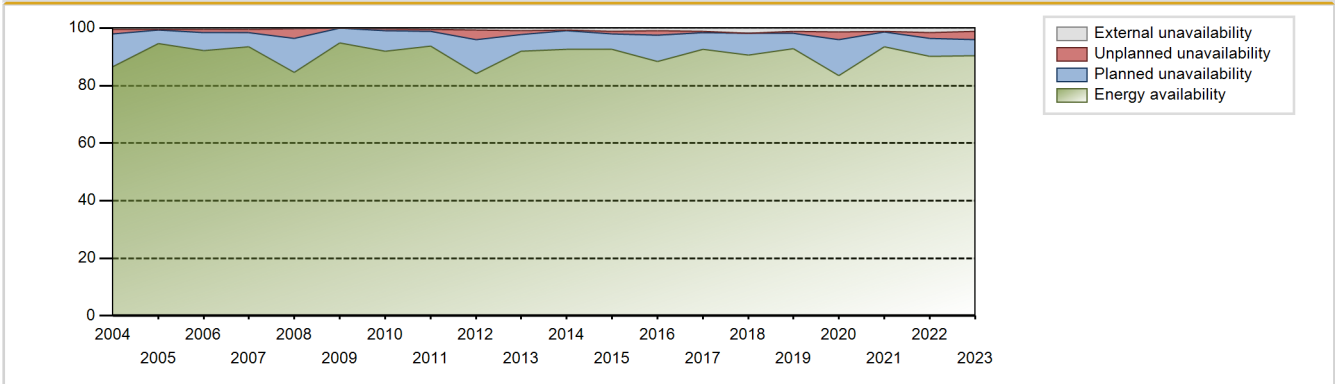
Electricity Production (net) [GWh]



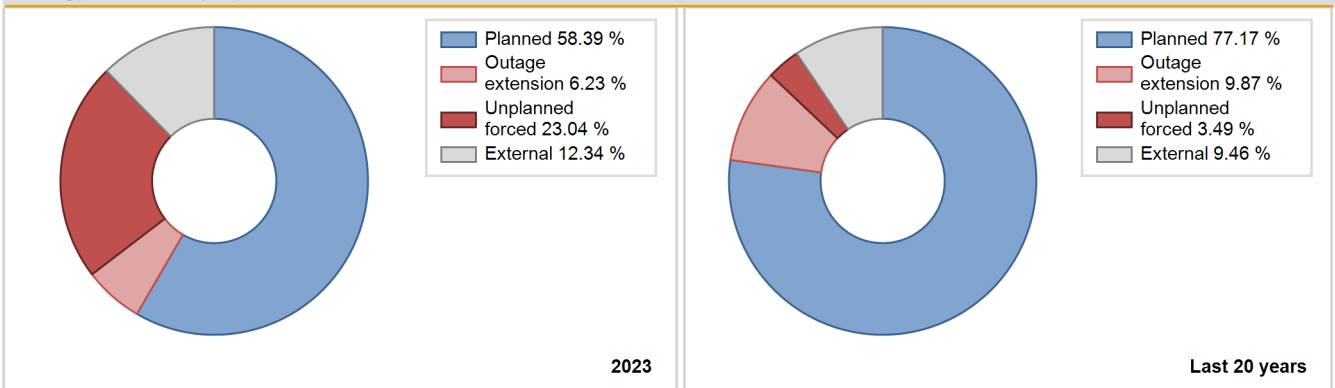
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1977 | 2505.50 | 7192 | 431 | 83.79 | 83.79 | 83.79 | 95.09 | 12.65 | 12.13 | 4.08 | 0.00 |
| 1978 | 2975.80 | 7531 | 430 | 78.93 | 78.93 | 79.00 | 85.97 | 9.27 | 8.06 | 13.01 | 0.00 |
| 1979 | 2901.70 | 7404 | 405 | 81.76 | 81.76 | 81.79 | 84.52 | 9.09 | 8.17 | 10.07 | 0.00 |
| 1980 | 1407.80 | 3482 | 445 | 36.65 | 36.65 | 36.02 | 39.64 | 55.36 | 45.45 | 17.90 | 0.00 |
| 1981 | 3105.10 | 7642 | 440 | 81.94 | 81.94 | 80.56 | 87.24 | 2.74 | 2.31 | 15.75 | 0.00 |
| 1982 | 3245.40 | 7576 | 440 | 84.19 | 84.19 | 84.20 | 86.48 | 4.46 | 3.93 | 11.88 | 0.00 |
| 1983 | 3337.40 | 7982 | 445 | 86.68 | 86.68 | 85.61 | 91.12 | 3.01 | 2.69 | 10.63 | 0.00 |
| 1984 | 3343.86 | 7653 | 445 | 85.79 | 85.79 | 85.55 | 87.12 | 0.31 | 0.27 | 13.94 | 0.00 |
| 1985 | 3599.97 | 8248 | 440 | 92.54 | 92.54 | 93.40 | 94.16 | 0.45 | 0.42 | 7.05 | 0.00 |
| 1986 | 3522.37 | 8093 | 445 | 91.10 | 91.10 | 90.36 | 92.39 | 2.67 | 2.49 | 6.40 | 0.00 |
| 1987 | 3600.36 | 8257 | 445 | 94.55 | 94.55 | 92.36 | 94.26 | 0.00 | 0.00 | 5.45 | 0.00 |
| 1988 | 3354.63 | 7678 | 445 | 87.03 | 87.03 | 85.82 | 87.41 | 1.21 | 1.07 | 11.90 | 0.00 |
| 1989 | 3575.75 | 8183 | 445 | 92.61 | 92.80 | 91.73 | 93.41 | 0.00 | 0.00 | 7.20 | 0.19 |
| 1990 | 3271.13 | 7605 | 445 | 85.48 | 85.50 | 83.91 | 86.82 | 4.46 | 3.99 | 10.50 | 0.03 |
| 1991 | 3360.90 | 7927 | 445 | 88.58 | 88.84 | 86.22 | 90.49 | 2.52 | 2.29 | 8.86 | 0.26 |
| 1992 | 3108.41 | 7186 | 445 | 80.19 | 80.30 | 79.52 | 81.81 | 0.44 | 0.35 | 19.35 | 0.11 |
| 1993 | 3443.16 | 8052 | 445 | 89.47 | 89.49 | 88.40 | 91.99 | 1.77 | 1.61 | 8.91 | 0.02 |
| 1994 | 3497.57 | 8017 | 445 | 90.70 | 90.76 | 89.72 | 91.52 | 2.31 | 2.15 | 7.09 | 0.06 |
| 1995 | 3389.06 | 7834 | 445 | 87.66 | 88.50 | 86.94 | 89.43 | 6.50 | 6.16 | 5.34 | 0.84 |
| 1996 | 3203.49 | 7281 | 445 | 82.04 | 82.51 | 81.95 | 82.89 | 0.00 | 0.00 | 17.49 | 0.47 |
| 1997 | 3794.83 | 8309 | 445 | 93.02 | 93.87 | 97.35 | 94.85 | 0.02 | 0.02 | 6.11 | 0.86 |
| 1998 | 3852.35 | 8234 | 488 | 91.35 | 93.39 | 90.12 | 94.00 | 0.05 | 0.05 | 6.56 | 2.04 |
| 1999 | 3883.28 | 8304 | 488 | 91.63 | 92.37 | 90.84 | 94.79 | 0.00 | 0.00 | 7.63 | 0.74 |
| 2000 | 3618.00 | 7720 | 488 | 84.91 | 86.50 | 84.40 | 87.89 | 0.06 | 0.05 | 13.45 | 1.59 |
| 2001 | 3920.99 | 8233 | 488 | 92.38 | 93.41 | 91.72 | 93.98 | 0.67 | 0.63 | 5.97 | 1.02 |
| 2002 | 3790.07 | 8095 | 488 | 89.27 | 91.40 | 88.66 | 92.41 | 0.72 | 0.66 | 7.94 | 2.13 |
| 2003 | 3938.98 | 8194 | 488 | 92.40 | 93.22 | 92.14 | 93.54 | 0.16 | 2.01 | 4.77 | 0.83 |
| 2004 | 3715.03 | 7647 | 488 | 86.51 | 86.91 | 86.66 | 87.05 | 0.24 | 1.55 | 11.54 | 0.40 |
| 2005 | 4062.43 | 8351 | 488 | 94.61 | 95.02 | 95.03 | 95.33 | 0.28 | 0.27 | 4.71 | 0.41 |
| 2006 | 3964.84 | 8138 | 488 | 92.08 | 92.63 | 92.74 | 92.89 | 0.18 | 0.95 | 6.42 | 0.55 |
| 2007 | 4028.12 | 8285 | 488 | 93.49 | 94.00 | 94.23 | 94.58 | 0.32 | 1.19 | 4.82 | 0.50 |
| 2008 | 3671.84 | 7571 | 488 | 84.51 | 84.87 | 85.66 | 86.19 | 0.09 | 3.25 | 11.88 | 0.36 |
| 2009 | 4084.91 | 8345 | 488 | 94.80 | 94.83 | 95.56 | 95.26 | 0.03 | 0.03 | 5.14 | 0.03 |
| 2010 | 3955.59 | 8123 | 488 | 91.95 | 92.33 | 92.53 | 92.73 | 0.53 | 0.61 | 7.07 | 0.38 |
| 2011 | 4026.87 | 8295 | 488 | 93.82 | 94.32 | 94.20 | 94.69 | 0.80 | 0.76 | 4.92 | 0.51 |
| 2012 | 3653.04 | 7473 | 496 | 84.08 | 84.86 | 83.86 | 85.08 | 0.00 | 3.32 | 11.82 | 0.78 |
| 2013 | 4000.24 | 8219 | 496 | 92.00 | 93.02 | 92.07 | 93.82 | 1.33 | 1.25 | 5.73 | 1.02 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2014 | 4010.58 | 8262 | 496 | 92.60 | 93.38 | 92.30 | 94.32 | 0.06 | 0.06 | 6.57 | 0.78 |
| 2015 | 4025.96 | 8248 | 496 | 92.68 | 93.76 | 92.66 | 94.16 | 0.07 | 0.99 | 5.25 | 1.08 |
| 2016 | 3862.81 | 7873 | 502 | 88.45 | 89.43 | 88.48 | 89.63 | 0.07 | 1.58 | 8.99 | 0.98 |
| 2017 | 4087.37 | 8246 | 507 | 92.71 | 93.85 | 92.71 | 94.13 | 0.15 | 0.55 | 5.59 | 1.15 |
| 2018 | 4021.00 | 8124 | 507 | 90.64 | 92.47 | 90.54 | 92.74 | 0.11 | 0.10 | 7.43 | 1.82 |
| 2019 | 4109.79 | 8270 | 507 | 92.90 | 94.10 | 92.54 | 94.41 | 0.05 | 0.71 | 5.19 | 1.20 |
| 2020 | 3709.11 | 7483 | 507 | 83.47 | 84.86 | 83.29 | 85.19 | 0.08 | 2.57 | 12.56 | 1.39 |
| 2021 | 4137.39 | 8325 | 507 | 93.40 | 94.66 | 93.16 | 95.03 | 0.13 | 0.17 | 5.17 | 1.26 |
| 2022 | 3995.96 | 8060 | 507 | 90.22 | 91.80 | 89.98 | 92.02 | 0.01 | 1.96 | 6.24 | 1.58 |
| 2023 | 3987.99 | 8200 | 507 | 90.47 | 91.65 | 89.79 | 93.61 | 2.34 | 2.79 | 5.56 | 1.18 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1977 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 51 | | | 167 | |
| C. Inspection, maintenance or repair combined with refuelling | 480 | | | 690 | 7 | |
| D. Inspection, maintenance or repair without refuelling | | | | 14 | | |
| E. Testing of plant systems or components | | | | 2 | | |
| L. Human factor related | | | | | 1 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 4 |
| Z. Other | | 52 | | | 13 | |
| Subtotal | 480 | 103 | | 706 | 188 | 4 |
| Total | | 583 | | | 898 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1977 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 11 |
| 14. Safety Systems | | 3 |
| 15. Reactor Cooling Systems | | 122 |
| 16. Steam generation systems | 51 | 6 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 3 |
| 31. Turbine and auxiliaries | | 12 |
| 32. Feedwater and Main Steam System | | 6 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 1 |
| Total | 51 | 167 |

2023 Operating Experience

FI-2

LOVIISA-2

FINLAND

Status at end of year : **Operational**
 Operator : FORTUMPH (FORTUM POWER AND HEAT OY (former IVO))
 Owner : FORTUMPH (FORTUM POWER AND HEAT OY (former IVO))
 Reactor Supplier : AEE (ATOMENERGOEXPORT)
 Turbine Supplier : AEE (ATOMENERGOEXPORT)



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1500 MWth
 Gross electrical power : 531 MWe
 Reference unit power (net) : 507 MWe

Key Dates

Construction Date : 1972-08-01
 Grid Date : 1980-11-04
 Commercial Date : 1981-01-05
 Age at end of year : 43 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.3
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 2.73
 Active core height/length [m] : 2.42
 Number of fissile fuel assemblies/bundles : 313
 Fuel linear heat generation rate [kW/m] : 15.7
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.25
 Reactor outlet temperature [°C] : 300
 Number of SG : 6
 Containment type : Single
 Containment design pressure [MPa] : 0.07

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.4
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 4

Non-electrical applications

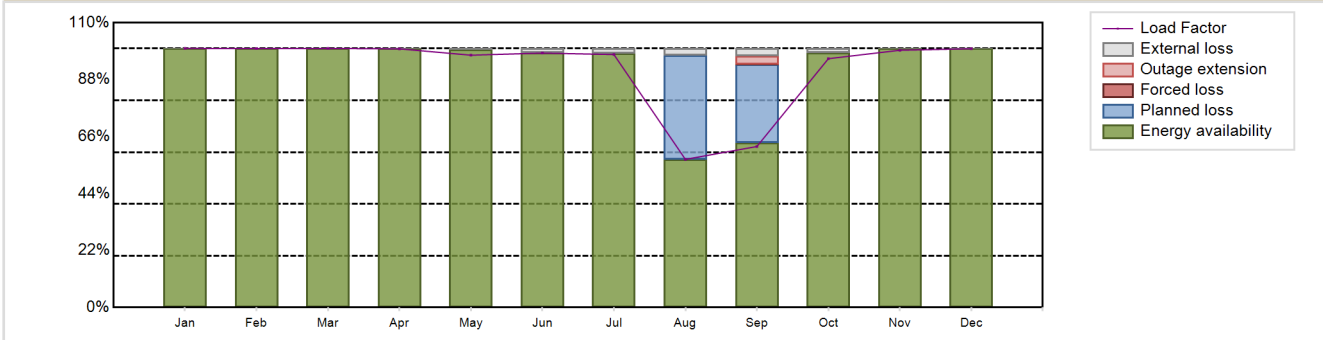
: none

Annual Production Results (2023)

Net Energy Production : 4100.21 GW(e).h
 Energy Availability Factor (EAF) : 92.89 %
 Unit Capability Factor (UCF) : 93.82 %
 Load Factor (LF) : 92.32 %
 Operating Factor (OF) : 95.06 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0.28 %
 Planned Unavailability Factor (PUF) : 5.91 %
 Externally cause unavailability (XUF) : 0.93 %
 Total off-line time : 433 hours

Annual Summary

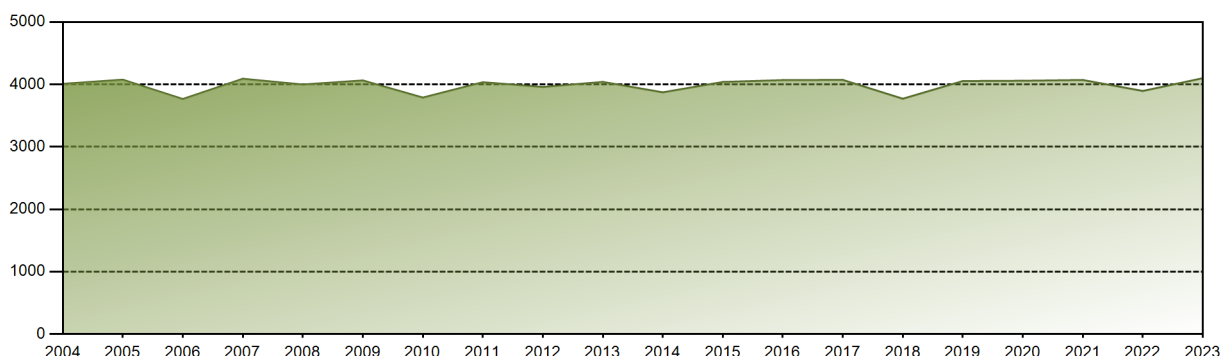


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 377.49 | 340.73 | 376.91 | 364.69 | 367.57 | 358.70 | 368.55 | 215.83 | 227.01 | 363.02 | 362.72 | 376.99 | 4100.21 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.51 | 98.26 | 98.05 | 57.22 | 63.51 | 98.45 | 100.00 | 100.00 | 92.89 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 59.77 | 66.32 | 100.00 | 100.00 | 100.00 | 93.82 |
| LF [%] | 100.07 | 100.01 | 100.06 | 99.90 | 97.45 | 98.26 | 97.70 | 57.22 | 62.19 | 96.11 | 99.36 | 99.94 | 92.32 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 63.04 | 78.06 | 100.00 | 100.00 | 100.00 | 95.06 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.38 | 0.00 | 0.00 | 0.00 | 0.28 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 40.23 | 30.30 | 0.00 | 0.00 | 0.00 | 5.91 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.49 | 1.74 | 1.95 | 2.55 | 2.81 | 1.55 | 0.00 | 0.00 | 0.93 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 160281.45 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.33 % |
| Cumulative Energy Availability Factor (EAF) | : 89.55 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.52 % |
| Cumulative Unit Capability Factor (UCF) | : 90.35 % | Cumulative Planned Unavailability Factor (PUF) | : 8.13 % |
| Cumulative Load Factor (LF) | : 89.45 % | Cumulative Externally cause unavailability (XUF) | : 0.8 % |
| Cumulative Operating Factor (OF) | : 91.3 % | | |

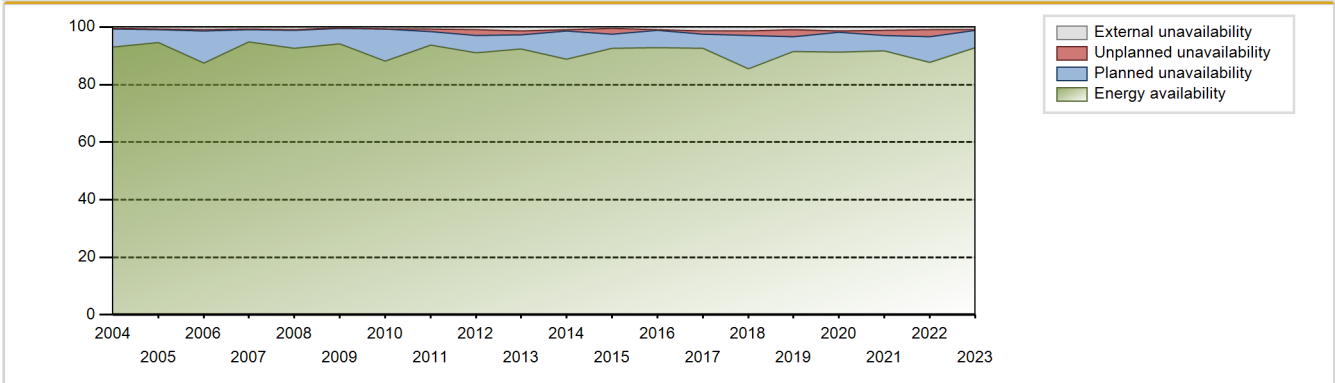
Electricity Production (net) [GWh]



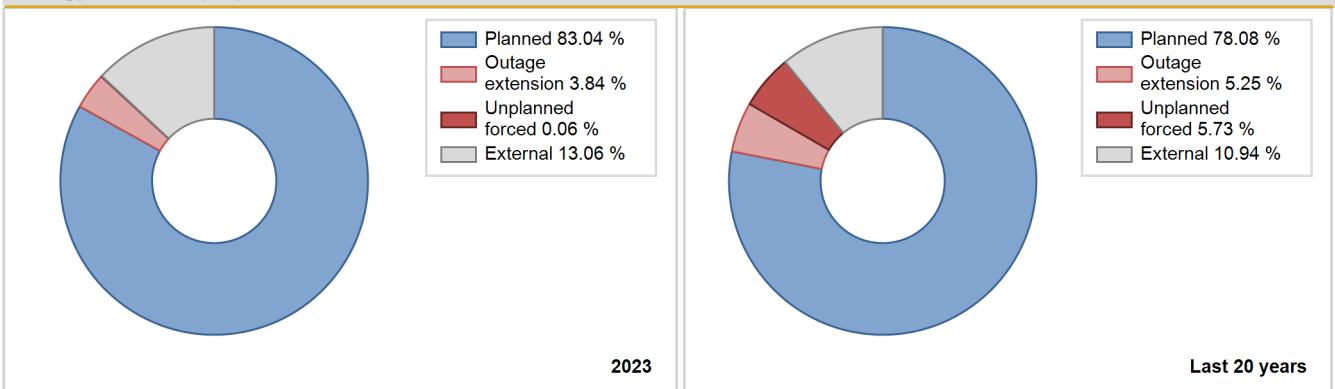
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 2714.20 | 7062 | 440 | 72.18 | 72.18 | 70.42 | 80.62 | 9.96 | 7.99 | 19.83 | 0.00 |
| 1982 | 2997.40 | 7046 | 440 | 78.00 | 78.00 | 77.77 | 80.43 | 0.30 | 0.23 | 21.76 | 0.00 |
| 1983 | 3474.50 | 8063 | 445 | 90.09 | 90.09 | 89.13 | 92.04 | 0.72 | 0.66 | 9.25 | 0.00 |
| 1984 | 3608.63 | 8251 | 445 | 92.57 | 92.57 | 92.32 | 93.93 | 0.93 | 0.87 | 6.56 | 0.00 |
| 1985 | 3549.84 | 8162 | 440 | 92.15 | 92.15 | 92.10 | 93.17 | 1.79 | 1.68 | 6.17 | 0.00 |
| 1986 | 3174.87 | 7273 | 445 | 81.46 | 81.46 | 81.44 | 83.03 | 3.74 | 3.17 | 15.37 | 0.00 |
| 1987 | 3572.08 | 8242 | 445 | 93.37 | 93.37 | 91.63 | 94.09 | 0.00 | 0.00 | 6.63 | 0.00 |
| 1988 | 3602.27 | 8305 | 445 | 94.69 | 94.69 | 92.16 | 94.55 | 0.00 | 0.00 | 5.31 | 0.00 |
| 1989 | 3550.96 | 8128 | 445 | 91.69 | 91.76 | 91.09 | 92.79 | 0.00 | 0.00 | 8.24 | 0.07 |
| 1990 | 3251.05 | 7584 | 445 | 85.28 | 85.32 | 83.40 | 86.58 | 4.24 | 3.78 | 10.90 | 0.04 |
| 1991 | 3442.19 | 7941 | 445 | 88.98 | 89.85 | 88.30 | 90.65 | 0.25 | 0.22 | 9.93 | 0.87 |
| 1992 | 3468.45 | 7931 | 445 | 89.10 | 89.53 | 88.73 | 90.29 | 0.66 | 0.60 | 9.88 | 0.43 |
| 1993 | 3550.79 | 8050 | 445 | 91.25 | 91.29 | 91.16 | 91.97 | 2.29 | 2.14 | 6.57 | 0.04 |
| 1994 | 3124.71 | 7170 | 445 | 80.50 | 81.20 | 80.16 | 81.85 | 1.87 | 1.55 | 17.25 | 0.70 |
| 1995 | 3060.25 | 7064 | 445 | 77.57 | 78.41 | 78.50 | 80.64 | 17.16 | 16.25 | 5.34 | 0.84 |
| 1996 | 3621.33 | 8227 | 445 | 92.73 | 93.08 | 92.64 | 93.66 | 0.00 | 0.00 | 6.92 | 0.35 |
| 1997 | 3804.70 | 8267 | 445 | 91.96 | 92.87 | 97.60 | 94.37 | 2.30 | 2.19 | 4.94 | 0.91 |
| 1998 | 3687.90 | 7892 | 488 | 86.41 | 88.55 | 86.27 | 90.09 | 0.70 | 0.63 | 10.82 | 2.14 |
| 1999 | 3974.34 | 8281 | 488 | 93.53 | 94.19 | 92.97 | 94.53 | 0.14 | 0.13 | 5.69 | 0.65 |
| 2000 | 3885.10 | 8314 | 488 | 90.90 | 94.11 | 90.63 | 94.65 | 0.25 | 0.23 | 5.66 | 3.21 |
| 2001 | 3781.06 | 8149 | 488 | 89.58 | 92.30 | 88.45 | 93.03 | 1.25 | 1.17 | 6.53 | 2.72 |
| 2002 | 3498.66 | 7463 | 488 | 82.56 | 84.51 | 81.84 | 85.19 | 1.54 | 4.75 | 10.74 | 1.94 |
| 2003 | 3736.65 | 8358 | 488 | 90.00 | 90.14 | 87.41 | 95.41 | 0.08 | 0.20 | 9.66 | 0.14 |
| 2004 | 4009.18 | 8231 | 488 | 93.11 | 93.59 | 93.53 | 93.70 | 0.25 | 0.23 | 6.18 | 0.47 |
| 2005 | 4076.12 | 8376 | 488 | 94.55 | 95.36 | 95.35 | 95.62 | 0.16 | 0.15 | 4.49 | 0.81 |
| 2006 | 3766.55 | 7863 | 488 | 87.47 | 88.49 | 88.11 | 89.76 | 0.51 | 0.45 | 11.06 | 1.01 |
| 2007 | 4090.87 | 8403 | 488 | 94.85 | 95.47 | 95.70 | 95.92 | 0.24 | 0.23 | 4.30 | 0.61 |
| 2008 | 3997.95 | 8240 | 488 | 92.52 | 93.47 | 93.27 | 93.81 | 0.02 | 0.22 | 6.32 | 0.95 |
| 2009 | 4063.83 | 8318 | 488 | 94.26 | 94.59 | 95.06 | 94.95 | 0.18 | 0.17 | 5.24 | 0.33 |
| 2010 | 3789.14 | 7797 | 488 | 88.09 | 88.80 | 88.64 | 89.01 | 0.00 | 0.00 | 11.20 | 0.70 |
| 2011 | 4035.30 | 8290 | 488 | 93.70 | 94.48 | 94.40 | 94.63 | 0.07 | 0.77 | 4.75 | 0.77 |
| 2012 | 3959.19 | 8141 | 496 | 91.02 | 92.04 | 90.87 | 92.68 | 2.12 | 1.99 | 5.97 | 1.02 |
| 2013 | 4040.04 | 8250 | 496 | 92.40 | 93.69 | 92.98 | 94.18 | 1.58 | 1.50 | 4.81 | 1.29 |
| 2014 | 3872.75 | 7912 | 496 | 88.91 | 89.73 | 89.13 | 90.32 | 0.29 | 0.64 | 9.63 | 0.82 |
| 2015 | 4039.11 | 8276 | 496 | 92.60 | 93.20 | 92.96 | 94.47 | 2.07 | 1.97 | 4.84 | 0.60 |
| 2016 | 4068.96 | 8304 | 502 | 92.94 | 93.97 | 93.30 | 94.54 | 0.10 | 0.09 | 5.94 | 1.04 |
| 2017 | 4071.92 | 8255 | 502 | 92.51 | 93.96 | 92.60 | 94.24 | 1.16 | 1.10 | 4.94 | 1.45 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2018 | 3770.71 | 7639 | 507 | 85.52 | 86.92 | 85.60 | 87.20 | 0.26 | 1.44 | 11.64 | 1.41 |
| 2019 | 4053.97 | 8142 | 507 | 91.58 | 92.48 | 91.28 | 92.95 | 0.19 | 2.56 | 4.96 | 0.91 |
| 2020 | 4058.51 | 8171 | 507 | 91.22 | 92.53 | 91.13 | 93.02 | 0.11 | 0.52 | 6.96 | 1.30 |
| 2021 | 4071.02 | 8170 | 507 | 91.81 | 93.01 | 91.66 | 93.26 | 0.00 | 1.80 | 5.20 | 1.19 |
| 2022 | 3894.87 | 7810 | 507 | 87.80 | 88.76 | 87.69 | 89.15 | 1.12 | 2.46 | 8.78 | 0.97 |
| 2023 | 4100.21 | 8327 | 507 | 92.89 | 93.82 | 92.32 | 95.06 | 0.00 | 0.28 | 5.91 | 0.93 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | | 82 |
| C. Inspection, maintenance or repair combined with refuelling | 408 | | | 642 | | 1 |
| D. Inspection, maintenance or repair without refuelling | | | | 28 | | |
| Z. Other | | 24 | | 1 | 13 | |
| Subtotal | 408 | 24 | | 671 | 96 | |
| Total | | 432 | | | 767 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 9 |
| 12. Reactor I&C Systems | | 9 |
| 14. Safety Systems | | 4 |
| 15. Reactor Cooling Systems | | 43 |
| 16. Steam generation systems | | 2 |
| 31. Turbine and auxiliaries | | 1 |
| 32. Feedwater and Main Steam System | | 12 |
| 34. Miscellaneous Systems | | 2 |
| 41. Main Generator Systems | | 1 |
| Total | | 83 |

2023 Operating Experience

FI-3

OLKILUOTO-1

FINLAND

Status at end of year : **Operational**
 Operator : TVO (TEOLLISUUDEN VOIMA OYJ)
 Owner : TVO (TEOLLISUUDEN VOIMA OYJ)
 Reactor Supplier : ASEASTAL (ASEA-ATOM / STAL-LAVAL)
 Turbine Supplier : ASEASTAL (ASEA-ATOM / STAL-LAVAL)



Reactor Unit Details

Reactor type and model : BWR / AA-III, BWR-2500
 Thermal power : 2500 MWth
 Gross electrical power : 920 MWe
 Reference unit power (net) : 890 MWe

Key Dates

Construction Date : 1974-02-01
 Grid Date : 1978-09-02
 Commercial Date : 1979-10-10
 Age at end of year : 45 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.85
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 20
 Average discharge burnup [MWd/t] : 47000
 Active core diameter [m] : 3.88
 Active core height/length [m] : 3.68
 Number of fissile fuel assemblies/bundles : 500
 Fuel linear heat generation rate [kW/m] : 16.3
 Number of control rod assemblies : 121
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.12
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : 4.8

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 4
 HP cylinder inlet steam pressure [MPa] : 6.7
 Output voltage [kV] : 20
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 4

Non-electrical applications

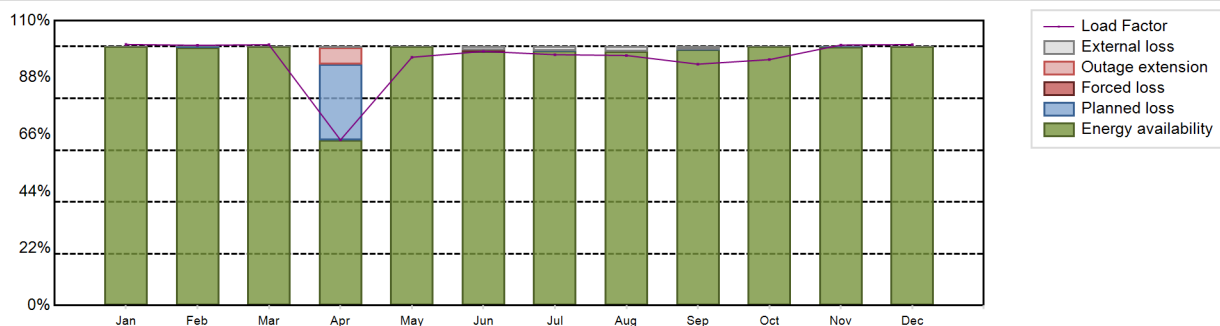
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7428.24 GW(e).h
 Energy Availability Factor (EAF) : 96.45 %
 Unit Capability Factor (UCF) : 96.98 %
 Load Factor (LF) : 95.28 %
 Operating Factor (OF) : 97.23 %

Forced Loss Rate (FLR) : 0.05 %
 Unplanned Capability Loss Factor (UCL) : 0.57 %
 Planned Unavailability Factor (PUF) : 2.45 %
 Externally cause unavailability (XUF) : 0.52 %
 Total off-line time : 243 hours

Annual Summary

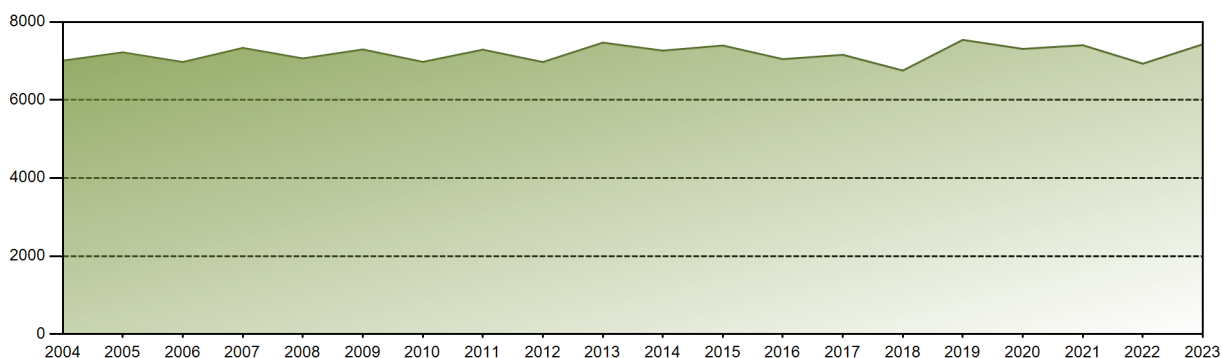


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 667.53 | 600.99 | 666.14 | 409.77 | 634.87 | 628.92 | 641.52 | 639.43 | 597.28 | 629.70 | 644.68 | 667.40 | 7428.24 |
| EAF [%] | 100.00 | 99.73 | 100.00 | 63.77 | 100.00 | 98.15 | 98.27 | 98.20 | 98.91 | 100.00 | 99.93 | 100.00 | 96.45 |
| UCF [%] | 100.00 | 99.73 | 100.00 | 64.18 | 100.00 | 99.42 | 99.99 | 100.00 | 99.95 | 100.00 | 99.93 | 100.00 | 96.98 |
| LF [%] | 100.81 | 100.49 | 100.74 | 63.95 | 95.88 | 98.15 | 96.88 | 96.57 | 93.21 | 94.97 | 100.60 | 100.79 | 95.28 |
| OF [%] | 100.00 | 100.00 | 100.00 | 66.25 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.23 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 6.38 | 0.00 | 0.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.57 |
| PUF [%] | 0.00 | 0.27 | 0.00 | 29.45 | 0.00 | 0.00 | 0.01 | 0.00 | 0.05 | 0.00 | 0.07 | 0.00 | 2.45 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.40 | 0.00 | 1.27 | 1.72 | 1.80 | 1.05 | 0.00 | 0.00 | 0.00 | 0.52 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 288862.97 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.38 % |
| Cumulative Energy Availability Factor (EAF) | : 92.75 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.55 % |
| Cumulative Unit Capability Factor (UCF) | : 93.21 % | Cumulative Planned Unavailability Factor (PUF) | : 5.25 % |
| Cumulative Load Factor (LF) | : 92.58 % | Cumulative Externally cause unavailability (XUF) | : 0.46 % |
| Cumulative Operating Factor (OF) | : 93.77 % | | |

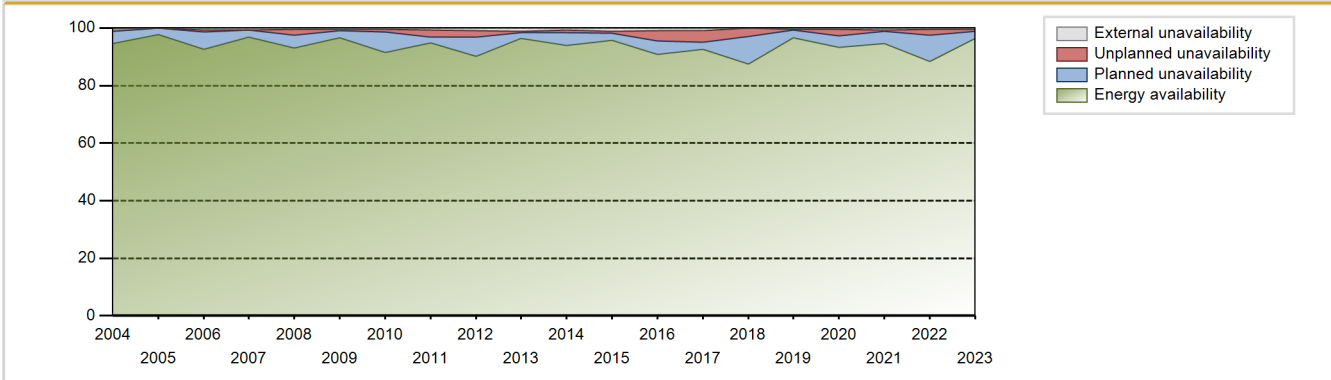
Electricity Production (net) [GWh]



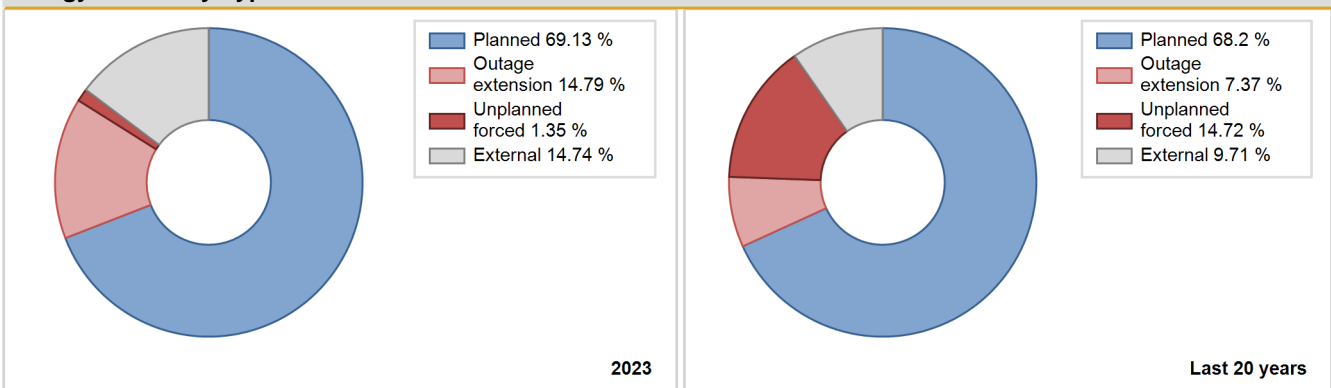
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1979 | 3465.00 | 5614 | 660 | 86.85 | 86.85 | 86.82 | 90.40 | 12.45 | 12.35 | 0.80 | 0.00 |
| 1980 | 4280.80 | 6849 | 658 | 76.31 | 76.31 | 74.06 | 77.97 | 3.12 | 2.46 | 21.23 | 0.00 |
| 1981 | 4549.20 | 7353 | 660 | 80.80 | 80.80 | 78.68 | 83.94 | 8.82 | 7.82 | 11.38 | 0.00 |
| 1982 | 4997.50 | 7903 | 658 | 86.68 | 86.68 | 86.70 | 90.22 | 3.90 | 3.51 | 9.81 | 0.00 |
| 1983 | 4808.30 | 7651 | 669 | 81.86 | 81.86 | 82.01 | 87.34 | 0.96 | 0.79 | 17.35 | 0.00 |
| 1984 | 5505.61 | 8247 | 694 | 91.94 | 91.94 | 90.30 | 93.89 | 0.33 | 0.30 | 7.76 | 0.00 |
| 1985 | 5414.51 | 8180 | 710 | 88.75 | 88.75 | 87.06 | 93.38 | 2.58 | 2.35 | 8.90 | 0.00 |
| 1986 | 5463.21 | 8008 | 710 | 90.08 | 90.08 | 87.84 | 91.42 | 0.72 | 0.65 | 9.27 | 0.00 |
| 1987 | 5636.46 | 8142 | 710 | 92.05 | 92.05 | 90.62 | 92.95 | 2.64 | 2.49 | 5.45 | 0.00 |
| 1988 | 5778.87 | 8248 | 710 | 94.07 | 94.29 | 92.66 | 93.90 | 1.20 | 1.15 | 4.56 | 0.22 |
| 1989 | 5056.20 | 7278 | 710 | 83.18 | 83.18 | 81.29 | 83.08 | 13.17 | 12.62 | 4.20 | 0.00 |
| 1990 | 5857.31 | 8356 | 710 | 95.60 | 95.60 | 94.17 | 95.39 | 0.57 | 0.55 | 3.86 | 0.00 |
| 1991 | 5873.22 | 8373 | 710 | 94.85 | 95.72 | 94.43 | 95.58 | 0.13 | 0.12 | 4.16 | 0.87 |
| 1992 | 5803.04 | 8251 | 710 | 93.23 | 93.72 | 93.05 | 93.93 | 0.44 | 0.42 | 5.87 | 0.49 |
| 1993 | 5944.92 | 8433 | 710 | 95.33 | 95.78 | 95.58 | 96.27 | 0.28 | 0.27 | 3.95 | 0.45 |
| 1994 | 5978.04 | 8485 | 710 | 96.01 | 96.50 | 96.12 | 96.86 | 0.05 | 0.05 | 3.45 | 0.49 |
| 1995 | 5931.50 | 8427 | 710 | 95.50 | 96.11 | 95.37 | 96.20 | 0.84 | 0.81 | 3.08 | 0.61 |
| 1996 | 5938.60 | 8212 | 710 | 92.08 | 92.19 | 95.22 | 93.49 | 1.22 | 1.14 | 6.67 | 0.11 |
| 1997 | 6374.15 | 8254 | 772 | 93.83 | 93.86 | 94.18 | 94.22 | 1.24 | 1.18 | 4.96 | 0.03 |
| 1998 | 6807.01 | 8384 | 840 | 94.95 | 95.57 | 92.51 | 95.71 | 0.22 | 0.21 | 4.22 | 0.62 |
| 1999 | 7111.82 | 8542 | 840 | 96.39 | 97.24 | 96.65 | 97.51 | 0.26 | 0.25 | 2.51 | 0.84 |
| 2000 | 7043.10 | 8448 | 840 | 95.17 | 95.81 | 95.45 | 96.17 | 0.13 | 0.13 | 4.06 | 0.65 |
| 2001 | 7163.80 | 8561 | 840 | 97.16 | 97.64 | 97.36 | 97.73 | 0.01 | 0.01 | 2.35 | 0.48 |
| 2002 | 6997.54 | 8377 | 840 | 95.05 | 95.51 | 95.09 | 95.62 | 0.65 | 0.63 | 3.86 | 0.46 |
| 2003 | 7127.43 | 8515 | 840 | 96.46 | 97.08 | 96.86 | 97.20 | 0.18 | 0.51 | 2.41 | 0.61 |
| 2004 | 7009.02 | 8329 | 840 | 94.70 | 94.70 | 94.99 | 94.82 | 0.80 | 1.19 | 4.11 | 0.00 |
| 2005 | 7221.07 | 8588 | 840 | 97.73 | 97.85 | 98.13 | 98.04 | 0.03 | 0.03 | 2.13 | 0.12 |
| 2006 | 6973.38 | 8206 | 860 | 92.64 | 93.34 | 93.64 | 93.68 | 0.35 | 0.60 | 6.06 | 0.71 |
| 2007 | 7334.94 | 8554 | 860 | 96.75 | 97.37 | 97.36 | 97.65 | 0.04 | 0.04 | 2.59 | 0.63 |
| 2008 | 7066.02 | 8288 | 860 | 93.14 | 93.59 | 93.54 | 94.35 | 0.78 | 2.09 | 4.32 | 0.44 |
| 2009 | 7295.77 | 8548 | 860 | 96.69 | 97.22 | 96.84 | 97.58 | 0.30 | 0.37 | 2.41 | 0.53 |
| 2010 | 6976.89 | 8120 | 880 | 91.41 | 92.00 | 91.54 | 92.69 | 0.65 | 0.90 | 7.11 | 0.59 |
| 2011 | 7289.82 | 8410 | 880 | 94.80 | 95.55 | 94.56 | 96.00 | 1.91 | 2.38 | 2.07 | 0.76 |
| 2012 | 6973.36 | 8013 | 880 | 90.08 | 90.91 | 90.21 | 91.22 | 2.52 | 2.35 | 6.74 | 0.83 |
| 2013 | 7470.41 | 8555 | 880 | 96.37 | 97.41 | 96.91 | 97.66 | 0.36 | 0.58 | 2.01 | 1.04 |
| 2014 | 7266.09 | 8337 | 880 | 94.00 | 94.81 | 94.26 | 95.17 | 0.38 | 0.89 | 4.30 | 0.81 |
| 2015 | 7396.91 | 8506 | 880 | 95.68 | 96.75 | 95.95 | 97.10 | 0.24 | 0.66 | 2.59 | 1.07 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|------|------|
| 2016 | 7047.81 | 8146 | 880 | 90.90 | 91.84 | 91.18 | 92.74 | 2.29 | 3.46 | 4.70 | 0.93 |
| 2017 | 7158.27 | 8289 | 880 | 92.65 | 93.67 | 92.86 | 94.62 | 3.26 | 3.82 | 2.51 | 1.02 |
| 2018 | 6755.36 | 7731 | 880 | 87.55 | 87.67 | 87.63 | 88.25 | 0.65 | 2.73 | 9.60 | 0.12 |
| 2019 | 7542.04 | 8539 | 890 | 96.52 | 96.96 | 96.74 | 97.48 | 0.27 | 0.32 | 2.72 | 0.44 |
| 2020 | 7310.06 | 8391 | 890 | 93.25 | 93.75 | 93.51 | 95.53 | 2.12 | 2.30 | 3.94 | 0.50 |
| 2021 | 7404.18 | 8375 | 890 | 94.57 | 95.31 | 94.97 | 95.61 | 0.19 | 0.34 | 4.35 | 0.74 |
| 2022 | 6931.89 | 7827 | 890 | 88.46 | 88.86 | 88.91 | 89.35 | 2.30 | 2.09 | 9.06 | 0.39 |
| 2023 | 7428.24 | 8517 | 890 | 96.45 | 96.98 | 95.28 | 97.23 | 0.05 | 0.57 | 2.45 | 0.52 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1979 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 46 | | | 97 | |
| B. Refuelling without maintenance | | | | 36 | | |
| C. Inspection, maintenance or repair combined with refuelling | 197 | | | 377 | 1 | |
| D. Inspection, maintenance or repair without refuelling | | | | 12 | | |
| E. Testing of plant systems or components | | | | 0 | 4 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 18 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 11 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| Z. Other | | | | | 24 | |
| Subtotal | 197 | 46 | | 443 | 127 | 12 |
| Total | | 243 | | | 582 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1979 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 17 |
| 12. Reactor I&C Systems | | 5 |
| 13. Reactor Auxiliary Systems | 46 | 23 |
| 14. Safety Systems | | 3 |
| 15. Reactor Cooling Systems | | 14 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 0 |
| 31. Turbine and auxiliaries | | 16 |
| 32. Feedwater and Main Steam System | | 5 |
| 33. Circulating Water System | | 3 |
| 41. Main Generator Systems | | 35 |
| 42. Electrical Power Supply Systems | | 1 |
| Total | 46 | 122 |

Highlights (2023)

The electricity production of the Olkiluoto power plant units OL1, OL2 and OL3 during 2023 was 24,671 GWh.

OL1's net production was 7,428 GWh.

The annual outages of 2023 at the Olkiluoto nuclear power plant were carried out from April 16 to May 19, 2023. OL2 was performed a maintenance outage taking more than 17 days, and OL1 performed a refueling outage that lasted over 10 days. The annual outage period was about four days longer than expected. The schedule was affected mainly from relief system. In all other respects annual outages were implemented according to plans. The OL3 plant unit first annual outage starts on March 3, 2024.

2023 Operating Experience

FI-4

OLKILUOTO-2

FINLAND

Status at end of year : **Operational**
 Operator : TVO (TEOLLISUUDEN VOIMA OYJ)
 Owner : TVO (TEOLLISUUDEN VOIMA OYJ)
 Reactor Supplier : ASEASTAL (ASEA-ATOM / STAL-LAVAL)
 Turbine Supplier : ASEASTAL (ASEA-ATOM / STAL-LAVAL)



Reactor Unit Details

Reactor type and model : BWR / AA-III, BWR-2500
 Thermal power : 2500 MWth
 Gross electrical power : 920 MWe
 Reference unit power (net) : 890 MWe

Key Dates

Construction Date : 1975-11-01
 Grid Date : 1980-02-18
 Commercial Date : 1982-07-10
 Age at end of year : 43 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.66
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 21
 Average discharge burnup [MWd/t] : 45500
 Active core diameter [m] : 4.00
 Active core height/length [m] : 3.68
 Number of fissile fuel assemblies/bundles : 500
 Fuel linear heat generation rate [kW/m] : 15.0
 Number of control rod assemblies : 121
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.12
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : 4.8

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 4
 HP cylinder inlet steam pressure [MPa] : 6.7
 Output voltage [kV] : 20
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 4

Non-electrical applications

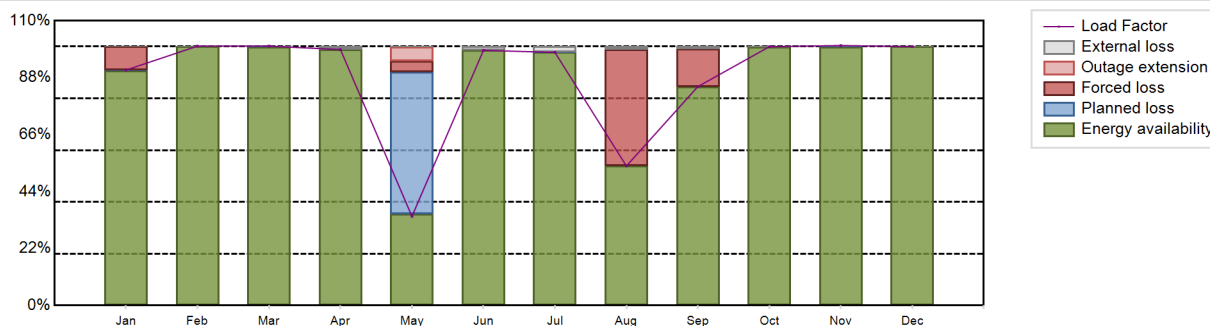
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6871.08 GW(e).h
 Energy Availability Factor (EAF) : 88.12 %
 Unit Capability Factor (UCF) : 88.71 %
 Load Factor (LF) : 88.13 %
 Operating Factor (OF) : 89.5 %

Forced Loss Rate (FLR) : 6.45 %
 Unplanned Capability Loss Factor (UCL) : 6.59 %
 Planned Unavailability Factor (PUF) : 4.7 %
 Externally cause unavailability (XUF) : 0.6 %
 Total off-line time : 920 hours

Annual Summary

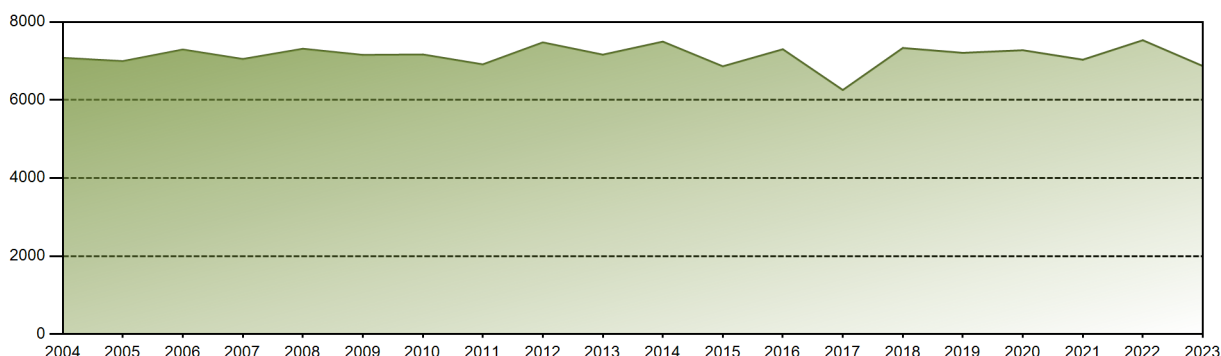


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 602.14 | 599.19 | 662.44 | 633.44 | 227.96 | 631.55 | 647.37 | 356.79 | 541.85 | 662.82 | 643.39 | 662.15 | 6871.08 |
| EAF [%] | 90.71 | 100.00 | 99.94 | 98.83 | 35.39 | 98.56 | 97.77 | 53.89 | 84.56 | 99.97 | 99.89 | 100.00 | 88.12 |
| UCF [%] | 90.71 | 100.00 | 99.94 | 100.00 | 35.58 | 100.00 | 99.92 | 55.08 | 85.54 | 100.00 | 99.89 | 100.00 | 88.71 |
| LF [%] | 90.94 | 100.19 | 100.18 | 98.85 | 34.43 | 98.56 | 97.77 | 53.88 | 84.56 | 99.97 | 100.40 | 100.00 | 88.13 |
| OF [%] | 94.22 | 100.00 | 100.00 | 100.00 | 39.11 | 100.00 | 100.00 | 55.38 | 87.22 | 100.00 | 100.00 | 100.00 | 89.50 |
| FLR [%] | 9.09 | 0.00 | 0.00 | 0.00 | 10.32 | 0.00 | 0.00 | 44.92 | 14.46 | 0.00 | 0.00 | 0.00 | 6.45 |
| UCL [%] | 9.07 | 0.00 | 0.00 | 0.00 | 9.59 | 0.00 | 0.00 | 44.92 | 14.46 | 0.00 | 0.00 | 0.00 | 6.59 |
| PUF [%] | 0.22 | 0.00 | 0.06 | 0.00 | 54.83 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 4.70 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 1.17 | 0.19 | 1.44 | 2.15 | 1.19 | 0.98 | 0.03 | 0.00 | 0.00 | 0.60 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 278960.82 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.33 % |
| Cumulative Energy Availability Factor (EAF) | : 92.99 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.66 % |
| Cumulative Unit Capability Factor (UCF) | : 93.53 % | Cumulative Planned Unavailability Factor (PUF) | : 4.81 % |
| Cumulative Load Factor (LF) | : 92.89 % | Cumulative Externally cause unavailability (XUF) | : 0.55 % |
| Cumulative Operating Factor (OF) | : 94.08 % | | |

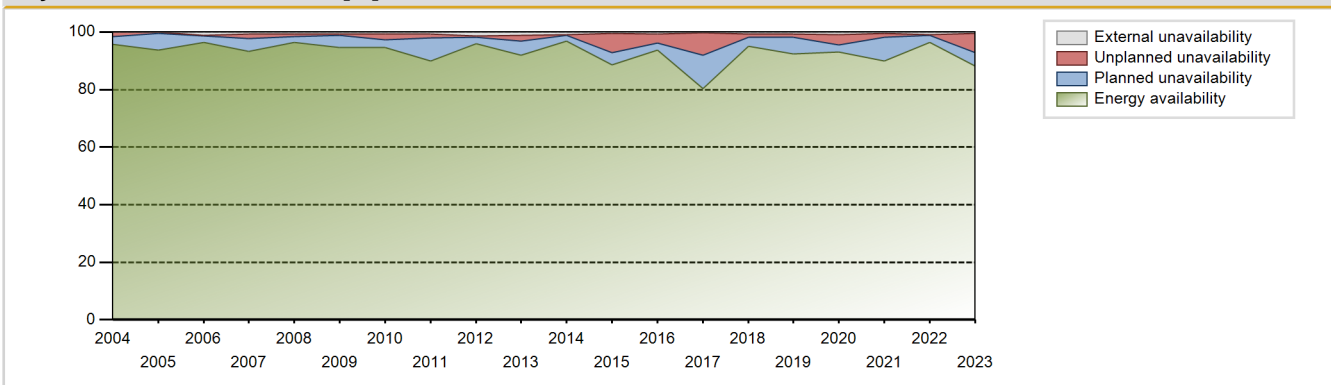
Electricity Production (net) [GWh]



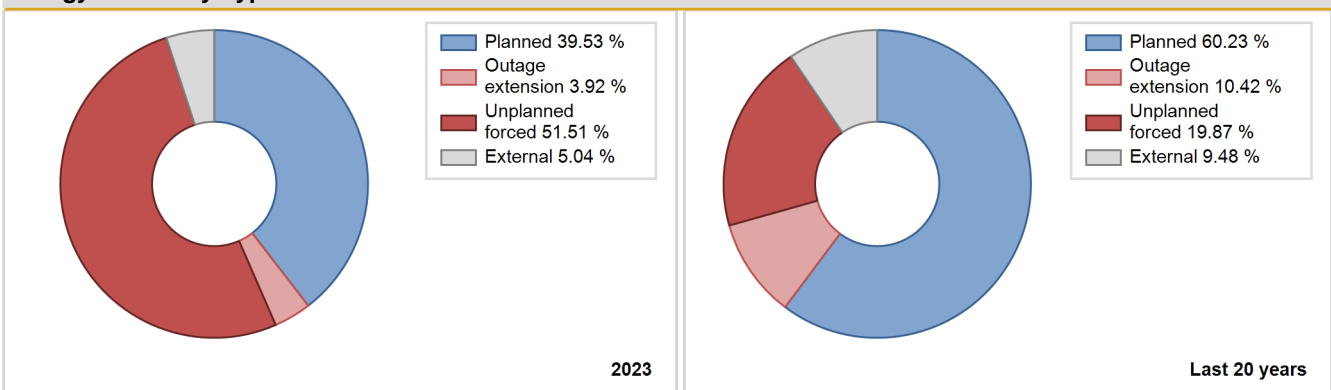
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1982 | 4587.10 | 7269 | 658 | 77.65 | 77.65 | 77.64 | 79.53 | 2.38 | 1.89 | 20.45 | 0.00 |
| 1983 | 5087.20 | 8221 | 657 | 86.75 | 86.75 | 88.39 | 93.85 | 5.00 | 4.57 | 8.69 | 0.00 |
| 1984 | 5341.30 | 8031 | 696 | 89.57 | 89.57 | 87.28 | 91.43 | 1.96 | 1.79 | 8.64 | 0.00 |
| 1985 | 5415.79 | 7912 | 710 | 88.16 | 88.16 | 87.08 | 90.32 | 1.98 | 1.78 | 10.06 | 0.00 |
| 1986 | 5840.21 | 8437 | 710 | 95.07 | 95.07 | 93.90 | 96.31 | 0.32 | 0.30 | 4.63 | 0.00 |
| 1987 | 5725.03 | 8379 | 710 | 93.71 | 93.71 | 92.05 | 95.65 | 1.41 | 1.34 | 4.95 | 0.00 |
| 1988 | 5713.20 | 8220 | 710 | 92.73 | 92.73 | 91.61 | 93.58 | 2.89 | 2.76 | 4.51 | 0.00 |
| 1989 | 5827.02 | 8363 | 710 | 94.94 | 94.94 | 93.69 | 95.47 | 0.39 | 0.37 | 4.69 | 0.00 |
| 1990 | 5749.87 | 8265 | 710 | 93.78 | 93.78 | 92.45 | 94.35 | 1.20 | 1.14 | 5.09 | 0.00 |
| 1991 | 5730.95 | 8216 | 710 | 92.96 | 93.67 | 92.14 | 93.79 | 2.10 | 2.01 | 4.32 | 0.71 |
| 1992 | 5790.44 | 8306 | 710 | 93.31 | 94.54 | 92.85 | 94.56 | 1.63 | 1.57 | 3.89 | 1.23 |
| 1993 | 5861.56 | 8327 | 710 | 94.38 | 95.14 | 94.24 | 95.06 | 0.16 | 0.15 | 4.71 | 0.76 |
| 1994 | 5732.63 | 8130 | 710 | 92.30 | 93.15 | 92.17 | 92.81 | 0.10 | 0.09 | 6.76 | 0.85 |
| 1995 | 5747.24 | 8236 | 710 | 92.47 | 93.71 | 92.42 | 94.03 | 1.88 | 1.79 | 4.50 | 1.24 |
| 1996 | 5915.41 | 8413 | 710 | 94.96 | 95.29 | 94.85 | 95.78 | 1.49 | 1.44 | 3.27 | 0.33 |
| 1997 | 6077.04 | 8258 | 736 | 93.74 | 94.56 | 94.14 | 94.27 | 0.22 | 0.21 | 5.23 | 0.82 |
| 1998 | 6628.46 | 8207 | 840 | 93.23 | 94.29 | 90.08 | 93.69 | 0.51 | 0.48 | 5.22 | 1.06 |
| 1999 | 7091.21 | 8505 | 840 | 96.43 | 96.86 | 96.37 | 97.09 | 0.17 | 0.17 | 2.97 | 0.43 |
| 2000 | 7028.90 | 8457 | 840 | 95.31 | 95.93 | 95.26 | 96.28 | 0.15 | 0.15 | 3.92 | 0.61 |
| 2001 | 6988.00 | 8387 | 840 | 95.12 | 95.12 | 94.97 | 95.74 | 0.52 | 0.49 | 4.39 | 0.00 |
| 2002 | 7108.51 | 8472 | 840 | 96.79 | 96.96 | 96.59 | 96.70 | 0.47 | 0.46 | 2.58 | 0.16 |
| 2003 | 7026.86 | 8378 | 840 | 95.16 | 95.48 | 95.49 | 95.64 | 0.39 | 0.62 | 3.90 | 0.33 |
| 2004 | 7080.70 | 8485 | 840 | 95.81 | 95.81 | 95.96 | 96.60 | 1.23 | 1.55 | 2.64 | 0.00 |
| 2005 | 6996.68 | 8248 | 860 | 93.80 | 93.82 | 93.96 | 94.16 | 0.05 | 0.41 | 5.77 | 0.01 |
| 2006 | 7294.36 | 8562 | 860 | 96.37 | 97.43 | 96.82 | 97.74 | 0.21 | 0.28 | 2.29 | 1.06 |
| 2007 | 7051.32 | 8258 | 860 | 93.21 | 94.01 | 93.60 | 94.27 | 1.01 | 1.53 | 4.45 | 0.81 |
| 2008 | 7313.82 | 8579 | 860 | 96.29 | 96.94 | 96.82 | 97.67 | 0.80 | 0.85 | 2.21 | 0.65 |
| 2009 | 7156.34 | 8365 | 860 | 94.53 | 95.20 | 94.99 | 95.49 | 0.14 | 0.58 | 4.23 | 0.66 |
| 2010 | 7167.34 | 8386 | 860 | 94.59 | 95.29 | 95.14 | 95.73 | 1.45 | 2.03 | 2.67 | 0.70 |
| 2011 | 6913.53 | 7987 | 880 | 89.88 | 90.69 | 90.71 | 91.18 | 0.39 | 1.31 | 8.00 | 0.81 |
| 2012 | 7477.19 | 8561 | 880 | 95.85 | 97.30 | 96.73 | 97.46 | 0.00 | 0.37 | 2.32 | 1.46 |
| 2013 | 7162.81 | 8171 | 880 | 92.03 | 93.11 | 92.92 | 93.28 | 1.98 | 2.15 | 4.74 | 1.09 |
| 2014 | 7496.54 | 8567 | 880 | 96.75 | 97.61 | 97.25 | 97.80 | 0.15 | 0.20 | 2.19 | 0.86 |
| 2015 | 6863.99 | 7856 | 880 | 88.52 | 89.08 | 89.04 | 89.68 | 6.32 | 6.70 | 4.22 | 0.56 |
| 2016 | 7300.52 | 8381 | 880 | 93.78 | 94.58 | 94.45 | 95.41 | 2.81 | 3.03 | 2.39 | 0.80 |
| 2017 | 6256.41 | 7132 | 880 | 80.36 | 80.53 | 81.16 | 81.42 | 1.89 | 7.84 | 11.63 | 0.17 |
| 2018 | 7333.77 | 8350 | 890 | 95.01 | 95.65 | 94.07 | 95.32 | 0.45 | 1.27 | 3.09 | 0.64 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|------|------|
| 2019 | 7209.08 | 8162 | 890 | 92.33 | 92.95 | 92.47 | 93.17 | 1.16 | 1.16 | 5.88 | 0.63 |
| 2020 | 7276.55 | 8289 | 890 | 93.13 | 93.97 | 93.08 | 94.36 | 2.87 | 3.58 | 2.45 | 0.84 |
| 2021 | 7033.38 | 7941 | 890 | 89.94 | 90.35 | 90.21 | 90.65 | 0.58 | 1.41 | 8.24 | 0.41 |
| 2022 | 7532.48 | 8539 | 890 | 96.47 | 97.29 | 96.61 | 97.48 | 0.00 | 0.42 | 2.29 | 0.82 |
| 2023 | 6871.08 | 7840 | 890 | 88.12 | 88.71 | 88.13 | 89.50 | 6.45 | 6.59 | 4.70 | 0.60 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1982 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 534 | | | 306 | |
| B. Refuelling without maintenance | | | | 33 | | |
| C. Inspection, maintenance or repair combined with refuelling | 387 | | | 360 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 8 | | |
| E. Testing of plant systems or components | | | | 17 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 24 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 11 |
| L. Human factor related | | | | | 7 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| P. Fire | | | | | 0 | |
| Z. Other | | | | | 1 | 0 |
| Subtotal | 387 | 534 | | 442 | 315 | 15 |
| Total | | 921 | | | 772 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1982 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 21 |
| 12. Reactor I&C Systems | | 1 |
| 13. Reactor Auxiliary Systems | 41 | 1 |
| 14. Safety Systems | | 4 |
| 15. Reactor Cooling Systems | | 21 |
| 21. Fuel Handling and Storage Facilities | | 2 |
| 31. Turbine and auxiliaries | 26 | 7 |
| 32. Feedwater and Main Steam System | 43 | 10 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 0 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | 424 | 218 |
| 42. Electrical Power Supply Systems | | 3 |
| Total | 534 | 290 |

Highlights (2023)

The electricity production of the Olkiluoto power plant units OL1, OL2 and OL3 during 2023 was 24,671 GWh.

OL2's net production was 6,871 GWh.

OL2 plant unit was out of production from January 27 to January 29 due to repair of one main steam line valve. After annual outage during the start-up operation on May 19 there happened automatic scram due to high conductivity in condenser.

There was cold shutdown due to leak in main generator cooling system from August 18 to September 4.

The annual outages of 2023 at the Olkiluoto nuclear power plant were carried out from April 16 to May 19, 2023. OL2 was performed a maintenance outage taking more than 17 days, and OL1 performed a refueling outage that lasted over 10 days. The annual outage period was about four days longer than expected. The schedule was affected mainly from relief system. In all other respects annual outages were implemented according to plans. The OL3 plant unit first annual outage starts on March 3, 2024.

2023 Operating Experience

FI-5

OLKILUOTO-3

FINLAND

Status at end of year : **Operational**
 Operator : TVO (TEOLLISUUDEN VOIMA OYJ)
 Owner : TVO (TEOLLISUUDEN VOIMA OYJ)
 Reactor Supplier : ORANO (ORANO)
 Turbine Supplier : SIEMENS (Siemens AG, Power Generation)



Reactor Unit Details

Reactor type and model : PWR / EPR
 Thermal power : 4300 MWth
 Gross electrical power : 1660 MWe
 Reference unit power (net) : 1600 MWe

Key Dates

Construction Date : 2005-08-12
 Grid Date : 2022-03-12
 Commercial Date : 2023-05-01
 Age at end of year : 1 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.54
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 47500
 Active core diameter [m] : 3.77
 Active core height/length [m] : 4.2
 Number of fissile fuel assemblies/bundles : 241
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : 89
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 312
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.53

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 7
 Output voltage [kV] : 27
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 6

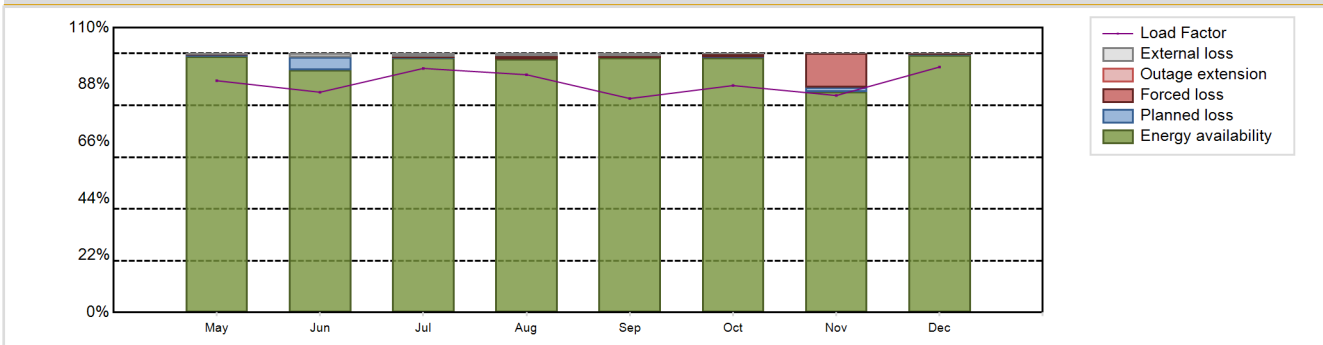
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 10371.84 GW(e).h
 Energy Availability Factor (EAF) : 96.28 %
 Unit Capability Factor (UCF) : 96.85 %
 Load Factor (LF) : 88.76 %
 Operating Factor (OF) : 98.57 %
 Forced Loss Rate (FLR) : 2.19 %
 Unplanned Capability Loss Factor (UCL) : 2.17 %
 Planned Unavailability Factor (PUF) : 0.98 %
 Externally cause unavailability (XUF) : 0.57 %
 Total off-line time : 1604 hours

Annual Summary

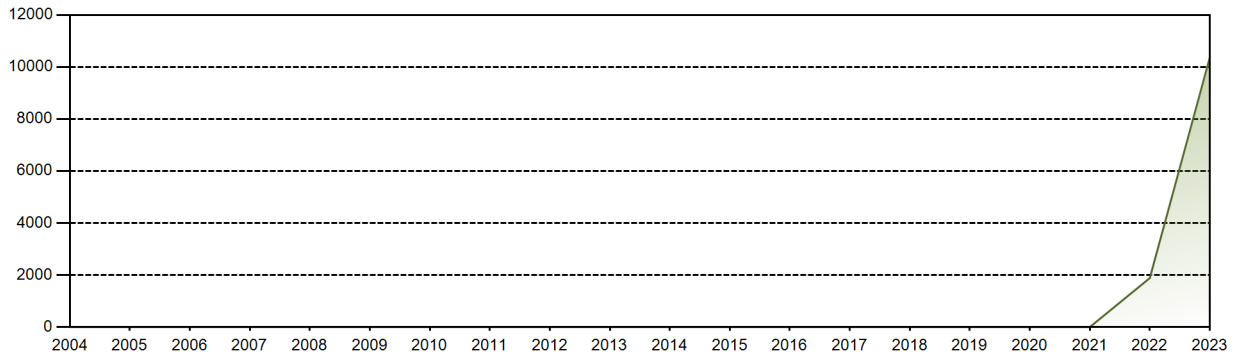


| | Apr | Jan | Feb | Mar | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-----|-----|-----|-----|---------|--------|---------|---------|--------|---------|--------|---------|---------|
| GW(e)-h | | | | | 1065.69 | 980.14 | 1122.28 | 1093.29 | 952.04 | 1044.85 | 965.31 | 1128.76 | 8352.35 |
| EAF [%] | | | | | 98.87 | 93.55 | 98.28 | 97.82 | 98.45 | 98.38 | 85.10 | 99.42 | 96.28 |
| UCF [%] | | | | | 99.23 | 94.94 | 99.30 | 98.61 | 99.28 | 98.60 | 85.10 | 99.42 | 96.85 |
| LF [%] | | | | | 89.52 | 85.08 | 94.28 | 91.84 | 82.64 | 87.66 | 83.79 | 94.82 | 88.76 |
| OF [%] | | | | | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.33 | 100.00 | 98.57 |
| FLR [%] | | | | | 0.03 | 0.00 | 0.62 | 1.39 | 0.72 | 1.23 | 13.38 | 0.45 | 2.19 |
| UCL [%] | | | | | 0.03 | 0.00 | 0.62 | 1.39 | 0.72 | 1.22 | 13.15 | 0.45 | 2.17 |
| PUF [%] | | | | | 0.74 | 5.06 | 0.08 | 0.00 | 0.00 | 0.18 | 1.75 | 0.13 | 0.98 |
| XUF [%] | | | | | 0.36 | 1.39 | 1.02 | 0.79 | 0.83 | 0.21 | 0.00 | 0.00 | 0.57 |

Historical Summary

| | | | |
|---|-------------------|---|----------|
| Lifetime energy generation | : 12258.4 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.19 % |
| Cumulative Energy Availability Factor (EAF) | : 96.28 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.17 % |
| Cumulative Unit Capability Factor (UCF) | : 96.85 % | Cumulative Planned Unavailability Factor (PUF) | : 0.98 % |
| Cumulative Load Factor (LF) | : 88.76 % | Cumulative Externally cause unavailability (XUF) | : 0.57 % |
| Cumulative Operating Factor (OF) | : 98.57 % | | |

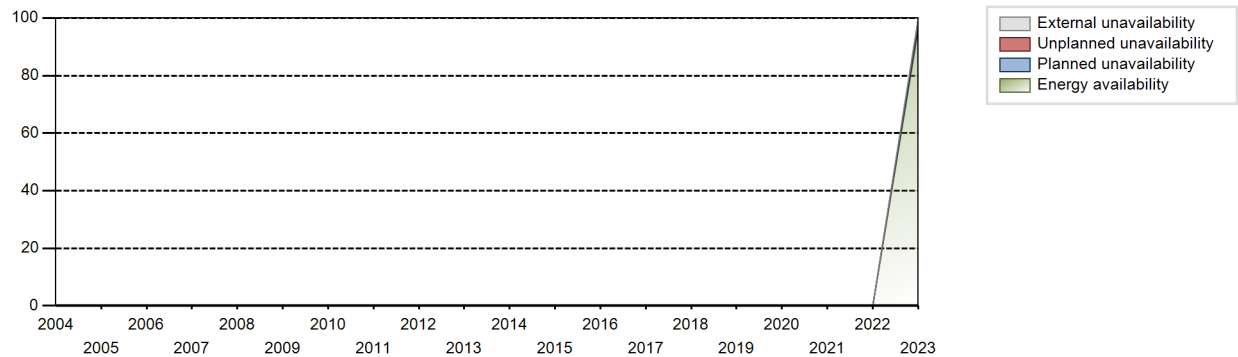
Electricity Production (net) [GWh]



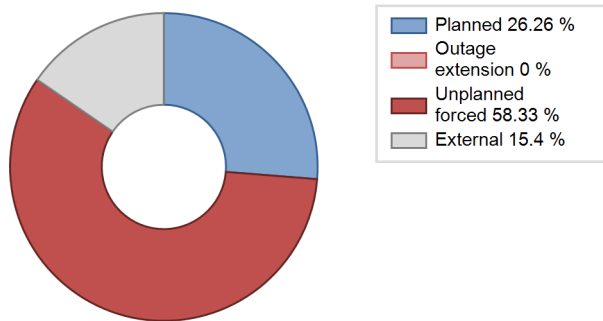
Performance for Years of Commercial Operation

| Year | Energy | Time Online | Reference Unit Power | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|----------|-------------|----------------------|-------|-------|-------|-------|------|------|------|------|
| | [GW-h] | [Hours] | [MW] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2023 | 10371.84 | 7156 | 1600 | 96.28 | 96.85 | 88.76 | 98.57 | 2.19 | 2.17 | 0.98 | 0.57 |

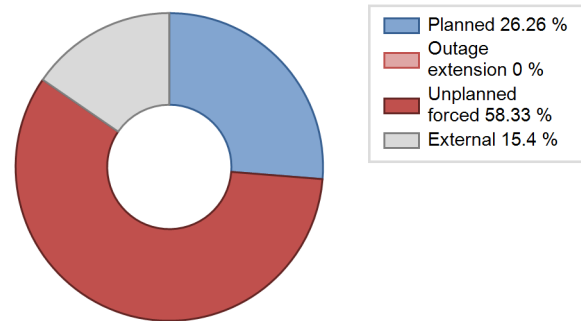
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2023 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1572 | | | 5849 | |
| E. Testing of plant systems or components | | 30 | | | 45 | |
| Z. Other | | | | | 3590 | |
| Subtotal | | 1602 | | | 9484 | |
| Total | | 1602 | | | 9484 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2023 to 2023 | |
|-------------------------------------|------------|-------------|-------------------------------------|-------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 916 | | 500 |
| 12. Reactor I&C Systems | | | | 60 |
| 31. Turbine and auxiliaries | | | | 197 |
| 32. Feedwater and Main Steam System | | 602 | | 1324 |
| 41. Main Generator Systems | | 53 | | 47 |
| 42. Electrical Power Supply Systems | | 30 | | 16 |
| Total | | 1601 | | 2144 |

Highlights (2023)

The electricity production of the Olkiluoto power plant units OL1, OL2 and OL3 during 2023 was 24,671 GWh.

OL3's net production was 10,372 GWh.

OL3 plant unit commissioning phase continued until January 10, when cold shutdown started due to feedwater pumps inspections. Cold shutdown due to feedwater pumps inspections and replacement of impellers ended February 5. February 12 the plant unit decided to run in cold shutdown due to inspections and maintenance of pressurizer valves. The maintenance works were completed in March 8th. Commissioning phase continued until April 16, when regular electricity production started.

Commercial operation started May 1. The plant unit has produced electricity throughout the rest of the year expect for two turbine trips in November. The first happened on November 19 due to failure in temperature measurement of the generator cooling system. Production continued November 22. The second turbine trip happened on November 29 because of the near failure test. Production continued November 30. The power of the plant unit has been limited from time to time by the system protection, grid limitation and also low demand of electricity.

The OL3 plant unit first annual outage starts on March 3, 2024.

2023 Operating Experience

FR-54

BELLEVILLE-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)



Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1363 MWe
 Reference unit power (net) : 1310 MWe

Key Dates

Construction Date : 1980-05-01
 Grid Date : 1987-10-14
 Commercial Date : 1988-06-01
 Age at end of year : 36 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2/MOX
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.25
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.5
 Number of control rod assemblies : 51
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

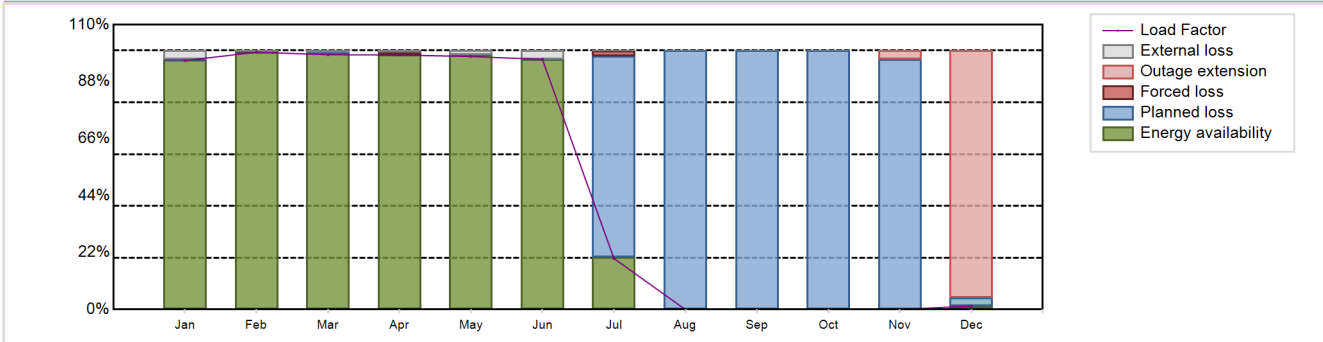
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5765.7 GW(e).h
 Energy Availability Factor (EAF) : 50.43 %
 Unit Capability Factor (UCF) : 51.3 %
 Load Factor (LF) : 50.24 %
 Operating Factor (OF) : 51.84 %
 Forced Loss Rate (FLR) : 0.53 %
 Unplanned Capability Loss Factor (UCL) : 8.64 %
 Planned Unavailability Factor (PUF) : 40.06 %
 Externally cause unavailability (XUF) : 0.87 %
 Total off-line time : 4219 hours

Annual Summary

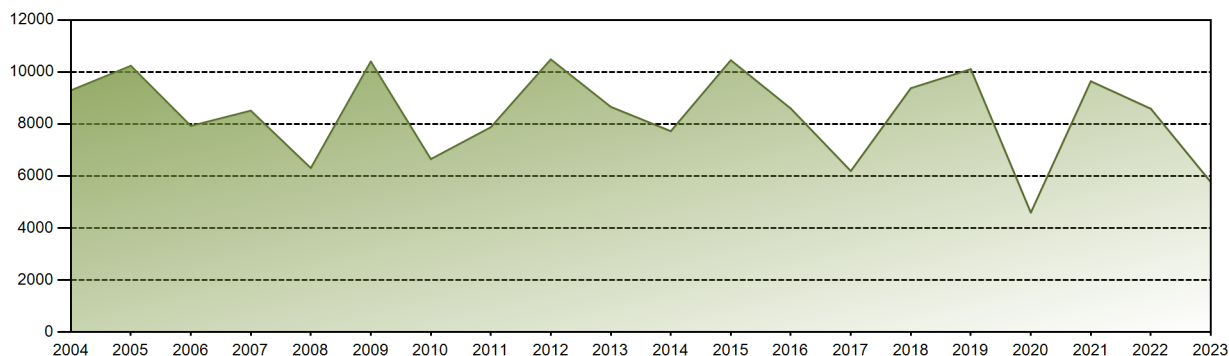


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|---------|
| GW(e)-h | 937.02 | 874.93 | 957.84 | 926.93 | 952.49 | 910.92 | 192.20 | 0.00 | 0.00 | 0.00 | 0.00 | 13.37 | 5765.70 |
| EAF [%] | 96.45 | 99.37 | 99.19 | 98.36 | 98.27 | 96.58 | 20.26 | 0.00 | 0.00 | 0.00 | 0.00 | 1.37 | 50.43 |
| UCF [%] | 99.88 | 99.83 | 99.94 | 98.98 | 99.93 | 99.95 | 20.33 | 0.00 | 0.00 | 0.00 | 0.00 | 1.37 | 51.30 |
| LF [%] | 96.14 | 99.39 | 98.41 | 98.27 | 97.73 | 96.58 | 19.72 | 0.00 | 0.00 | 0.00 | 0.00 | 1.37 | 50.24 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 22.58 | 0.00 | 0.00 | 0.00 | 0.00 | 4.03 | 51.84 |
| FLR [%] | 0.08 | 0.15 | 0.00 | 0.99 | 0.00 | 0.00 | 9.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.53 |
| UCL [%] | 0.08 | 0.15 | 0.00 | 0.99 | 0.00 | 0.00 | 2.07 | 0.00 | 0.00 | 0.00 | 3.33 | 95.31 | 8.64 |
| PUF [%] | 0.04 | 0.02 | 0.06 | 0.02 | 0.07 | 0.05 | 77.60 | 100.00 | 100.00 | 100.00 | 96.67 | 3.31 | 40.06 |
| XUF [%] | 3.43 | 0.46 | 0.75 | 0.63 | 1.65 | 3.37 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.87 |

Historical Summary

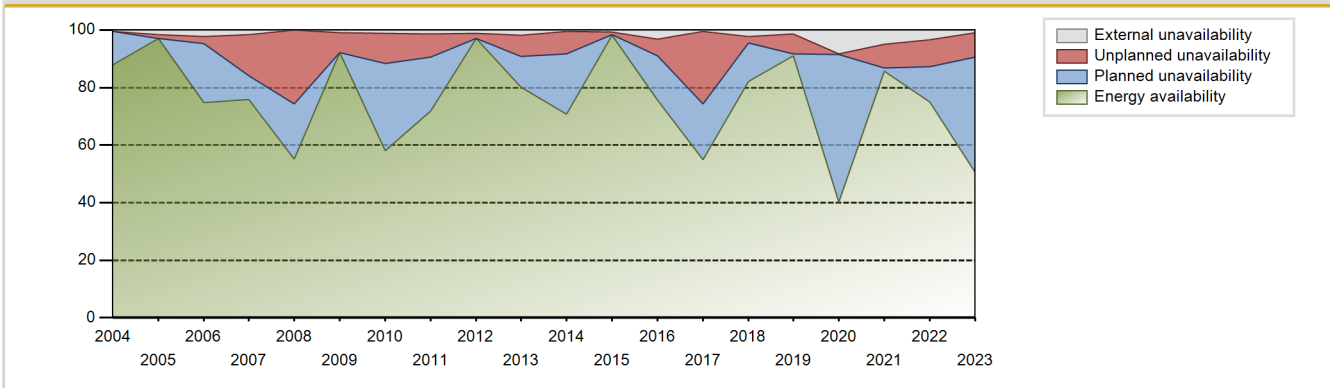
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 291246.47 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.05 % |
| Cumulative Energy Availability Factor (EAF) | : 75.06 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.48 % |
| Cumulative Unit Capability Factor (UCF) | : 76.74 % | Cumulative Planned Unavailability Factor (PUF) | : 14.79 % |
| Cumulative Load Factor (LF) | : 70.58 % | Cumulative Externally cause unavailability (XUF) | : 1.68 % |
| Cumulative Operating Factor (OF) | : 77.23 % | | |

Electricity Production (net) [GWh]

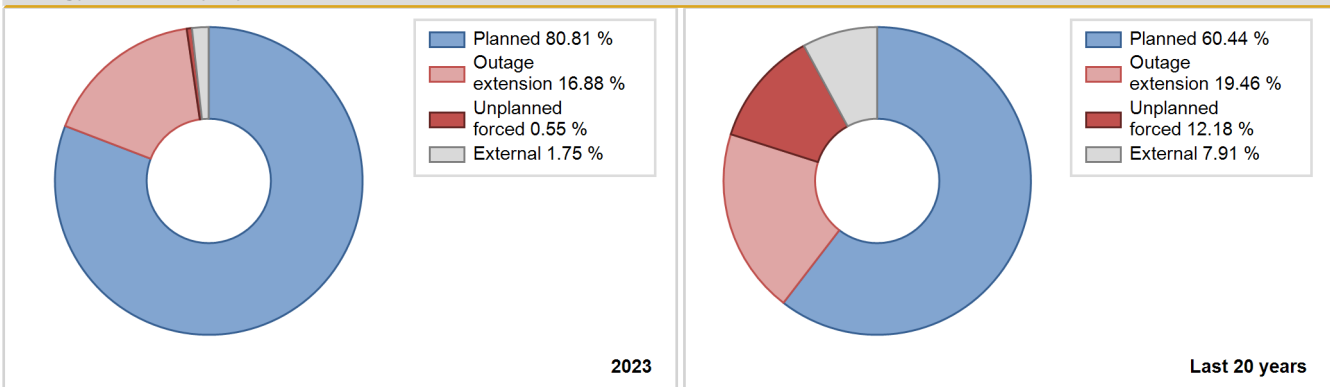


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 6283.00 | 6478 | 1310 | 85.78 | 86.06 | 64.40 | 86.06 | 13.94 | 13.94 | 0.00 | 0.28 |
| 1989 | 5152.56 | 4244 | 1310 | 45.97 | 46.53 | 44.90 | 48.45 | 30.63 | 20.55 | 32.93 | 0.55 |
| 1990 | 7914.26 | 6408 | 1310 | 71.15 | 71.43 | 68.97 | 73.15 | 12.19 | 9.92 | 18.66 | 0.27 |
| 1991 | 8660.21 | 7092 | 1310 | 79.28 | 80.80 | 75.47 | 80.96 | 5.38 | 4.59 | 14.61 | 1.51 |
| 1992 | 8494.33 | 7600 | 1310 | 91.19 | 91.82 | 73.82 | 86.52 | 6.07 | 5.94 | 2.25 | 0.63 |
| 1993 | 7921.46 | 6873 | 1310 | 71.25 | 77.46 | 69.03 | 78.46 | 7.73 | 6.49 | 16.05 | 6.21 |
| 1994 | 6575.76 | 5848 | 1310 | 63.98 | 65.16 | 57.30 | 66.76 | 24.97 | 21.69 | 13.15 | 1.18 |
| 1995 | 7740.91 | 6796 | 1310 | 73.44 | 76.23 | 67.46 | 77.58 | 8.01 | 6.64 | 17.14 | 2.79 |
| 1996 | 7365.06 | 6002 | 1310 | 76.49 | 76.80 | 64.00 | 68.33 | 12.12 | 10.59 | 12.61 | 0.30 |
| 1997 | 9785.27 | 8294 | 1310 | 93.24 | 93.41 | 85.27 | 94.68 | 5.22 | 5.14 | 1.44 | 0.18 |
| 1998 | 5740.91 | 4865 | 1310 | 51.18 | 53.72 | 50.03 | 55.54 | 38.57 | 33.73 | 12.56 | 2.54 |
| 1999 | 9580.49 | 7957 | 1310 | 90.43 | 91.97 | 83.49 | 90.83 | 1.39 | 1.30 | 6.73 | 1.54 |
| 2000 | 4238.57 | 3459 | 1310 | 37.89 | 37.99 | 36.83 | 39.38 | 9.13 | 3.82 | 58.19 | 0.10 |
| 2001 | 9564.53 | 7774 | 1310 | 86.79 | 87.31 | 83.35 | 88.74 | 2.17 | 1.94 | 10.75 | 0.52 |
| 2002 | 9567.30 | 8447 | 1310 | 98.94 | 99.55 | 83.37 | 96.43 | 0.13 | 0.13 | 0.32 | 0.62 |
| 2003 | 8401.73 | 6871 | 1310 | 75.45 | 77.63 | 73.21 | 78.44 | 8.55 | 7.26 | 15.11 | 2.19 |
| 2004 | 9291.01 | 7645 | 1310 | 88.02 | 88.59 | 80.73 | 87.02 | 0.00 | 0.00 | 11.41 | 0.57 |
| 2005 | 10236.41 | 8646 | 1310 | 97.11 | 98.77 | 89.19 | 98.69 | 1.21 | 1.21 | 0.02 | 1.66 |
| 2006 | 7926.72 | 6870 | 1310 | 74.83 | 77.06 | 69.07 | 78.42 | 2.85 | 2.54 | 20.41 | 2.23 |
| 2007 | 8512.07 | 7213 | 1310 | 75.83 | 77.52 | 74.18 | 82.34 | 7.36 | 14.23 | 8.25 | 1.69 |
| 2008 | 6304.96 | 5615 | 1310 | 55.20 | 55.31 | 54.79 | 63.92 | 21.25 | 25.63 | 19.05 | 0.11 |
| 2009 | 10402.30 | 8350 | 1310 | 92.08 | 93.04 | 90.65 | 95.32 | 6.93 | 6.92 | 0.04 | 0.96 |
| 2010 | 6650.30 | 5370 | 1310 | 58.15 | 59.20 | 57.95 | 61.30 | 3.94 | 10.48 | 30.32 | 1.04 |
| 2011 | 7876.28 | 6525 | 1310 | 71.77 | 73.05 | 68.63 | 74.49 | 2.44 | 8.05 | 18.90 | 1.28 |
| 2012 | 10483.62 | 8691 | 1310 | 97.02 | 98.09 | 91.11 | 98.94 | 1.82 | 1.82 | 0.09 | 1.07 |
| 2013 | 8658.64 | 7309 | 1310 | 80.18 | 82.02 | 75.45 | 83.44 | 1.60 | 7.40 | 10.59 | 1.84 |
| 2014 | 7723.74 | 6391 | 1310 | 70.68 | 71.19 | 67.31 | 72.96 | 7.15 | 7.79 | 21.01 | 0.51 |
| 2015 | 10451.61 | 8660 | 1310 | 98.29 | 99.02 | 91.08 | 98.86 | 0.96 | 0.96 | 0.02 | 0.74 |
| 2016 | 8593.89 | 7106 | 1310 | 75.60 | 78.78 | 74.68 | 80.90 | 4.70 | 5.82 | 15.39 | 3.19 |
| 2017 | 6191.21 | 4991 | 1310 | 54.88 | 55.44 | 53.95 | 56.97 | 4.33 | 25.13 | 19.43 | 0.56 |
| 2018 | 9375.77 | 7412 | 1310 | 82.19 | 84.49 | 81.70 | 84.61 | 1.42 | 2.29 | 13.21 | 2.30 |
| 2019 | 10111.20 | 8130 | 1310 | 91.04 | 92.33 | 88.11 | 92.81 | 0.30 | 7.09 | 0.58 | 1.29 |
| 2020 | 4590.82 | 3767 | 1310 | 40.13 | 48.36 | 39.90 | 42.88 | 0.46 | 0.22 | 51.42 | 8.22 |
| 2021 | 9643.04 | 7845 | 1310 | 85.62 | 90.48 | 84.03 | 89.55 | 2.90 | 8.32 | 1.21 | 4.85 |
| 2022 | 8586.60 | 6891 | 1310 | 75.10 | 78.53 | 74.82 | 78.66 | 3.40 | 9.24 | 12.23 | 3.43 |
| 2023 | 5765.70 | 4541 | 1310 | 50.43 | 51.30 | 50.24 | 51.84 | 0.53 | 8.64 | 40.06 | 0.87 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 733 | | | 568 | |
| B. Refuelling without maintenance | | | | 121 | | |
| C. Inspection, maintenance or repair combined with refuelling | 3485 | | | 1248 | 6 | |
| D. Inspection, maintenance or repair without refuelling | | | | 5 | | |
| E. Testing of plant systems or components | 0 | | | 36 | | 0 |
| H. Nuclear regulatory requirements | | | | | 66 | |
| L. Human factor related | | | | | 14 | |
| M. Governmental requirements or court decisions | | | | | | 3 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 29 |
| O. Load dispatching, prioritization | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 2 | 43 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 1 |
| Z. Other | | | | | 16 | 4 |
| Subtotal | 3485 | 733 | | 1410 | 674 | 80 |
| Total | | 4218 | | | 2164 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 20 |
| 12. Reactor I&C Systems | | 51 |
| 13. Reactor Auxiliary Systems | | 38 |
| 14. Safety Systems | | 26 |
| 15. Reactor Cooling Systems | | 26 |
| 16. Steam generation systems | | 38 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 7 |
| 31. Turbine and auxiliaries | | 52 |
| 32. Feedwater and Main Steam System | | 61 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | 733 | 181 |
| 35. All other I&C Systems | | 10 |
| 41. Main Generator Systems | | 30 |
| 42. Electrical Power Supply Systems | | 19 |
| Total | 733 | 560 |

2023 Operating Experience

FR-55

BELLEVILLE-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)



Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1363 MWe
 Reference unit power (net) : 1310 MWe

Key Dates

Construction Date : 1980-08-01
 Grid Date : 1988-07-06
 Commercial Date : 1989-01-01
 Age at end of year : 35 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.25
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.5
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

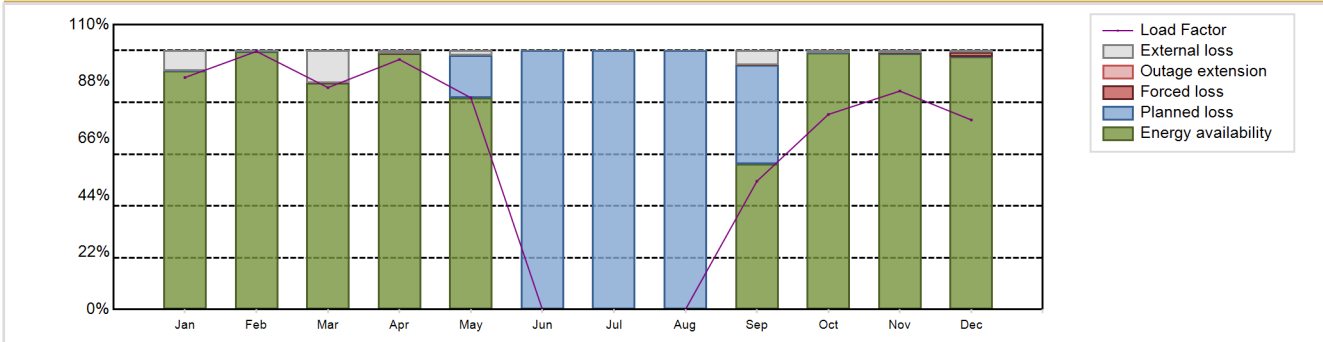
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7004.38 GW(e).h
 Energy Availability Factor (EAF) : 67.41 %
 Unit Capability Factor (UCF) : 70.09 %
 Load Factor (LF) : 61.04 %
 Operating Factor (OF) : 70.68 %
 Forced Loss Rate (FLR) : 0.22 %
 Unplanned Capability Loss Factor (UCL) : 0.16 %
 Planned Unavailability Factor (PUF) : 29.75 %
 Externally cause unavailability (XUF) : 2.68 %
 Total off-line time : 2568 hours

Annual Summary

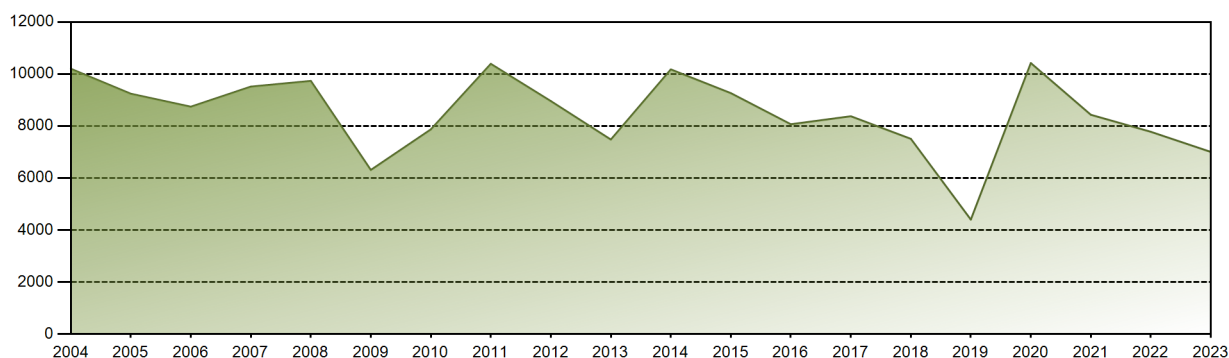


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 873.22 | 877.60 | 834.25 | 910.65 | 796.88 | 0.00 | 0.00 | 0.00 | 467.16 | 735.33 | 795.74 | 713.53 | 7004.38 |
| EAF [%] | 92.10 | 99.57 | 87.39 | 98.89 | 81.76 | 0.00 | 0.00 | 0.00 | 56.22 | 99.11 | 98.89 | 97.60 | 67.41 |
| UCF [%] | 99.96 | 99.97 | 99.89 | 99.93 | 83.61 | 0.00 | 0.00 | 0.00 | 61.83 | 99.96 | 99.86 | 98.35 | 70.09 |
| LF [%] | 89.59 | 99.69 | 85.71 | 96.55 | 81.76 | 0.00 | 0.00 | 0.00 | 49.53 | 75.35 | 84.37 | 73.21 | 61.04 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 83.87 | 0.00 | 0.00 | 0.00 | 66.81 | 99.87 | 100.00 | 100.00 | 70.68 |
| FLR [%] | 0.00 | 0.00 | 0.10 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 1.62 | 0.22 |
| UCL [%] | 0.00 | 0.00 | 0.10 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 1.62 | 0.16 |
| PUF [%] | 0.04 | 0.03 | 0.01 | 0.04 | 16.39 | 100.00 | 100.00 | 100.00 | 38.17 | 0.04 | 0.05 | 0.02 | 29.75 |
| XUF [%] | 7.86 | 0.40 | 12.50 | 1.04 | 1.85 | 0.00 | 0.00 | 0.00 | 5.60 | 0.85 | 0.97 | 0.75 | 2.68 |

Historical Summary

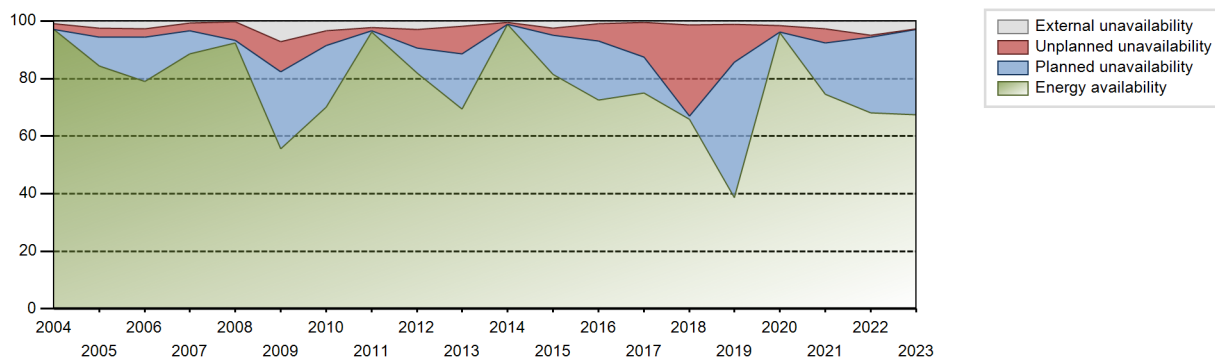
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 290196.67 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.63 % |
| Cumulative Energy Availability Factor (EAF) | : 76.49 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.34 % |
| Cumulative Unit Capability Factor (UCF) | : 78.47 % | Cumulative Planned Unavailability Factor (PUF) | : 14.19 % |
| Cumulative Load Factor (LF) | : 71.65 % | Cumulative Externally cause unavailability (XUF) | : 1.98 % |
| Cumulative Operating Factor (OF) | : 78.71 % | | |

Electricity Production (net) [GWh]

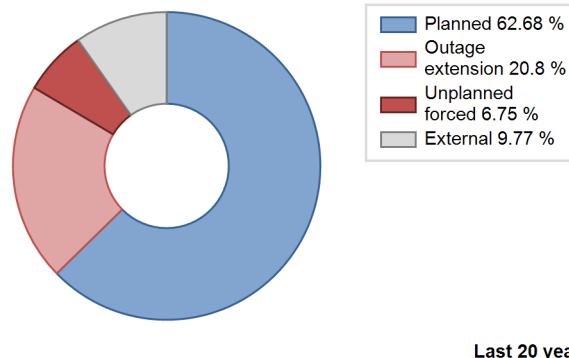
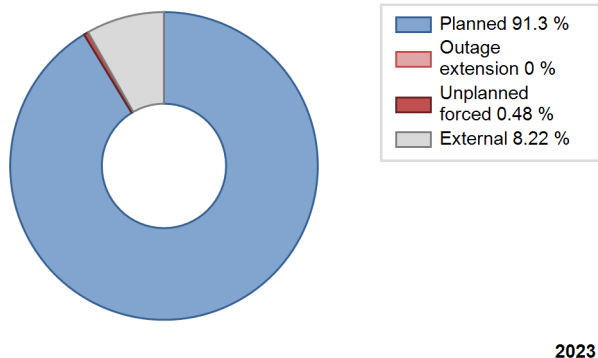


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 8505.66 | 7419 | 1310 | 86.64 | 86.97 | 74.12 | 84.69 | 12.32 | 12.23 | 0.80 | 0.33 |
| 1990 | 6323.98 | 5350 | 1310 | 56.88 | 58.44 | 55.11 | 61.07 | 15.85 | 11.01 | 30.55 | 1.56 |
| 1991 | 7876.29 | 6578 | 1310 | 70.27 | 73.35 | 68.64 | 75.09 | 11.31 | 9.35 | 17.30 | 3.08 |
| 1992 | 8262.05 | 6904 | 1310 | 75.27 | 75.86 | 71.80 | 78.60 | 8.44 | 7.00 | 17.15 | 0.59 |
| 1993 | 8871.34 | 7435 | 1310 | 80.13 | 83.38 | 77.31 | 84.87 | 1.52 | 1.28 | 15.33 | 3.25 |
| 1994 | 8241.32 | 7122 | 1310 | 76.93 | 80.38 | 71.82 | 81.30 | 4.04 | 3.39 | 16.23 | 3.45 |
| 1995 | 7960.50 | 7438 | 1310 | 97.53 | 99.26 | 69.37 | 84.91 | 0.58 | 0.58 | 0.16 | 1.73 |
| 1996 | 7229.81 | 6666 | 1310 | 71.15 | 74.45 | 62.83 | 75.89 | 13.79 | 11.91 | 13.64 | 3.30 |
| 1997 | 8508.10 | 7339 | 1310 | 82.04 | 84.87 | 74.14 | 83.78 | 1.24 | 1.07 | 14.07 | 2.83 |
| 1998 | 5068.01 | 4239 | 1310 | 45.03 | 45.03 | 44.16 | 48.39 | 54.74 | 54.45 | 0.51 | 0.01 |
| 1999 | 4899.26 | 4040 | 1310 | 43.32 | 44.82 | 42.69 | 46.12 | 7.10 | 3.43 | 51.75 | 1.50 |
| 2000 | 9882.48 | 8271 | 1310 | 96.68 | 97.43 | 85.88 | 94.16 | 2.11 | 2.10 | 0.47 | 0.75 |
| 2001 | 8457.97 | 6935 | 1310 | 78.58 | 79.16 | 73.70 | 79.17 | 8.87 | 7.71 | 13.14 | 0.57 |
| 2002 | 9378.75 | 7687 | 1310 | 84.29 | 86.15 | 81.73 | 87.75 | 2.17 | 1.91 | 11.94 | 1.86 |
| 2003 | 8624.72 | 7135 | 1310 | 79.44 | 80.37 | 75.16 | 81.45 | 7.22 | 6.25 | 13.37 | 0.93 |
| 2004 | 10202.59 | 8621 | 1310 | 97.05 | 98.01 | 88.66 | 98.14 | 1.97 | 1.97 | 0.03 | 0.95 |
| 2005 | 9242.31 | 7767 | 1310 | 84.39 | 86.90 | 80.53 | 88.65 | 0.73 | 3.01 | 10.09 | 2.51 |
| 2006 | 8743.63 | 7309 | 1310 | 79.06 | 81.71 | 76.19 | 83.44 | 1.88 | 2.91 | 15.38 | 2.65 |
| 2007 | 9516.03 | 7895 | 1310 | 88.63 | 89.44 | 82.92 | 90.13 | 2.27 | 2.63 | 7.94 | 0.81 |
| 2008 | 9734.88 | 8327 | 1310 | 92.36 | 92.61 | 84.60 | 94.80 | 1.98 | 6.39 | 1.00 | 0.25 |
| 2009 | 6310.85 | 5166 | 1310 | 55.55 | 62.73 | 54.99 | 58.97 | 1.45 | 10.48 | 26.79 | 7.18 |
| 2010 | 7869.74 | 6361 | 1310 | 70.02 | 73.51 | 68.58 | 72.61 | 2.31 | 4.98 | 21.51 | 3.49 |
| 2011 | 10390.88 | 8727 | 1310 | 96.07 | 98.36 | 90.55 | 99.62 | 1.07 | 1.07 | 0.58 | 2.28 |
| 2012 | 8959.34 | 7456 | 1310 | 81.86 | 84.76 | 77.86 | 84.88 | 1.03 | 6.41 | 8.83 | 2.89 |
| 2013 | 7480.48 | 6273 | 1310 | 69.44 | 71.15 | 65.19 | 71.61 | 3.40 | 9.79 | 19.06 | 1.71 |
| 2014 | 10177.69 | 8753 | 1310 | 98.91 | 99.44 | 88.69 | 99.92 | 0.53 | 0.53 | 0.03 | 0.54 |
| 2015 | 9264.45 | 7444 | 1310 | 81.50 | 84.06 | 80.73 | 84.98 | 2.65 | 2.29 | 13.65 | 2.56 |
| 2016 | 8068.56 | 6779 | 1310 | 72.65 | 73.67 | 70.12 | 77.17 | 2.11 | 5.83 | 20.50 | 1.03 |
| 2017 | 8376.52 | 6633 | 1310 | 75.05 | 75.51 | 72.99 | 75.72 | 1.17 | 12.12 | 12.36 | 0.47 |
| 2018 | 7508.77 | 6173 | 1310 | 65.77 | 67.09 | 65.43 | 70.47 | 5.52 | 31.75 | 1.16 | 1.32 |
| 2019 | 4402.58 | 3481 | 1310 | 38.58 | 39.65 | 38.36 | 39.74 | 5.69 | 13.16 | 47.19 | 1.07 |
| 2020 | 10421.33 | 8606 | 1310 | 95.84 | 97.41 | 90.56 | 97.97 | 2.34 | 2.33 | 0.26 | 1.57 |
| 2021 | 8432.45 | 6773 | 1310 | 74.48 | 77.22 | 73.48 | 77.32 | 0.39 | 4.85 | 17.93 | 2.74 |
| 2022 | 7778.25 | 6194 | 1310 | 68.17 | 73.16 | 67.78 | 70.71 | 0.75 | 0.56 | 26.28 | 4.99 |
| 2023 | 7004.38 | 6192 | 1310 | 67.41 | 70.09 | 61.04 | 70.68 | 0.22 | 0.16 | 29.75 | 2.68 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|-------------|-------------|-----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 444 | |
| B. Refuelling without maintenance | 2507 | | | 177 | | |
| C. Inspection, maintenance or repair combined with refuelling | 30 | | | 990 | | |
| E. Testing of plant systems or components | 0 | | | 29 | | |
| H. Nuclear regulatory requirements | | | | | 88 | |
| L. Human factor related | | | | | 16 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 30 | | 1 | 38 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 3 |
| Z. Other | | | | | 34 | 3 |
| Subtotal | 2537 | | 30 | 1196 | 583 | 45 |
| Total | | 2567 | | | 1824 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 27 |
| 12. Reactor I&C Systems | | 41 |
| 13. Reactor Auxiliary Systems | | 9 |
| 14. Safety Systems | | 20 |
| 15. Reactor Cooling Systems | | 30 |
| 16. Steam generation systems | | 26 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 7 |
| 21. Fuel Handling and Storage Facilities | | 10 |
| 31. Turbine and auxiliaries | | 33 |
| 32. Feedwater and Main Steam System | | 11 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 199 |
| 35. All other I&C Systems | | 6 |
| 41. Main Generator Systems | | 4 |
| 42. Electrical Power Supply Systems | | 13 |
| Total | | 438 |

2023 Operating Experience

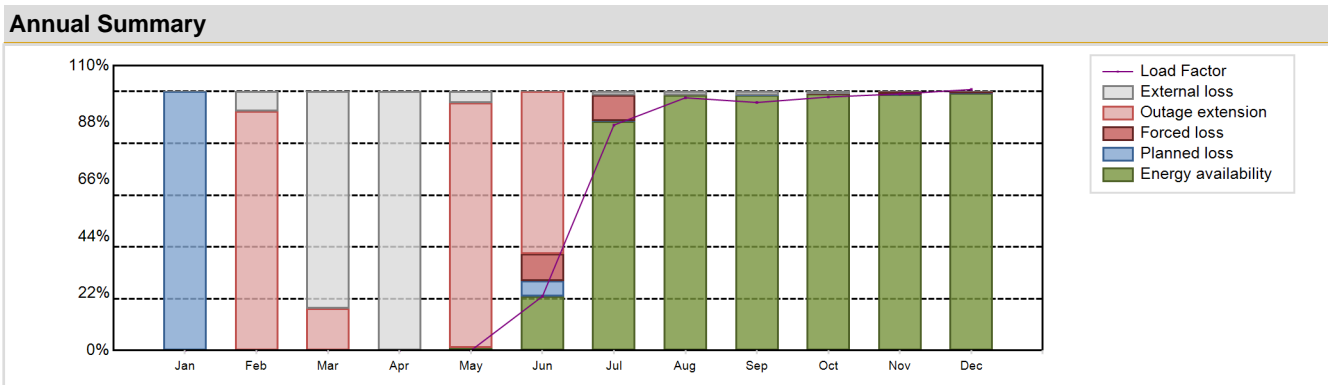
FR-32 **BLAYAIS-1** **FRANCE**

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP1 | Construction Date | : 1977-01-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1981-06-12 |
| Gross electrical power | : 951 MWe | Commercial Date | : 1981-12-01 |
| Reference unit power (net) | : 910 MWe | Age at end of year | : 42 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 323 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33735 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 28 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4010.38 GW(e).h | Forced Loss Rate (FLR) | : 2.65 % |
| Energy Availability Factor (EAF) | : 50.81 % | Unplanned Capability Loss Factor (UCL) | : 23.47 % |
| Unit Capability Factor (UCF) | : 67.51 % | Planned Unavailability Factor (PUF) | : 9.02 % |
| Load Factor (LF) | : 50.31 % | Externally cause unavailability (XUF) | : 16.7 % |
| Operating Factor (OF) | : 52.37 % | Total off-line time | : 4172 hours |

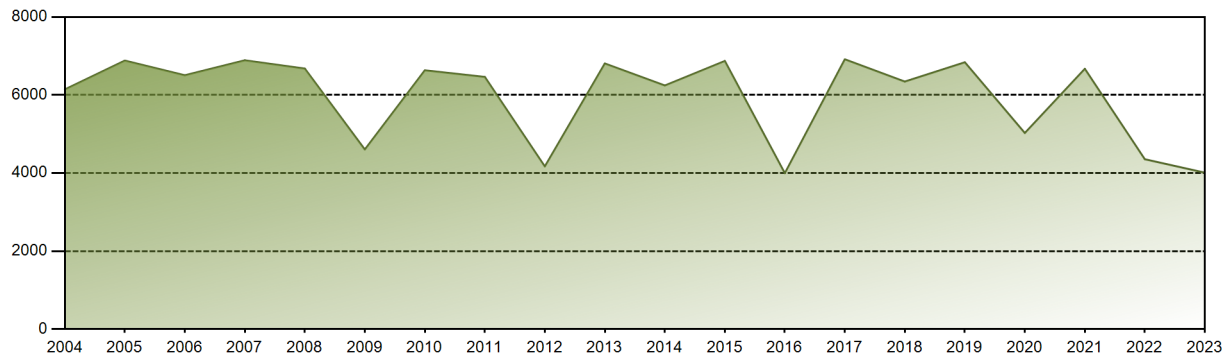


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|-------|-------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 137.03 | 589.50 | 660.80 | 627.62 | 663.75 | 649.27 | 682.41 | 4010.38 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.18 | 20.92 | 88.36 | 98.54 | 98.64 | 99.20 | 98.99 | 99.37 | 50.81 |
| UCF [%] | 0.00 | 7.59 | 83.85 | 100.00 | 5.61 | 20.92 | 89.68 | 100.00 | 99.95 | 99.97 | 98.99 | 99.37 | 67.51 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.91 | 87.07 | 97.60 | 95.79 | 97.91 | 99.10 | 100.79 | 50.31 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 27.22 | 97.45 | 100.00 | 100.00 | 99.87 | 99.31 | 100.00 | 52.37 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 33.14 | 10.10 | 0.00 | 0.00 | 0.00 | 1.01 | 0.59 | 2.65 |
| UCL [%] | 0.00 | 92.41 | 16.15 | 0.00 | 94.39 | 73.04 | 10.08 | 0.00 | 0.00 | 0.00 | 1.01 | 0.59 | 23.47 |
| PUF [%] | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.04 | 0.25 | 0.00 | 0.05 | 0.03 | 0.00 | 0.04 | 9.02 |
| XUF [%] | 0.00 | 7.59 | 83.85 | 100.00 | 4.44 | 0.00 | 1.32 | 1.46 | 1.31 | 0.78 | 0.00 | 0.00 | 16.70 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 242466.82 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.24 % |
| Cumulative Energy Availability Factor (EAF) | : 75.64 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.13 % |
| Cumulative Unit Capability Factor (UCF) | : 78.75 % | Cumulative Planned Unavailability Factor (PUF) | : 14.12 % |
| Cumulative Load Factor (LF) | : 72.04 % | Cumulative Externally cause unavailability (XUF) | : 3.11 % |
| Cumulative Operating Factor (OF) | : 76.99 % | | |

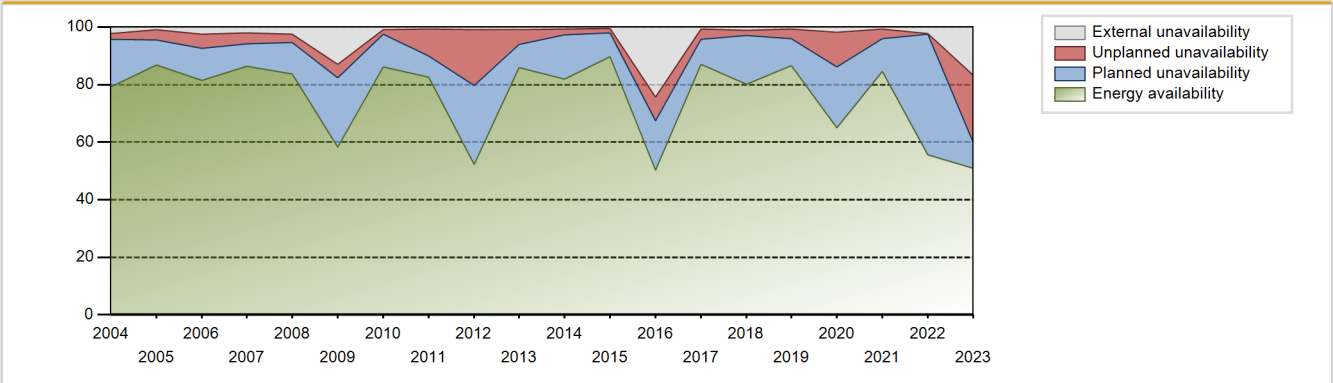
Electricity Production (net) [GWh]



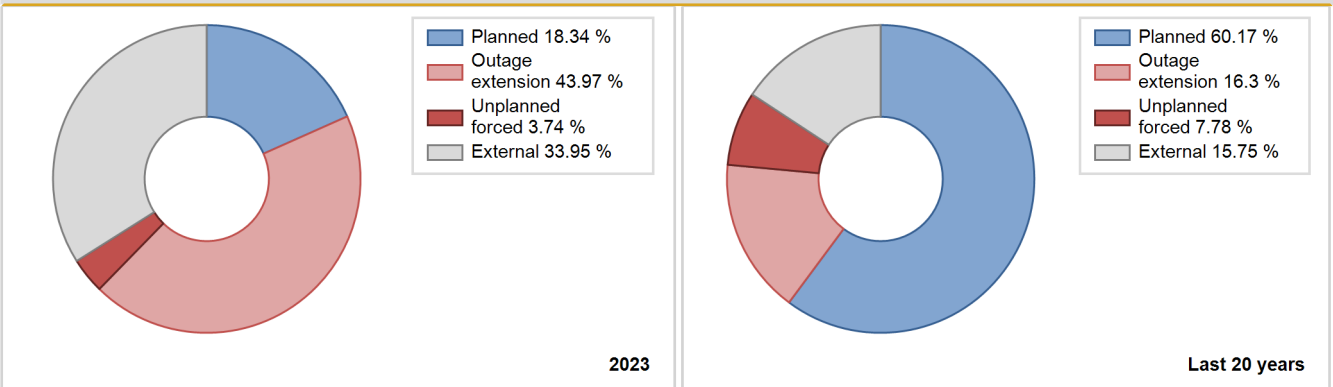
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 1636.20 | 2584 | 915 | 65.60 | 65.60 | 65.60 | 70.16 | 7.37 | 5.22 | 29.18 | 0.00 |
| 1982 | 6129.80 | 7588 | 910 | 81.46 | 81.46 | 76.90 | 86.62 | 18.54 | 18.54 | 0.00 | 0.00 |
| 1983 | 3453.00 | 4285 | 910 | 43.92 | 43.92 | 43.32 | 48.92 | 31.78 | 20.46 | 35.62 | 0.00 |
| 1984 | 6509.00 | 7536 | 910 | 84.55 | 84.55 | 81.43 | 85.79 | 7.30 | 6.66 | 8.79 | 0.00 |
| 1985 | 6225.20 | 7348 | 910 | 82.83 | 82.96 | 78.09 | 83.88 | 3.26 | 2.79 | 14.24 | 0.14 |
| 1986 | 6460.60 | 7754 | 910 | 86.95 | 87.82 | 81.05 | 88.52 | 2.13 | 1.91 | 10.26 | 0.87 |
| 1987 | 5586.60 | 6793 | 910 | 76.23 | 78.16 | 70.08 | 77.55 | 6.57 | 5.50 | 16.35 | 1.92 |
| 1988 | 5730.00 | 7069 | 910 | 81.27 | 82.09 | 71.68 | 80.48 | 6.23 | 5.45 | 12.46 | 0.81 |
| 1989 | 6222.43 | 7419 | 910 | 83.31 | 84.25 | 78.06 | 84.69 | 3.77 | 3.30 | 12.46 | 0.94 |
| 1990 | 5822.59 | 6834 | 910 | 76.90 | 77.20 | 73.04 | 78.01 | 5.32 | 4.34 | 18.47 | 0.30 |
| 1991 | 6379.04 | 7400 | 910 | 83.31 | 83.76 | 80.02 | 84.47 | 4.09 | 3.57 | 12.67 | 0.45 |
| 1992 | 4349.17 | 5079 | 910 | 56.60 | 57.49 | 54.41 | 57.82 | 20.87 | 15.16 | 27.35 | 0.89 |
| 1993 | 5979.16 | 7253 | 910 | 78.32 | 83.74 | 75.01 | 82.80 | 5.60 | 4.97 | 11.29 | 5.42 |
| 1994 | 3474.92 | 5119 | 910 | 85.78 | 86.60 | 43.59 | 58.44 | 2.06 | 1.82 | 11.58 | 0.82 |
| 1995 | 6075.80 | 7206 | 910 | 84.28 | 87.09 | 76.22 | 82.26 | 0.91 | 0.80 | 12.11 | 2.81 |
| 1996 | 6639.15 | 7798 | 910 | 85.56 | 88.50 | 83.06 | 88.78 | 1.49 | 1.34 | 10.17 | 2.94 |
| 1997 | 6196.60 | 7621 | 910 | 84.56 | 90.12 | 77.73 | 87.00 | 0.52 | 0.47 | 9.41 | 5.56 |
| 1998 | 5917.56 | 7078 | 910 | 78.22 | 81.11 | 74.23 | 80.80 | 7.37 | 6.46 | 12.43 | 2.89 |
| 1999 | 6046.81 | 7082 | 910 | 77.91 | 80.86 | 75.85 | 80.84 | 11.17 | 10.17 | 8.97 | 2.96 |
| 2000 | 2854.09 | 3602 | 910 | 36.56 | 53.42 | 35.71 | 41.01 | 35.61 | 29.54 | 17.04 | 16.86 |
| 2001 | 4881.50 | 5768 | 910 | 64.02 | 66.25 | 61.24 | 65.84 | 27.08 | 24.61 | 9.15 | 2.23 |
| 2002 | 6861.10 | 8251 | 910 | 92.98 | 95.04 | 86.07 | 94.19 | 1.80 | 1.74 | 3.22 | 2.06 |
| 2003 | 4541.69 | 5321 | 910 | 58.11 | 61.76 | 56.97 | 60.74 | 17.16 | 12.79 | 25.45 | 3.65 |
| 2004 | 6144.26 | 7217 | 910 | 79.22 | 81.48 | 76.87 | 82.16 | 2.45 | 2.05 | 16.47 | 2.26 |
| 2005 | 6883.56 | 7841 | 910 | 86.82 | 87.72 | 86.34 | 89.50 | 2.13 | 3.67 | 8.60 | 0.90 |
| 2006 | 6507.99 | 7440 | 910 | 81.57 | 84.05 | 81.64 | 84.93 | 3.56 | 4.99 | 10.96 | 2.48 |
| 2007 | 6891.00 | 7791 | 910 | 86.39 | 88.34 | 86.43 | 88.93 | 3.05 | 3.94 | 7.72 | 1.94 |
| 2008 | 6678.68 | 7651 | 910 | 83.66 | 86.10 | 83.55 | 87.10 | 0.82 | 2.98 | 10.93 | 2.44 |
| 2009 | 4604.59 | 5461 | 910 | 58.38 | 71.43 | 57.76 | 62.34 | 0.51 | 4.54 | 24.02 | 13.05 |
| 2010 | 6634.72 | 7679 | 910 | 86.10 | 87.01 | 83.23 | 87.66 | 0.42 | 1.68 | 11.31 | 0.91 |
| 2011 | 6465.19 | 7370 | 910 | 82.66 | 83.46 | 81.10 | 84.13 | 0.67 | 9.26 | 7.28 | 0.80 |
| 2012 | 4170.62 | 4690 | 910 | 52.22 | 53.05 | 52.18 | 53.39 | 14.15 | 19.44 | 27.52 | 0.83 |
| 2013 | 6809.65 | 7659 | 910 | 85.90 | 86.91 | 85.42 | 87.43 | 0.67 | 5.01 | 8.08 | 1.02 |
| 2014 | 6245.02 | 7214 | 910 | 81.80 | 82.57 | 78.34 | 82.35 | 0.54 | 2.04 | 15.39 | 0.77 |
| 2015 | 6874.30 | 7961 | 910 | 89.68 | 90.19 | 86.23 | 90.88 | 1.74 | 1.60 | 8.21 | 0.51 |
| 2016 | 3996.76 | 4637 | 910 | 50.28 | 74.65 | 50.00 | 52.79 | 1.07 | 8.30 | 17.04 | 24.37 |
| 2017 | 6916.74 | 7783 | 910 | 87.06 | 87.77 | 86.77 | 88.85 | 0.68 | 3.52 | 8.70 | 0.72 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2018 | 6345.55 | 7164 | 910 | 80.08 | 81.21 | 79.60 | 81.78 | 0.73 | 1.73 | 17.07 | 1.13 |
| 2019 | 6840.40 | 7698 | 910 | 86.68 | 87.34 | 85.81 | 87.88 | 1.01 | 3.51 | 9.16 | 0.66 |
| 2020 | 5026.78 | 5834 | 910 | 64.88 | 66.80 | 62.89 | 66.42 | 11.13 | 11.84 | 21.35 | 1.92 |
| 2021 | 6673.16 | 7546 | 910 | 84.51 | 85.29 | 83.71 | 86.14 | 1.44 | 3.20 | 11.51 | 0.78 |
| 2022 | 4354.20 | 5055 | 910 | 55.51 | 57.84 | 54.62 | 57.71 | 0.35 | 0.21 | 41.95 | 2.33 |
| 2023 | 4010.38 | 4588 | 910 | 50.81 | 67.51 | 50.31 | 52.37 | 2.65 | 23.47 | 9.02 | 16.70 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|-------------|-------------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1973 | | | 452 | 0 |
| B. Refuelling without maintenance | | | | 183 | | |
| C. Inspection, maintenance or repair combined with refuelling | 744 | | | 977 | 4 | |
| D. Inspection, maintenance or repair without refuelling | | | | 28 | | |
| E. Testing of plant systems or components | | | | 1 | 1 | |
| H. Nuclear regulatory requirements | | | | | 51 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 10 | 1 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 0 | | | 44 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 1427 | | 15 | 107 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 1 |
| Z. Other | | | | | 15 | |
| Subtotal | 744 | 1973 | 1427 | 1189 | 548 | 155 |
| Total | | 4144 | | | 1892 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 21 |
| 12. Reactor I&C Systems | | 52 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | | 21 |
| 15. Reactor Cooling Systems | | 51 |
| 16. Steam generation systems | | 57 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 4 |
| 21. Fuel Handling and Storage Facilities | | 35 |
| 31. Turbine and auxiliaries | 5 | 27 |
| 32. Feedwater and Main Steam System | | 33 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | 1895 | 109 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | 73 | 62 |
| 42. Electrical Power Supply Systems | | 25 |
| Total | 1973 | 504 |

2023 Operating Experience

FR-33

BLAYAIS-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : FRAM (FRAMATOME)

Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2785 MWth
 Gross electrical power : 951 MWe
 Reference unit power (net) : 910 MWe

Key Dates

Construction Date : 1977-01-01
 Grid Date : 1982-07-17
 Commercial Date : 1983-02-01
 Age at end of year : 41 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.44
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 323
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

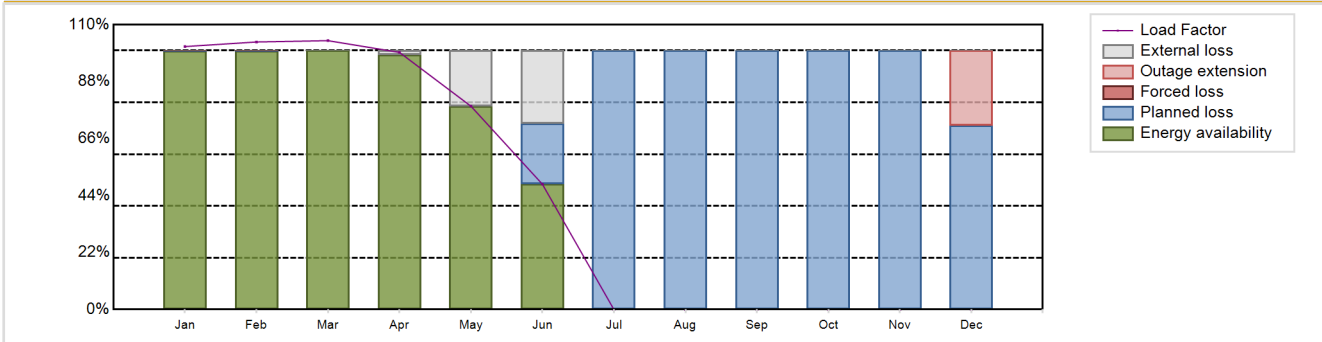
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3520.88 GW(e).h
 Energy Availability Factor (EAF) : 43.36 %
 Unit Capability Factor (UCF) : 47.64 %
 Load Factor (LF) : 44.17 %
 Operating Factor (OF) : 47.67 %
 Forced Loss Rate (FLR) : 0.01 %
 Unplanned Capability Loss Factor (UCL) : 2.47 %
 Planned Unavailability Factor (PUF) : 49.88 %
 Externally cause unavailability (XUF) : 4.29 %
 Total off-line time : 4584 hours

Annual Summary

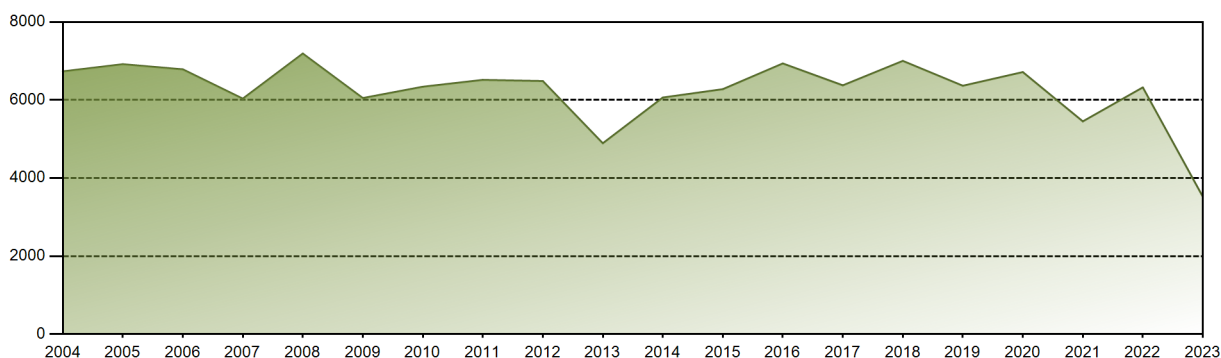


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|---------|
| GW(e)-h | 687.64 | 631.86 | 702.07 | 650.66 | 531.64 | 317.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3520.88 |
| EAF [%] | 99.89 | 99.98 | 100.00 | 98.26 | 78.53 | 48.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 43.36 |
| UCF [%] | 99.89 | 99.98 | 100.00 | 100.00 | 100.00 | 76.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 47.64 |
| LF [%] | 101.57 | 103.33 | 103.84 | 99.31 | 78.52 | 48.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 44.17 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 76.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 47.67 |
| FLR [%] | 0.04 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| UCL [%] | 0.04 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 29.03 | 2.47 |
| PUF [%] | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 23.39 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 70.97 | 49.88 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 1.74 | 21.47 | 28.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.29 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 251107.51 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.69 % |
| Cumulative Energy Availability Factor (EAF) | : 79.27 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.7 % |
| Cumulative Unit Capability Factor (UCF) | : 81.3 % | Cumulative Planned Unavailability Factor (PUF) | : 15 % |
| Cumulative Load Factor (LF) | : 76.37 % | Cumulative Externally cause unavailability (XUF) | : 2.04 % |
| Cumulative Operating Factor (OF) | : 79.95 % | | |

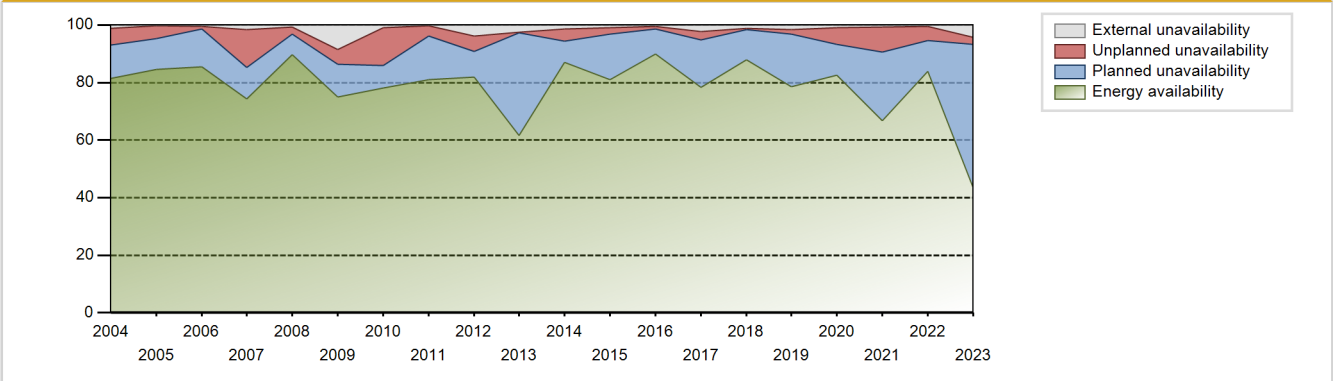
Electricity Production (net) [GWh]



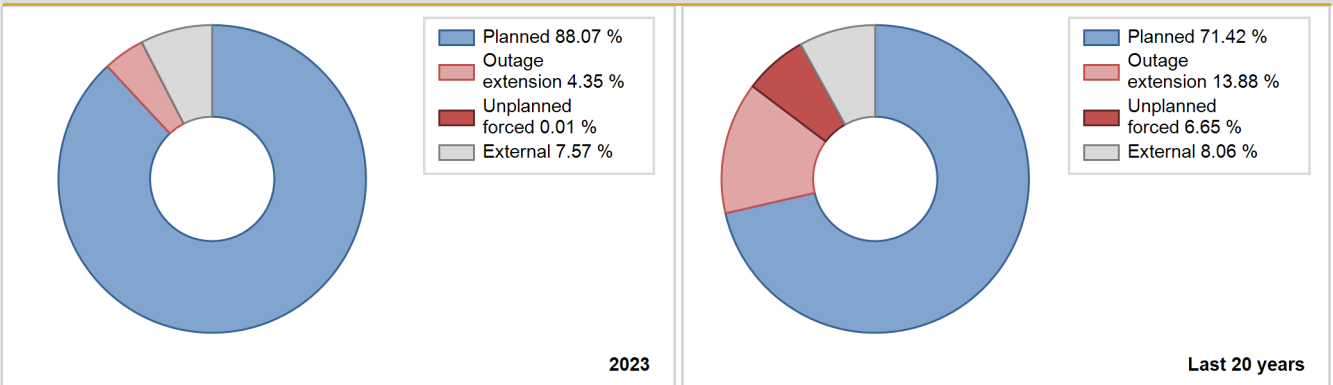
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 5094.00 | 5817 | 910 | 62.33 | 62.33 | 61.55 | 63.87 | 9.70 | 6.69 | 30.98 | 0.00 |
| 1984 | 6645.00 | 7716 | 910 | 85.54 | 85.54 | 83.13 | 87.84 | 4.07 | 3.63 | 10.83 | 0.00 |
| 1985 | 6819.70 | 7937 | 910 | 89.90 | 90.00 | 85.55 | 90.61 | 1.61 | 1.47 | 8.53 | 0.11 |
| 1986 | 6048.40 | 7142 | 910 | 82.86 | 83.21 | 75.87 | 81.53 | 3.13 | 2.68 | 14.10 | 0.36 |
| 1987 | 5987.10 | 7218 | 910 | 84.20 | 84.82 | 75.11 | 82.40 | 4.93 | 4.40 | 10.78 | 0.63 |
| 1988 | 4162.00 | 5718 | 910 | 90.75 | 91.17 | 52.07 | 65.10 | 4.68 | 4.48 | 4.35 | 0.41 |
| 1989 | 5560.97 | 6720 | 910 | 73.44 | 76.95 | 69.76 | 76.71 | 3.25 | 2.59 | 20.46 | 3.51 |
| 1990 | 5656.42 | 7381 | 910 | 85.73 | 87.37 | 70.96 | 84.26 | 2.33 | 2.08 | 10.54 | 1.65 |
| 1991 | 5326.54 | 6789 | 910 | 75.13 | 78.33 | 66.82 | 77.50 | 3.66 | 2.98 | 18.69 | 3.20 |
| 1992 | 5953.25 | 7505 | 910 | 83.74 | 86.89 | 74.48 | 85.44 | 0.72 | 0.63 | 12.48 | 3.16 |
| 1993 | 5253.21 | 6203 | 910 | 67.00 | 71.03 | 65.90 | 70.81 | 1.73 | 1.25 | 27.72 | 4.02 |
| 1994 | 6692.60 | 7658 | 910 | 88.12 | 88.74 | 83.96 | 87.42 | 0.21 | 0.19 | 11.07 | 0.62 |
| 1995 | 6725.49 | 7775 | 910 | 85.61 | 87.94 | 84.37 | 88.76 | 1.75 | 1.57 | 10.49 | 2.33 |
| 1996 | 6709.81 | 7587 | 910 | 85.04 | 87.36 | 83.94 | 86.37 | 0.45 | 0.40 | 12.24 | 2.32 |
| 1997 | 6769.92 | 7681 | 910 | 84.77 | 88.67 | 84.93 | 87.68 | 1.95 | 1.77 | 9.56 | 3.90 |
| 1998 | 6974.32 | 7883 | 910 | 87.20 | 90.03 | 87.49 | 89.99 | 0.11 | 0.10 | 9.87 | 2.83 |
| 1999 | 5836.20 | 6544 | 910 | 73.05 | 75.10 | 73.21 | 74.70 | 12.55 | 10.78 | 14.12 | 2.05 |
| 2000 | 4941.11 | 5592 | 910 | 63.00 | 75.24 | 61.81 | 63.66 | 5.56 | 4.43 | 20.33 | 12.24 |
| 2001 | 6547.95 | 7358 | 910 | 81.93 | 83.56 | 82.14 | 84.00 | 4.64 | 4.06 | 12.38 | 1.63 |
| 2002 | 5971.95 | 7357 | 910 | 82.72 | 84.35 | 74.92 | 83.98 | 7.27 | 6.61 | 9.05 | 1.62 |
| 2003 | 5181.16 | 5784 | 910 | 63.69 | 66.03 | 65.00 | 66.03 | 2.06 | 1.39 | 32.58 | 2.34 |
| 2004 | 6734.56 | 7346 | 910 | 81.47 | 82.57 | 84.25 | 83.63 | 6.55 | 5.78 | 11.65 | 1.09 |
| 2005 | 6918.75 | 7513 | 910 | 84.65 | 84.96 | 86.78 | 85.76 | 0.15 | 4.32 | 10.71 | 0.32 |
| 2006 | 6786.69 | 7599 | 910 | 85.44 | 86.03 | 85.14 | 86.75 | 0.92 | 0.80 | 13.17 | 0.59 |
| 2007 | 6035.60 | 6686 | 910 | 74.27 | 75.83 | 75.71 | 76.32 | 0.19 | 13.19 | 10.99 | 1.56 |
| 2008 | 7191.21 | 7977 | 910 | 89.67 | 90.28 | 89.96 | 90.81 | 0.04 | 2.58 | 7.15 | 0.60 |
| 2009 | 6050.55 | 6736 | 910 | 75.02 | 83.55 | 75.90 | 76.89 | 1.67 | 5.01 | 11.44 | 8.53 |
| 2010 | 6341.07 | 6919 | 910 | 78.18 | 79.08 | 79.55 | 78.98 | 12.48 | 13.07 | 7.85 | 0.90 |
| 2011 | 6516.19 | 7156 | 910 | 80.96 | 81.16 | 81.74 | 81.69 | 0.19 | 3.54 | 15.30 | 0.20 |
| 2012 | 6486.49 | 7345 | 910 | 81.81 | 85.65 | 81.15 | 83.62 | 0.53 | 5.29 | 9.06 | 3.84 |
| 2013 | 4891.24 | 5591 | 910 | 61.69 | 64.21 | 61.36 | 63.82 | 0.19 | 0.13 | 35.67 | 2.52 |
| 2014 | 6064.42 | 7030 | 910 | 87.12 | 88.54 | 76.08 | 80.25 | 0.53 | 4.12 | 7.34 | 1.41 |
| 2015 | 6278.21 | 7227 | 910 | 81.02 | 81.87 | 78.76 | 82.50 | 1.19 | 2.32 | 15.81 | 0.85 |
| 2016 | 6937.64 | 8106 | 910 | 89.90 | 90.40 | 86.79 | 92.28 | 1.02 | 0.95 | 8.65 | 0.50 |
| 2017 | 6376.49 | 6972 | 910 | 78.39 | 80.73 | 79.99 | 79.59 | 0.05 | 2.93 | 16.34 | 2.34 |
| 2018 | 7003.89 | 7825 | 910 | 87.94 | 89.08 | 87.86 | 89.33 | 0.10 | 0.36 | 10.55 | 1.14 |
| 2019 | 6366.21 | 7008 | 910 | 78.57 | 80.19 | 79.86 | 80.00 | 0.63 | 1.57 | 18.23 | 1.62 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2020 | 6716.68 | 7468 | 910 | 82.49 | 83.37 | 84.03 | 85.02 | 2.07 | 5.81 | 10.82 | 0.88 |
| 2021 | 5452.66 | 6016 | 910 | 66.74 | 67.48 | 68.40 | 68.68 | 2.95 | 8.62 | 23.90 | 0.74 |
| 2022 | 6323.87 | 7395 | 910 | 83.93 | 84.43 | 79.33 | 84.42 | 1.42 | 4.84 | 10.73 | 0.50 |
| 2023 | 3520.88 | 4176 | 910 | 43.36 | 47.64 | 44.17 | 47.67 | 0.01 | 2.47 | 49.88 | 4.29 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 216 | | | 241 | |
| B. Refuelling without maintenance | | | | 159 | | |
| C. Inspection, maintenance or repair combined with refuelling | 4367 | | | 1108 | 2 | |
| D. Inspection, maintenance or repair without refuelling | | | | 17 | | |
| E. Testing of plant systems or components | | | | 50 | 0 | |
| H. Nuclear regulatory requirements | | | | | 12 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 20 |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 44 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 15 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 7 |
| Z. Other | | | | | 19 | 2 |
| Subtotal | 4367 | 216 | | 1334 | 280 | 92 |
| Total | | 4583 | | | 1706 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 17 |
| 12. Reactor I&C Systems | | 6 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | | 10 |
| 15. Reactor Cooling Systems | | 20 |
| 16. Steam generation systems | | 28 |
| 21. Fuel Handling and Storage Facilities | | 2 |
| 31. Turbine and auxiliaries | | 27 |
| 32. Feedwater and Main Steam System | | 37 |
| 33. Circulating Water System | | 4 |
| 34. Miscellaneous Systems | 216 | 62 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 6 |
| 42. Electrical Power Supply Systems | | 15 |
| Total | 216 | 241 |

2023 Operating Experience

FR-34 **BLAYAIS-3** **FRANCE**

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP1 | Construction Date | : 1978-04-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1983-08-17 |
| Gross electrical power | : 951 MWe | Commercial Date | : 1983-11-14 |
| Reference unit power (net) | : 910 MWe | Age at end of year | : 40 years |

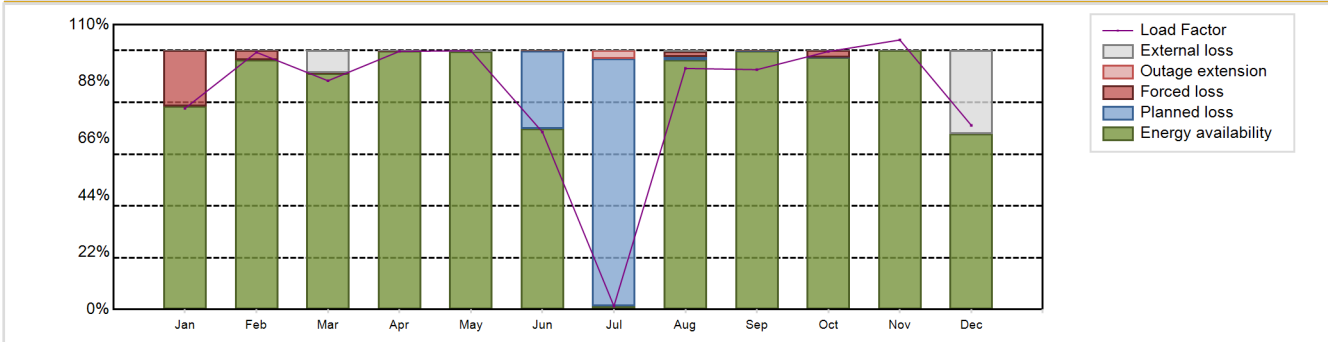
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.8 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 323 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 5 |
| Refuelling frequency [month] | : 24 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 33735 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.44 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 28 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 6594.91 GW(e).h | Forced Loss Rate (FLR) | : 2.8 % |
| Energy Availability Factor (EAF) | : 82.99 % | Unplanned Capability Loss Factor (UCL) | : 2.76 % |
| Unit Capability Factor (UCF) | : 86.51 % | Planned Unavailability Factor (PUF) | : 10.72 % |
| Load Factor (LF) | : 82.73 % | Externally cause unavailability (XUF) | : 3.52 % |
| Operating Factor (OF) | : 84.89 % | Total off-line time | : 1324 hours |

Annual Summary

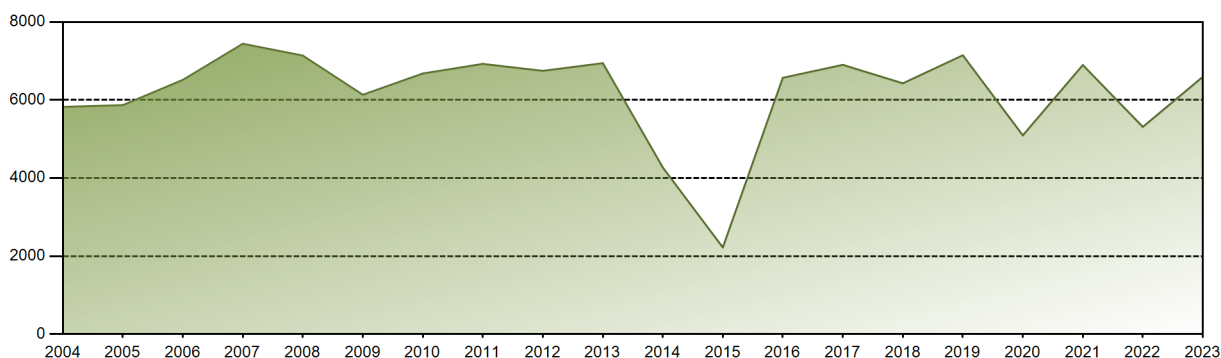


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 525.98 | 607.52 | 597.31 | 653.22 | 676.67 | 449.14 | 8.80 | 630.35 | 606.97 | 675.50 | 682.07 | 481.39 | 6594.91 |
| EAF [%] | 78.41 | 96.49 | 91.30 | 99.87 | 99.74 | 69.73 | 1.30 | 96.36 | 99.97 | 97.34 | 100.00 | 67.93 | 82.99 |
| UCF [%] | 78.41 | 96.49 | 99.95 | 99.94 | 100.00 | 69.73 | 1.30 | 96.77 | 99.97 | 97.34 | 100.00 | 100.00 | 86.51 |
| LF [%] | 77.69 | 99.35 | 88.34 | 99.70 | 99.94 | 68.55 | 1.30 | 93.10 | 92.64 | 99.64 | 104.10 | 71.10 | 82.73 |
| OF [%] | 79.30 | 100.00 | 100.00 | 100.00 | 100.00 | 70.14 | 3.23 | 100.00 | 100.00 | 99.87 | 100.00 | 68.55 | 84.89 |
| FLR [%] | 21.59 | 3.51 | 0.01 | 0.01 | 0.00 | 0.14 | 0.00 | 1.88 | 0.02 | 2.63 | 0.00 | 0.00 | 2.80 |
| UCL [%] | 21.59 | 3.51 | 0.01 | 0.01 | 0.00 | 0.10 | 3.16 | 1.85 | 0.02 | 2.63 | 0.00 | 0.00 | 2.76 |
| PUF [%] | 0.00 | 0.00 | 0.05 | 0.04 | 0.00 | 30.17 | 95.54 | 1.38 | 0.01 | 0.03 | 0.00 | 0.00 | 10.72 |
| XUF [%] | 0.00 | 0.00 | 8.65 | 0.07 | 0.26 | 0.00 | 0.00 | 0.41 | 0.00 | 0.00 | 0.00 | 32.07 | 3.52 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 246121.98 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.62 % |
| Cumulative Energy Availability Factor (EAF) | : 78.56 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.44 % |
| Cumulative Unit Capability Factor (UCF) | : 80.5 % | Cumulative Planned Unavailability Factor (PUF) | : 15.06 % |
| Cumulative Load Factor (LF) | : 76.53 % | Cumulative Externally cause unavailability (XUF) | : 1.93 % |
| Cumulative Operating Factor (OF) | : 79.35 % | | |

Electricity Production (net) [GWh]

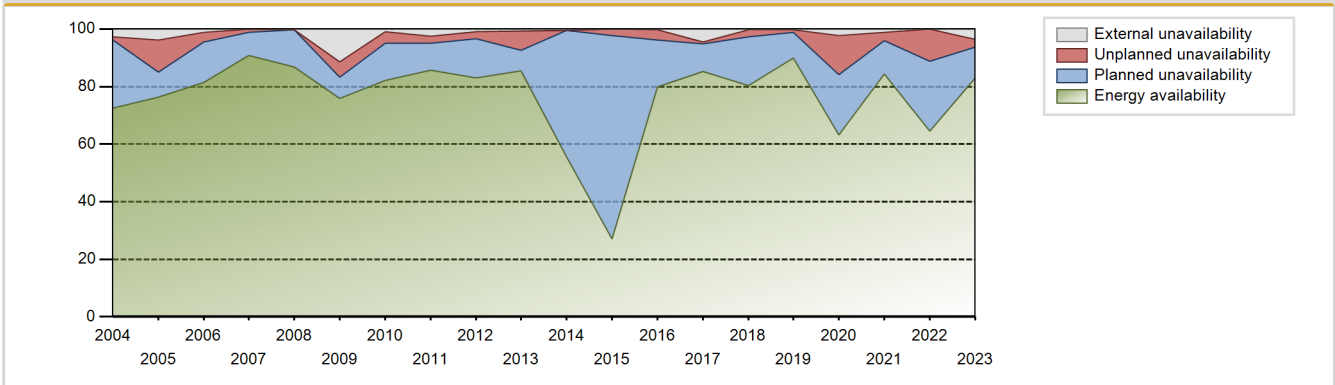


Performance for Years of Commercial Operation

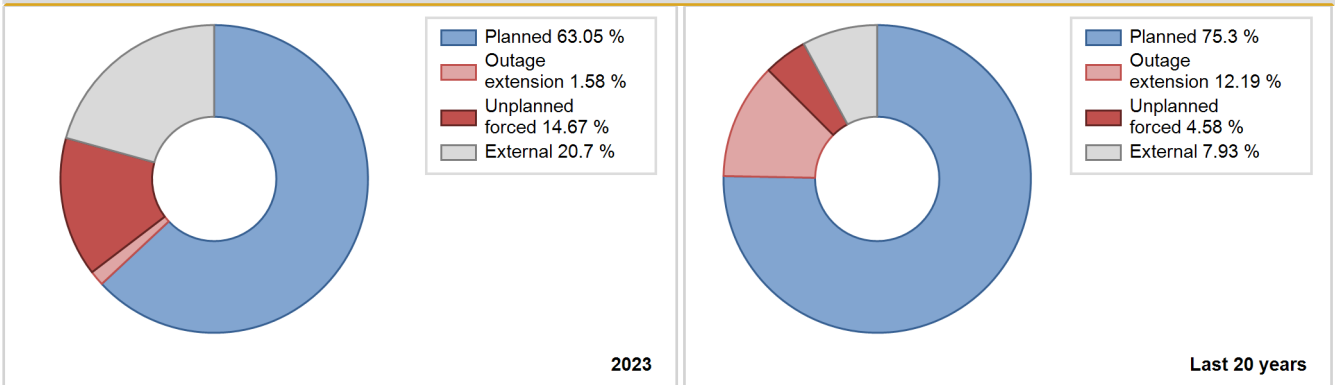
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 1912.00 | 2739 | 910 | 87.37 | 87.37 | 87.37 | 86.95 | 0.00 | 0.00 | 12.63 | 0.00 |
| 1984 | 5944.00 | 7055 | 910 | 80.35 | 80.35 | 74.36 | 80.32 | 4.20 | 3.53 | 16.13 | 0.00 |
| 1985 | 6568.90 | 7729 | 910 | 86.57 | 86.96 | 82.40 | 88.23 | 2.89 | 2.59 | 10.45 | 0.40 |
| 1986 | 6504.90 | 7759 | 910 | 88.15 | 88.26 | 81.60 | 88.57 | 1.39 | 1.25 | 10.50 | 0.11 |
| 1987 | 4304.70 | 5473 | 910 | 93.47 | 93.91 | 54.00 | 62.48 | 0.41 | 0.39 | 5.70 | 0.44 |
| 1988 | 5287.00 | 6708 | 910 | 81.56 | 82.76 | 66.14 | 76.37 | 5.58 | 4.89 | 12.35 | 1.20 |
| 1989 | 6086.42 | 7292 | 910 | 78.54 | 82.65 | 76.35 | 83.24 | 5.65 | 4.94 | 12.40 | 4.11 |
| 1990 | 4871.16 | 5673 | 910 | 62.81 | 64.32 | 61.11 | 64.76 | 17.56 | 13.70 | 21.98 | 1.51 |
| 1991 | 6372.29 | 7448 | 910 | 83.97 | 84.62 | 79.94 | 85.02 | 3.34 | 2.93 | 12.45 | 0.65 |
| 1992 | 5967.94 | 7220 | 910 | 81.80 | 83.02 | 74.66 | 82.19 | 5.19 | 4.54 | 12.44 | 1.22 |
| 1993 | 6285.26 | 7728 | 910 | 79.77 | 87.71 | 78.85 | 88.22 | 1.40 | 1.25 | 11.04 | 7.94 |
| 1994 | 4212.82 | 4979 | 910 | 57.74 | 57.77 | 52.85 | 56.84 | 20.93 | 15.29 | 26.93 | 0.03 |
| 1995 | 6739.57 | 7525 | 910 | 85.38 | 85.89 | 84.54 | 85.90 | 0.25 | 0.21 | 13.89 | 0.51 |
| 1996 | 6924.05 | 7744 | 910 | 86.76 | 87.15 | 86.62 | 88.16 | 2.56 | 2.29 | 10.57 | 0.39 |
| 1997 | 6614.05 | 7659 | 910 | 86.41 | 86.41 | 82.97 | 87.43 | 0.38 | 0.33 | 13.26 | 0.00 |
| 1998 | 6970.16 | 7954 | 910 | 87.77 | 90.07 | 87.44 | 90.80 | 1.63 | 1.50 | 8.44 | 2.30 |
| 1999 | 5123.02 | 5861 | 910 | 64.20 | 66.83 | 64.27 | 66.91 | 24.93 | 22.19 | 10.98 | 2.63 |
| 2000 | 6183.61 | 7143 | 910 | 78.19 | 80.27 | 77.36 | 81.32 | 11.24 | 10.17 | 9.56 | 2.08 |
| 2001 | 6707.06 | 7540 | 910 | 84.22 | 85.36 | 84.14 | 86.07 | 3.65 | 3.23 | 11.40 | 1.15 |
| 2002 | 6882.02 | 7682 | 910 | 86.44 | 87.52 | 86.33 | 87.69 | 3.06 | 2.77 | 9.71 | 1.08 |
| 2003 | 5844.86 | 6725 | 910 | 73.57 | 86.51 | 73.32 | 76.77 | 2.41 | 2.14 | 11.36 | 12.93 |
| 2004 | 5822.81 | 6699 | 910 | 72.46 | 75.20 | 72.84 | 76.26 | 1.50 | 1.15 | 23.65 | 2.74 |
| 2005 | 5868.13 | 6875 | 910 | 76.42 | 80.27 | 73.61 | 78.48 | 1.83 | 11.21 | 8.52 | 3.85 |
| 2006 | 6515.66 | 7340 | 910 | 81.51 | 82.76 | 81.75 | 83.80 | 0.38 | 3.30 | 13.95 | 1.25 |
| 2007 | 7441.68 | 8035 | 910 | 90.86 | 90.92 | 93.35 | 91.72 | 1.11 | 1.02 | 8.06 | 0.06 |
| 2008 | 7138.33 | 7676 | 910 | 86.85 | 87.02 | 89.30 | 87.39 | 0.04 | 0.04 | 12.94 | 0.17 |
| 2009 | 6134.50 | 6949 | 910 | 75.79 | 87.09 | 76.95 | 79.33 | 1.16 | 5.43 | 7.48 | 11.31 |
| 2010 | 6679.72 | 7390 | 910 | 82.23 | 83.14 | 83.79 | 84.36 | 2.65 | 4.05 | 12.82 | 0.91 |
| 2011 | 6925.35 | 7769 | 910 | 85.73 | 88.23 | 86.88 | 88.69 | 0.20 | 2.48 | 9.29 | 2.51 |
| 2012 | 6747.82 | 7436 | 910 | 83.03 | 83.86 | 84.42 | 84.65 | 1.77 | 2.46 | 13.68 | 0.83 |
| 2013 | 6944.29 | 7535 | 910 | 85.41 | 86.05 | 87.11 | 86.02 | 0.03 | 6.65 | 7.30 | 0.64 |
| 2014 | 4270.69 | 4677 | 910 | 55.53 | 55.92 | 53.57 | 53.39 | 0.31 | 0.17 | 43.91 | 0.38 |
| 2015 | 2219.74 | 2748 | 910 | 27.06 | 27.11 | 27.85 | 31.37 | 7.87 | 2.32 | 70.58 | 0.04 |
| 2016 | 6569.71 | 7181 | 910 | 79.82 | 80.04 | 82.19 | 81.75 | 1.18 | 3.63 | 16.32 | 0.23 |
| 2017 | 6902.06 | 7507 | 910 | 85.20 | 89.60 | 86.58 | 85.70 | 0.15 | 0.70 | 9.70 | 4.40 |
| 2018 | 6427.78 | 7110 | 910 | 80.36 | 80.69 | 80.63 | 81.16 | 0.60 | 2.34 | 16.97 | 0.33 |
| 2019 | 7147.00 | 7935 | 910 | 89.85 | 90.14 | 89.66 | 90.58 | 1.06 | 0.97 | 8.89 | 0.29 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|-------|-------|------|
| 2020 | 5093.20 | 5757 | 910 | 63.21 | 65.58 | 63.72 | 65.54 | 2.49 | 13.45 | 20.97 | 2.37 |
| 2021 | 6897.13 | 7425 | 910 | 84.37 | 85.57 | 86.52 | 84.76 | 2.21 | 2.87 | 11.57 | 1.20 |
| 2022 | 5310.70 | 5740 | 910 | 64.62 | 64.62 | 66.62 | 65.53 | 1.87 | 11.29 | 24.09 | 0.00 |
| 2023 | 6594.91 | 7436 | 910 | 82.99 | 86.51 | 82.73 | 84.89 | 2.80 | 2.76 | 10.72 | 3.52 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|-------------|------------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 178 | | | 293 | |
| B. Refuelling without maintenance | 911 | | | 136 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1117 | 4 | |
| D. Inspection, maintenance or repair without refuelling | | | | 18 | 0 | |
| E. Testing of plant systems or components | | | | 4 | 0 | |
| H. Nuclear regulatory requirements | | | | | 20 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 6 |
| L. Human factor related | | | | | 2 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 30 |
| O. Load dispatching, prioritization | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 1 | 18 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 234 | | | 6 |
| Z. Other | | | | | 42 | 10 |
| Subtotal | 911 | 178 | 234 | 1275 | 362 | 70 |
| Total | | 1323 | | | 1707 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 10 |
| 12. Reactor I&C Systems | | 18 |
| 13. Reactor Auxiliary Systems | | 25 |
| 14. Safety Systems | | 7 |
| 15. Reactor Cooling Systems | | 7 |
| 16. Steam generation systems | | 56 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | 154 | 15 |
| 32. Feedwater and Main Steam System | | 9 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | 24 | 103 |
| 35. All other I&C Systems | | 3 |
| 41. Main Generator Systems | | 31 |
| 42. Electrical Power Supply Systems | | 16 |
| Total | 178 | 302 |

2023 Operating Experience

FR-35

BLAYAIS-4

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2785 MWth
 Gross electrical power : 951 MWe
 Reference unit power (net) : 910 MWe

Key Dates

Construction Date : 1978-04-01
 Grid Date : 1983-05-16
 Commercial Date : 1983-10-01
 Age at end of year : 40 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.44
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 323
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

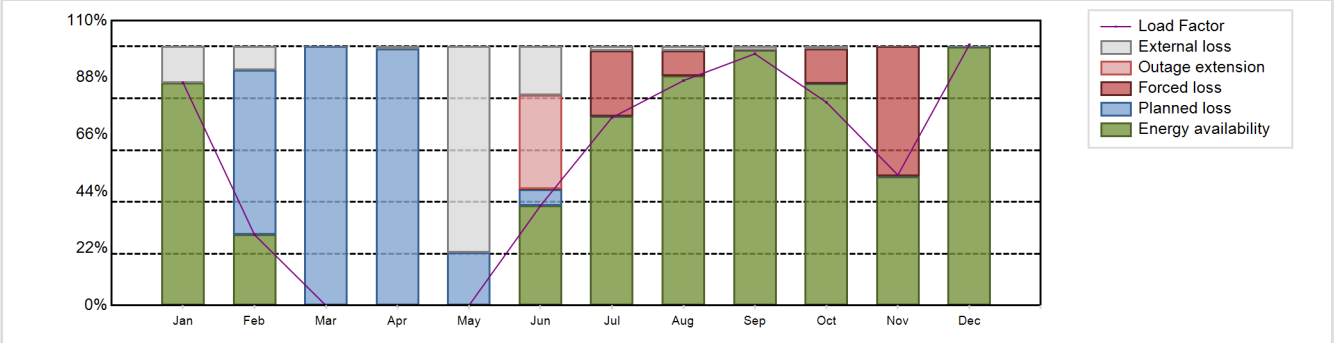
: none

Annual Production Results (2023)

Net Energy Production : 4262.81 GW(e).h
 Energy Availability Factor (EAF) : 54.28 %
 Unit Capability Factor (UCF) : 65 %
 Load Factor (LF) : 53.47 %
 Operating Factor (OF) : 60.06 %

Forced Loss Rate (FLR) : 11.27 %
 Unplanned Capability Loss Factor (UCL) : 11.24 %
 Planned Unavailability Factor (PUF) : 23.76 %
 Externally cause unavailability (XUF) : 10.72 %
 Total off-line time : 3499 hours

Annual Summary

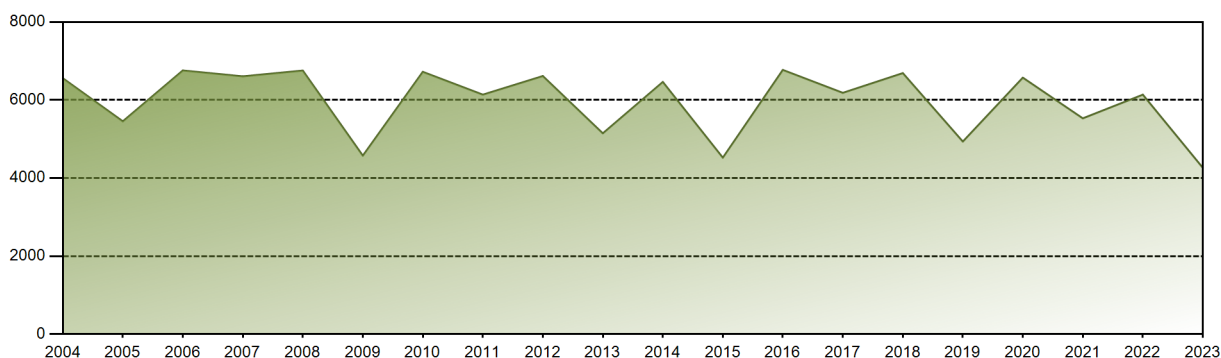


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 582.75 | 167.27 | 0.00 | 0.00 | 0.00 | 252.31 | 491.35 | 587.93 | 636.92 | 532.32 | 330.23 | 681.75 | 4262.81 |
| EAF [%] | 86.07 | 27.36 | 0.00 | 0.00 | 0.00 | 38.51 | 72.94 | 88.81 | 98.52 | 85.67 | 49.86 | 99.96 | 54.28 |
| UCF [%] | 100.00 | 36.52 | 0.00 | 0.97 | 79.57 | 57.32 | 74.52 | 90.38 | 99.89 | 86.46 | 49.86 | 99.96 | 65.00 |
| LF [%] | 86.07 | 27.35 | 0.00 | 0.00 | 0.00 | 38.51 | 72.57 | 86.84 | 97.21 | 78.52 | 50.40 | 100.70 | 53.47 |
| OF [%] | 100.00 | 37.05 | 0.00 | 0.00 | 0.00 | 45.56 | 100.00 | 97.04 | 100.00 | 86.71 | 50.56 | 100.00 | 60.06 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.49 | 25.44 | 9.62 | 0.03 | 13.44 | 50.10 | 0.00 | 11.27 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 36.54 | 25.43 | 9.62 | 0.03 | 13.42 | 50.07 | 0.00 | 11.24 |
| PUF [%] | 0.00 | 63.48 | 100.00 | 99.03 | 20.43 | 6.14 | 0.05 | 0.00 | 0.08 | 0.12 | 0.08 | 0.04 | 23.76 |
| XUF [%] | 13.93 | 9.16 | 0.00 | 0.97 | 79.57 | 18.81 | 1.58 | 1.57 | 1.37 | 0.79 | 0.00 | 0.00 | 10.72 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 240914.24 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.53 % |
| Cumulative Energy Availability Factor (EAF) | : 78.04 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.66 % |
| Cumulative Unit Capability Factor (UCF) | : 81.02 % | Cumulative Planned Unavailability Factor (PUF) | : 13.32 % |
| Cumulative Load Factor (LF) | : 74.54 % | Cumulative Externally cause unavailability (XUF) | : 2.98 % |
| Cumulative Operating Factor (OF) | : 80.18 % | | |

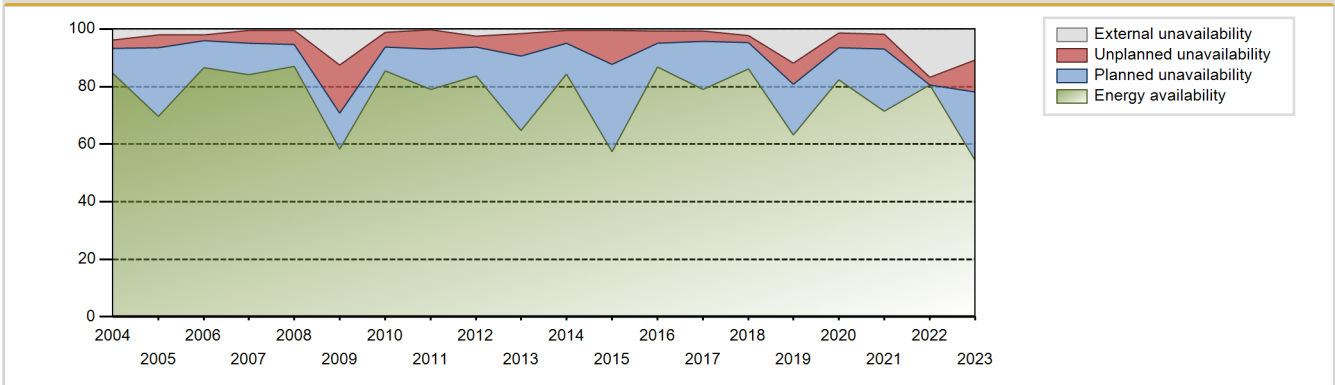
Electricity Production (net) [GWh]



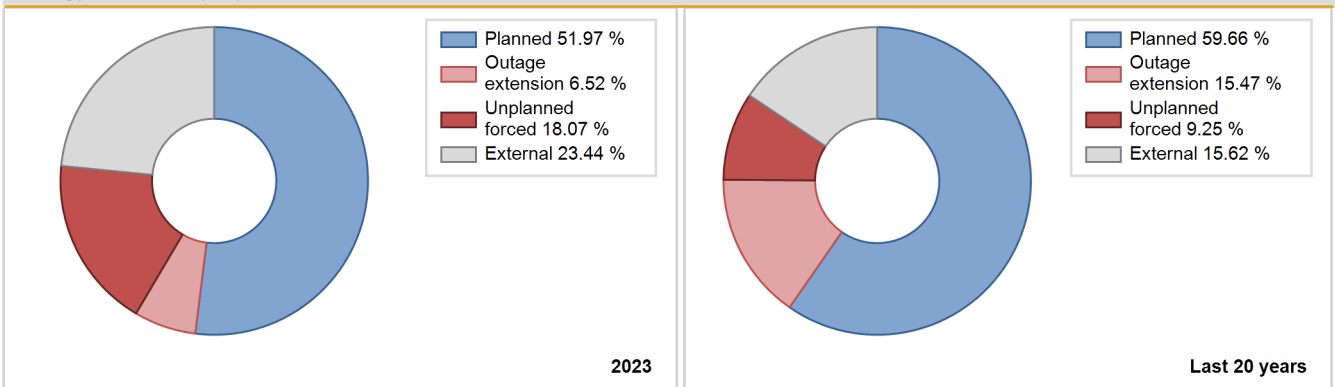
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 3356.00 | 4418 | 910 | 93.49 | 93.49 | 94.46 | 94.75 | 6.51 | 6.51 | 0.00 | 0.00 |
| 1984 | 6012.00 | 6780 | 910 | 76.00 | 76.00 | 75.21 | 77.19 | 3.36 | 2.64 | 21.36 | 0.00 |
| 1985 | 5972.60 | 7024 | 910 | 78.72 | 78.77 | 74.92 | 80.18 | 14.40 | 13.25 | 7.98 | 0.06 |
| 1986 | 6278.10 | 7412 | 910 | 81.87 | 82.50 | 78.76 | 84.61 | 5.24 | 4.56 | 12.94 | 0.62 |
| 1987 | 6104.60 | 7437 | 910 | 83.87 | 85.61 | 76.58 | 84.90 | 4.28 | 3.83 | 10.56 | 1.74 |
| 1988 | 4337.00 | 5662 | 910 | 70.16 | 71.53 | 54.26 | 64.46 | 10.95 | 8.79 | 19.68 | 1.36 |
| 1989 | 5816.26 | 7250 | 910 | 87.48 | 89.41 | 72.96 | 82.76 | 10.17 | 10.12 | 0.47 | 1.93 |
| 1990 | 5912.31 | 7347 | 910 | 78.18 | 83.42 | 74.17 | 83.87 | 4.46 | 3.89 | 12.69 | 5.24 |
| 1991 | 5467.70 | 6496 | 910 | 73.14 | 73.50 | 68.59 | 74.16 | 12.22 | 10.23 | 16.27 | 0.36 |
| 1992 | 6120.58 | 7430 | 910 | 83.48 | 84.10 | 76.57 | 84.59 | 0.53 | 0.44 | 15.45 | 0.62 |
| 1993 | 5096.35 | 6854 | 910 | 72.90 | 85.31 | 63.93 | 78.24 | 2.81 | 2.47 | 12.22 | 12.41 |
| 1994 | 5897.06 | 7308 | 910 | 81.85 | 82.61 | 73.98 | 83.42 | 4.78 | 4.14 | 13.25 | 0.76 |
| 1995 | 5342.37 | 6198 | 910 | 71.47 | 75.19 | 67.02 | 70.75 | 1.19 | 0.90 | 23.91 | 3.72 |
| 1996 | 6719.61 | 7761 | 910 | 86.92 | 88.17 | 84.06 | 88.35 | 1.73 | 1.55 | 10.27 | 1.26 |
| 1997 | 6497.20 | 7705 | 910 | 86.56 | 89.14 | 81.50 | 87.96 | 0.83 | 0.75 | 10.12 | 2.58 |
| 1998 | 6692.57 | 7930 | 910 | 87.93 | 90.26 | 83.96 | 90.53 | 1.47 | 1.35 | 8.39 | 2.33 |
| 1999 | 6161.15 | 7369 | 910 | 80.20 | 83.33 | 77.29 | 84.12 | 4.52 | 3.94 | 12.73 | 3.13 |
| 2000 | 5467.51 | 6559 | 910 | 72.53 | 75.05 | 68.40 | 74.67 | 15.60 | 13.87 | 11.08 | 2.53 |
| 2001 | 6370.03 | 7297 | 910 | 82.09 | 82.44 | 79.91 | 83.30 | 5.22 | 4.54 | 13.01 | 0.35 |
| 2002 | 6462.24 | 7623 | 910 | 85.09 | 86.19 | 81.07 | 87.02 | 3.08 | 2.74 | 11.07 | 1.10 |
| 2003 | 5311.06 | 6292 | 910 | 68.45 | 72.86 | 66.62 | 71.83 | 17.64 | 15.61 | 11.53 | 4.41 |
| 2004 | 6560.31 | 7749 | 910 | 84.57 | 88.32 | 82.07 | 88.22 | 3.30 | 3.01 | 8.66 | 3.75 |
| 2005 | 5454.68 | 6357 | 910 | 69.58 | 71.55 | 68.43 | 72.57 | 3.26 | 4.42 | 24.03 | 1.96 |
| 2006 | 6758.43 | 7827 | 910 | 86.48 | 88.49 | 84.78 | 89.35 | 2.00 | 1.96 | 9.55 | 2.01 |
| 2007 | 6607.83 | 7484 | 910 | 84.23 | 84.69 | 82.89 | 85.43 | 3.51 | 4.38 | 10.94 | 0.46 |
| 2008 | 6755.66 | 7760 | 910 | 86.97 | 87.44 | 84.52 | 88.34 | 1.07 | 4.83 | 7.73 | 0.46 |
| 2009 | 4574.28 | 5295 | 910 | 58.35 | 70.81 | 57.38 | 60.45 | 1.33 | 16.86 | 12.33 | 12.46 |
| 2010 | 6723.73 | 7718 | 910 | 85.49 | 86.58 | 84.35 | 88.11 | 3.34 | 5.11 | 8.31 | 1.09 |
| 2011 | 6138.08 | 7079 | 910 | 79.11 | 79.42 | 77.00 | 80.81 | 2.44 | 6.58 | 14.00 | 0.30 |
| 2012 | 6615.11 | 7653 | 910 | 83.71 | 86.20 | 82.76 | 87.12 | 0.70 | 3.69 | 10.11 | 2.49 |
| 2013 | 5146.77 | 5924 | 910 | 64.78 | 66.27 | 64.56 | 67.63 | 2.73 | 7.86 | 25.87 | 1.49 |
| 2014 | 6463.78 | 7566 | 910 | 84.41 | 84.81 | 81.09 | 86.37 | 5.02 | 4.48 | 10.70 | 0.40 |
| 2015 | 4522.44 | 5124 | 910 | 57.32 | 57.84 | 56.73 | 58.49 | 5.33 | 11.75 | 30.42 | 0.52 |
| 2016 | 6772.22 | 7859 | 910 | 86.75 | 87.42 | 84.72 | 89.47 | 1.11 | 4.22 | 8.36 | 0.67 |
| 2017 | 6184.82 | 7044 | 910 | 78.98 | 79.62 | 77.59 | 80.41 | 0.67 | 3.72 | 16.65 | 0.64 |
| 2018 | 6690.11 | 7744 | 910 | 86.13 | 88.42 | 83.92 | 88.40 | 1.33 | 2.38 | 9.20 | 2.28 |
| 2019 | 4935.56 | 5685 | 910 | 63.09 | 74.97 | 61.91 | 64.90 | 1.58 | 7.26 | 17.77 | 11.88 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2020 | 6573.47 | 7472 | 910 | 82.40 | 83.86 | 82.24 | 85.06 | 0.29 | 5.06 | 11.08 | 1.46 |
| 2021 | 5530.48 | 6379 | 910 | 71.51 | 73.31 | 69.38 | 72.82 | 1.50 | 5.05 | 21.63 | 1.80 |
| 2022 | 6137.48 | 8095 | 910 | 80.54 | 97.33 | 76.99 | 92.41 | 2.65 | 2.65 | 0.02 | 16.79 |
| 2023 | 4262.81 | 5261 | 910 | 54.28 | 65.00 | 53.47 | 60.06 | 11.27 | 11.24 | 23.76 | 10.72 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|-------------|-------------|------------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 737 | | | 358 | |
| B. Refuelling without maintenance | 24 | | | 135 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2007 | | | 981 | 22 | |
| D. Inspection, maintenance or repair without refuelling | | | | 5 | 7 | |
| E. Testing of plant systems or components | | | | 2 | 0 | |
| H. Nuclear regulatory requirements | | | | | 7 | |
| L. Human factor related | | | | | 12 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 21 |
| O. Load dispatching, prioritization | | | | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 729 | | | 65 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 13 |
| Z. Other | | | | | 24 | 4 |
| Subtotal | 2031 | 737 | 729 | 1123 | 430 | 105 |
| Total | | 3497 | | | 1658 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 7 |
| 12. Reactor I&C Systems | | 41 |
| 13. Reactor Auxiliary Systems | | 11 |
| 14. Safety Systems | | 35 |
| 15. Reactor Cooling Systems | | 6 |
| 16. Steam generation systems | | 32 |
| 21. Fuel Handling and Storage Facilities | | 17 |
| 31. Turbine and auxiliaries | 22 | 40 |
| 32. Feedwater and Main Steam System | | 5 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | 261 | 93 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | 454 | 51 |
| 42. Electrical Power Supply Systems | | 18 |
| Total | 737 | 365 |

2023 Operating Experience

FR-13

BUGEY-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : FRAM (FRAMATOME)

Reactor Unit Details

Reactor type and model : PWR / CP0
 Thermal power : 2785 MWth
 Gross electrical power : 945 MWe
 Reference unit power (net) : 910 MWe

Key Dates

Construction Date : 1972-11-01
 Grid Date : 1978-05-10
 Commercial Date : 1979-03-01
 Age at end of year : 45 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

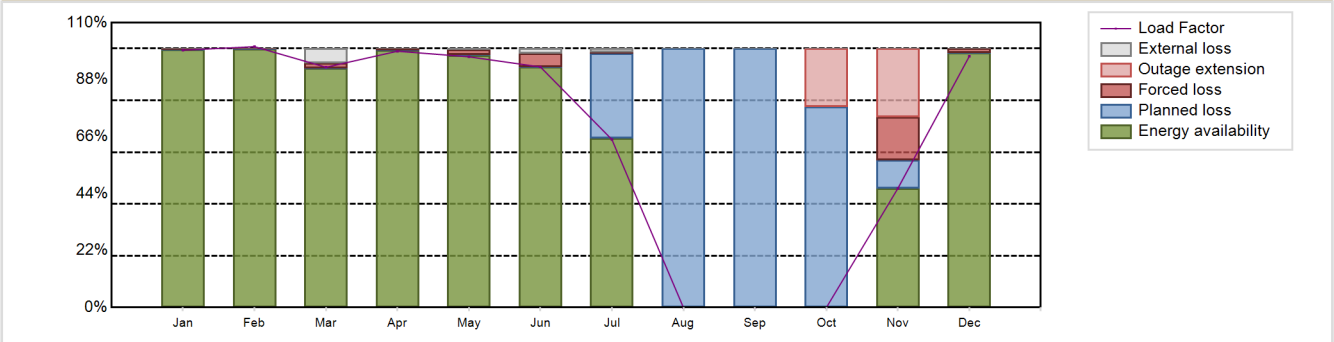
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5226.93 GW(e).h
 Energy Availability Factor (EAF) : 65.75 %
 Unit Capability Factor (UCF) : 66.52 %
 Load Factor (LF) : 65.57 %
 Operating Factor (OF) : 68.45 %

Forced Loss Rate (FLR) : 3.49 %
 Unplanned Capability Loss Factor (UCL) : 6.49 %
 Planned Unavailability Factor (PUF) : 26.99 %
 Externally cause unavailability (XUF) : 0.77 %
 Total off-line time : 2764 hours

Annual Summary

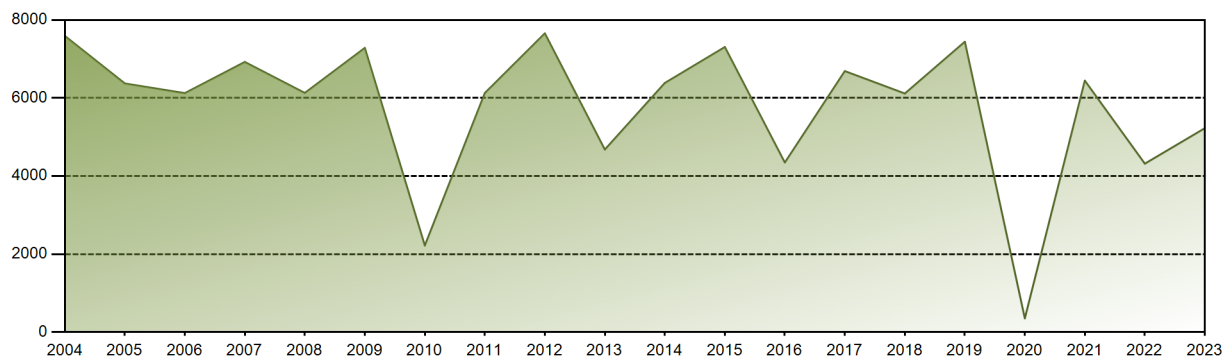


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 672.93 | 616.07 | 627.39 | 648.52 | 655.55 | 608.68 | 439.25 | 0.00 | 0.00 | 0.00 | 301.41 | 657.12 | 5226.93 |
| EAF [%] | 99.66 | 99.86 | 92.41 | 99.41 | 97.45 | 92.99 | 65.36 | 0.00 | 0.00 | 0.00 | 46.02 | 98.41 | 65.75 |
| UCF [%] | 99.66 | 99.86 | 97.95 | 99.41 | 97.77 | 94.84 | 66.84 | 0.00 | 0.00 | 0.00 | 46.02 | 98.41 | 66.52 |
| LF [%] | 99.39 | 100.74 | 92.79 | 98.98 | 96.83 | 92.90 | 64.88 | 0.00 | 0.00 | 0.00 | 46.00 | 97.06 | 65.57 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.25 | 67.88 | 0.00 | 0.00 | 0.00 | 59.86 | 100.00 | 68.45 |
| FLR [%] | 0.34 | 0.06 | 2.05 | 0.58 | 2.18 | 5.15 | 0.68 | 0.00 | 0.00 | 0.00 | 26.58 | 1.59 | 3.49 |
| UCL [%] | 0.34 | 0.06 | 2.05 | 0.58 | 2.18 | 5.15 | 0.46 | 0.00 | 0.00 | 22.42 | 43.12 | 1.59 | 6.49 |
| PUF [%] | 0.00 | 0.07 | 0.00 | 0.01 | 0.05 | 0.01 | 32.70 | 100.00 | 100.00 | 77.58 | 10.86 | 0.01 | 26.99 |
| XUF [%] | 0.00 | 0.00 | 5.55 | 0.00 | 0.32 | 1.85 | 1.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.77 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 245472.55 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.48 % |
| Cumulative Energy Availability Factor (EAF) | : 71.64 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 9.61 % |
| Cumulative Unit Capability Factor (UCF) | : 73.83 % | Cumulative Planned Unavailability Factor (PUF) | : 16.56 % |
| Cumulative Load Factor (LF) | : 67.94 % | Cumulative Externally cause unavailability (XUF) | : 2.19 % |
| Cumulative Operating Factor (OF) | : 73.46 % | | |

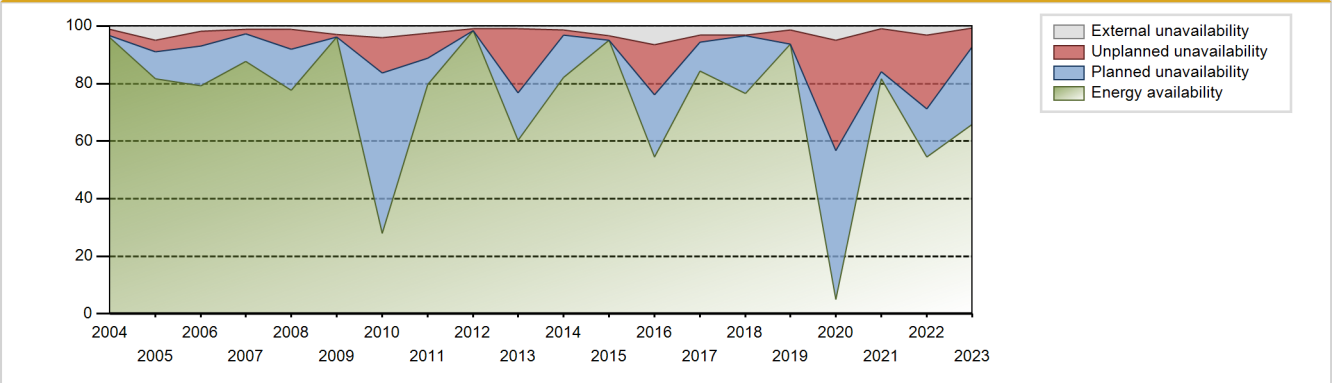
Electricity Production (net) [GWh]



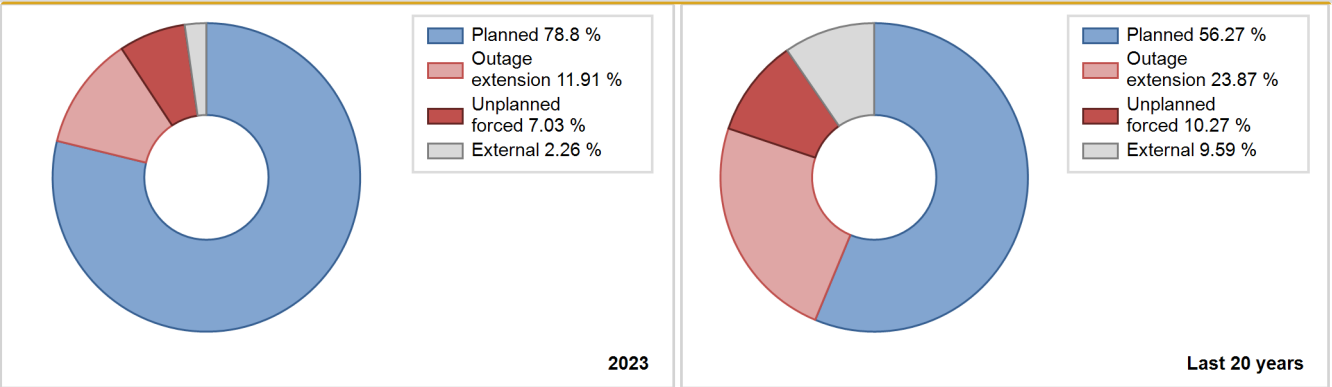
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1979 | 4379.00 | 5588 | 925 | 53.15 | 53.15 | 52.04 | 60.48 | 3.85 | 2.13 | 44.72 | 0.00 |
| 1980 | 4460.00 | 5271 | 920 | 55.71 | 55.71 | 55.19 | 60.01 | 21.66 | 15.40 | 28.89 | 0.00 |
| 1981 | 5209.60 | 6017 | 920 | 65.16 | 65.16 | 64.64 | 68.69 | 13.23 | 9.93 | 24.90 | 0.00 |
| 1982 | 3341.70 | 3863 | 920 | 41.65 | 41.65 | 41.46 | 44.10 | 42.64 | 30.96 | 27.40 | 0.00 |
| 1983 | 6725.00 | 7689 | 920 | 85.30 | 85.30 | 83.45 | 87.77 | 6.98 | 6.40 | 8.30 | 0.00 |
| 1984 | 5748.00 | 6580 | 920 | 87.95 | 87.95 | 71.13 | 74.91 | 4.49 | 4.13 | 7.92 | 0.00 |
| 1985 | 5948.80 | 7118 | 920 | 76.00 | 79.74 | 73.81 | 81.26 | 6.30 | 5.36 | 14.90 | 3.74 |
| 1986 | 5945.60 | 7515 | 920 | 84.51 | 86.37 | 73.77 | 85.79 | 3.30 | 2.94 | 10.68 | 1.86 |
| 1987 | 3581.10 | 4729 | 920 | 51.62 | 53.37 | 44.43 | 53.98 | 37.63 | 32.20 | 14.43 | 1.75 |
| 1988 | 4495.00 | 5718 | 920 | 63.15 | 67.02 | 55.62 | 65.10 | 22.17 | 19.09 | 13.88 | 3.87 |
| 1989 | 4700.83 | 5721 | 920 | 61.06 | 64.74 | 58.33 | 65.31 | 20.60 | 16.79 | 18.47 | 3.68 |
| 1990 | 4878.71 | 6213 | 920 | 69.32 | 69.66 | 60.54 | 70.92 | 11.42 | 8.98 | 21.36 | 0.34 |
| 1991 | 4927.21 | 6001 | 920 | 64.44 | 66.70 | 61.14 | 68.50 | 2.73 | 1.87 | 31.42 | 2.26 |
| 1992 | 3918.31 | 4781 | 910 | 50.22 | 53.86 | 49.02 | 54.43 | 19.55 | 13.09 | 33.06 | 3.64 |
| 1993 | 4509.91 | 5718 | 910 | 94.18 | 99.21 | 56.57 | 65.27 | 0.79 | 0.79 | 0.00 | 5.03 |
| 1994 | 5782.19 | 6811 | 910 | 76.55 | 77.70 | 72.53 | 77.75 | 5.88 | 4.86 | 17.44 | 1.15 |
| 1995 | 6045.65 | 7051 | 910 | 78.10 | 79.65 | 75.84 | 80.49 | 4.74 | 3.96 | 16.39 | 1.55 |
| 1996 | 5533.91 | 6863 | 910 | 75.43 | 78.74 | 69.23 | 78.13 | 8.62 | 7.42 | 13.84 | 3.30 |
| 1997 | 5477.66 | 6815 | 910 | 81.00 | 84.40 | 68.71 | 77.80 | 4.70 | 4.16 | 11.44 | 3.40 |
| 1998 | 5379.41 | 6605 | 910 | 72.90 | 77.60 | 67.48 | 75.40 | 7.39 | 6.19 | 16.21 | 4.70 |
| 1999 | 5960.27 | 7050 | 910 | 77.52 | 78.94 | 74.77 | 80.48 | 8.83 | 7.64 | 13.42 | 1.42 |
| 2000 | 5183.54 | 6025 | 910 | 66.29 | 68.50 | 64.85 | 68.59 | 0.55 | 0.38 | 31.13 | 2.20 |
| 2001 | 5685.92 | 6493 | 910 | 72.23 | 72.27 | 71.33 | 74.12 | 26.61 | 26.21 | 1.53 | 0.03 |
| 2002 | 5542.28 | 6212 | 910 | 69.90 | 70.17 | 69.53 | 70.91 | 20.40 | 17.98 | 11.85 | 0.26 |
| 2003 | 5521.65 | 6579 | 910 | 71.00 | 74.83 | 69.27 | 75.10 | 4.82 | 3.79 | 21.38 | 3.83 |
| 2004 | 7593.43 | 8571 | 910 | 95.97 | 97.12 | 95.00 | 97.58 | 2.17 | 2.16 | 0.72 | 1.14 |
| 2005 | 6373.89 | 7607 | 910 | 81.71 | 86.74 | 79.96 | 86.84 | 2.19 | 3.88 | 9.38 | 5.03 |
| 2006 | 6125.65 | 7158 | 910 | 79.17 | 80.93 | 76.85 | 81.72 | 1.63 | 5.28 | 13.79 | 1.76 |
| 2007 | 6925.13 | 7880 | 910 | 87.64 | 88.72 | 86.86 | 89.94 | 1.48 | 1.63 | 9.65 | 1.07 |
| 2008 | 6130.76 | 7517 | 910 | 77.74 | 78.90 | 76.70 | 85.58 | 8.03 | 6.89 | 14.21 | 1.16 |
| 2009 | 7285.26 | 8731 | 910 | 96.09 | 98.97 | 91.39 | 99.67 | 0.98 | 0.98 | 0.05 | 2.88 |
| 2010 | 2218.07 | 2732 | 910 | 27.93 | 31.94 | 27.82 | 31.19 | 1.30 | 12.29 | 55.77 | 4.01 |
| 2011 | 6127.50 | 7260 | 910 | 79.65 | 82.06 | 76.87 | 82.88 | 2.28 | 8.69 | 9.26 | 2.41 |
| 2012 | 7658.29 | 8712 | 910 | 98.37 | 99.27 | 95.81 | 99.18 | 0.72 | 0.72 | 0.01 | 0.90 |
| 2013 | 4679.30 | 5482 | 910 | 60.35 | 61.21 | 58.70 | 62.58 | 1.56 | 22.31 | 16.49 | 0.85 |
| 2014 | 6386.08 | 7390 | 910 | 82.10 | 83.54 | 80.11 | 84.36 | 1.95 | 1.67 | 14.79 | 1.44 |
| 2015 | 7307.72 | 8526 | 910 | 95.01 | 98.48 | 91.67 | 97.33 | 1.50 | 1.50 | 0.02 | 3.47 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2016 | 4345.61 | 5400 | 910 | 54.40 | 60.80 | 54.36 | 61.48 | 3.78 | 17.55 | 21.65 | 6.39 |
| 2017 | 6690.06 | 7569 | 910 | 84.40 | 87.66 | 83.92 | 86.40 | 2.60 | 2.34 | 10.00 | 3.25 |
| 2018 | 6115.35 | 6916 | 910 | 76.59 | 79.71 | 76.71 | 78.95 | 0.09 | 0.19 | 20.10 | 3.12 |
| 2019 | 7443.41 | 8383 | 910 | 93.64 | 95.04 | 93.37 | 95.70 | 4.95 | 4.95 | 0.01 | 1.39 |
| 2020 | 351.50 | 412 | 910 | 5.02 | 9.95 | 4.40 | 4.69 | 2.79 | 38.40 | 51.64 | 4.93 |
| 2021 | 6445.92 | 7527 | 910 | 81.63 | 82.65 | 80.86 | 85.92 | 2.64 | 14.79 | 2.56 | 1.03 |
| 2022 | 4317.13 | 5083 | 910 | 54.42 | 57.50 | 54.16 | 58.03 | 22.94 | 25.64 | 16.86 | 3.09 |
| 2023 | 5226.93 | 5996 | 910 | 65.75 | 66.52 | 65.57 | 68.45 | 3.49 | 6.49 | 26.99 | 0.77 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1979 to 2023 | | |
|--|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 477 | | | 640 | |
| B. Refuelling without maintenance | | | | 31 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2281 | | | 1250 | 30 | |
| D. Inspection, maintenance or repair without refuelling | | | | 84 | | |
| E. Testing of plant systems or components | | | | 8 | 0 | |
| H. Nuclear regulatory requirements | | | | | 29 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 11 | |
| M. Governmental requirements or court decisions | | | | | | 1 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 14 |
| O. Load dispatching, prioritization | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant , spare part delivery problems etc.) | | | | | | 33 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 1 |
| Z. Other | | | | 2 | 67 | |
| Subtotal | 2281 | 477 | | 1375 | 777 | 50 |
| Total | | 2758 | | | 2202 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1979 to 2023 | |
|--|------------|------------|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 164 |
| 12. Reactor I&C Systems | | | | 19 |
| 13. Reactor Auxiliary Systems | | | | 10 |
| 14. Safety Systems | | | | 47 |
| 15. Reactor Cooling Systems | | | | 24 |
| 16. Steam generation systems | | | | 24 |
| 21. Fuel Handling and Storage Facilities | | | | 4 |
| 31. Turbine and auxiliaries | | 1 | | 35 |
| 32. Feedwater and Main Steam System | | 98 | | 33 |
| 33. Circulating Water System | | | | 1 |
| 34. Miscellaneous Systems | | 378 | | 210 |
| 35. All other I&C Systems | | | | 3 |
| 41. Main Generator Systems | | | | 49 |
| 42. Electrical Power Supply Systems | | | | 26 |
| Total | | 477 | | 649 |

2023 Operating Experience

FR-14

BUGEY-3

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : FRAM (FRAMATOME)

Reactor Unit Details

Reactor type and model : PWR / CP0
 Thermal power : 2785 MWth
 Gross electrical power : 945 MWe
 Reference unit power (net) : 910 MWe

Key Dates

Construction Date : 1973-09-01
 Grid Date : 1978-09-21
 Commercial Date : 1979-03-01
 Age at end of year : 45 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

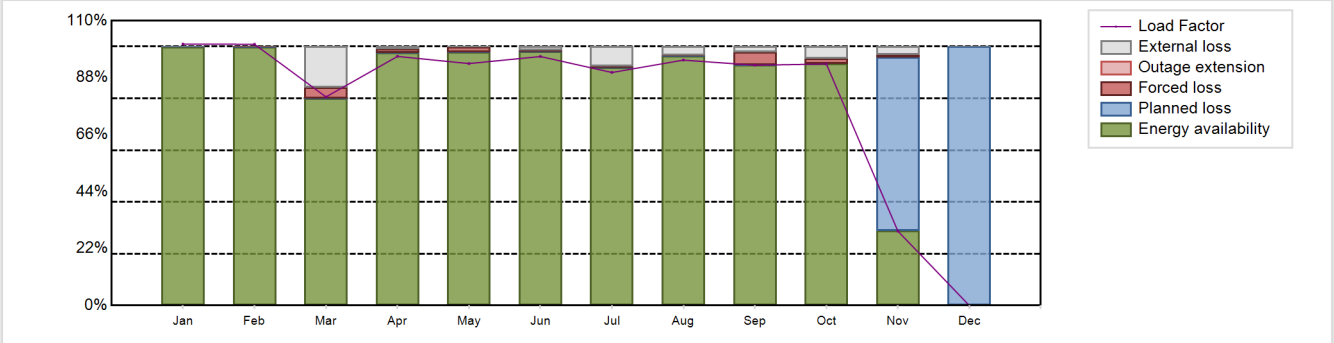
: none

Annual Production Results (2023)

Net Energy Production : 6418.38 GW(e).h
 Energy Availability Factor (EAF) : 81.27 %
 Unit Capability Factor (UCF) : 84.56 %
 Load Factor (LF) : 80.52 %
 Operating Factor (OF) : 84.22 %

Forced Loss Rate (FLR) : 1.65 %
 Unplanned Capability Loss Factor (UCL) : 1.42 %
 Planned Unavailability Factor (PUF) : 14.02 %
 Externally cause unavailability (XUF) : 3.28 %
 Total off-line time : 1382 hours

Annual Summary

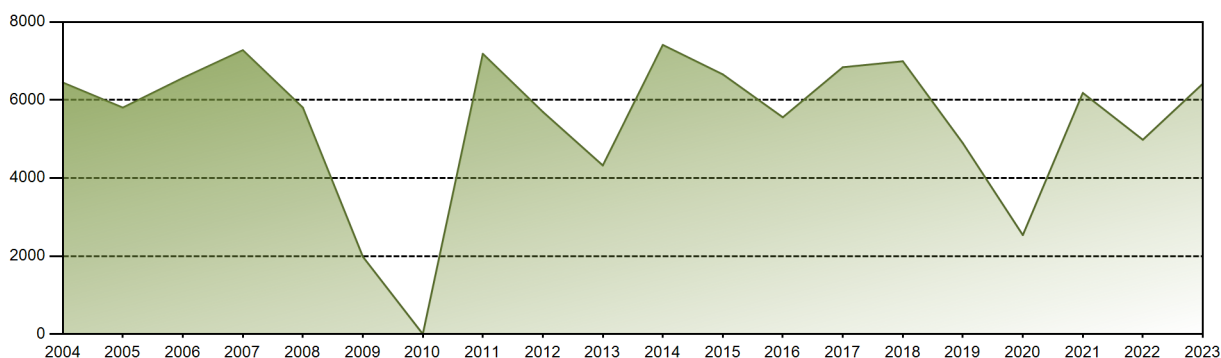


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 683.60 | 617.06 | 544.73 | 630.36 | 632.66 | 630.09 | 609.33 | 641.75 | 608.06 | 632.33 | 188.41 | 0.00 | 6418.38 |
| EAF [%] | 99.92 | 99.96 | 79.98 | 97.60 | 97.97 | 98.10 | 91.96 | 96.38 | 92.87 | 93.31 | 28.78 | 0.00 | 81.27 |
| UCF [%] | 99.92 | 99.96 | 95.75 | 98.37 | 98.13 | 99.59 | 99.47 | 99.68 | 95.09 | 97.88 | 31.91 | 0.00 | 84.56 |
| LF [%] | 100.97 | 100.91 | 80.57 | 96.21 | 93.44 | 96.17 | 90.00 | 94.79 | 92.81 | 93.27 | 28.76 | 0.00 | 80.52 |
| OF [%] | 100.00 | 100.00 | 83.58 | 100.00 | 100.00 | 100.00 | 95.16 | 100.00 | 100.00 | 99.87 | 33.47 | 0.00 | 84.22 |
| FLR [%] | 0.00 | 0.02 | 4.24 | 1.62 | 1.86 | 0.41 | 0.53 | 0.29 | 4.90 | 2.12 | 3.01 | 0.00 | 1.65 |
| UCL [%] | 0.00 | 0.02 | 4.24 | 1.62 | 1.86 | 0.41 | 0.53 | 0.29 | 4.90 | 2.12 | 0.99 | 0.00 | 1.42 |
| PUF [%] | 0.08 | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.02 | 0.01 | 0.00 | 67.10 | 100.00 | 14.02 |
| XUF [%] | 0.00 | 0.00 | 15.78 | 0.76 | 0.16 | 1.48 | 7.51 | 3.31 | 2.22 | 4.57 | 3.14 | 0.00 | 3.28 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 240435.64 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 9.34 % |
| Cumulative Energy Availability Factor (EAF) | : 70.88 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 11.88 % |
| Cumulative Unit Capability Factor (UCF) | : 73.34 % | Cumulative Planned Unavailability Factor (PUF) | : 14.79 % |
| Cumulative Load Factor (LF) | : 66.72 % | Cumulative Externally cause unavailability (XUF) | : 2.46 % |
| Cumulative Operating Factor (OF) | : 72.17 % | | |

Electricity Production (net) [GWh]

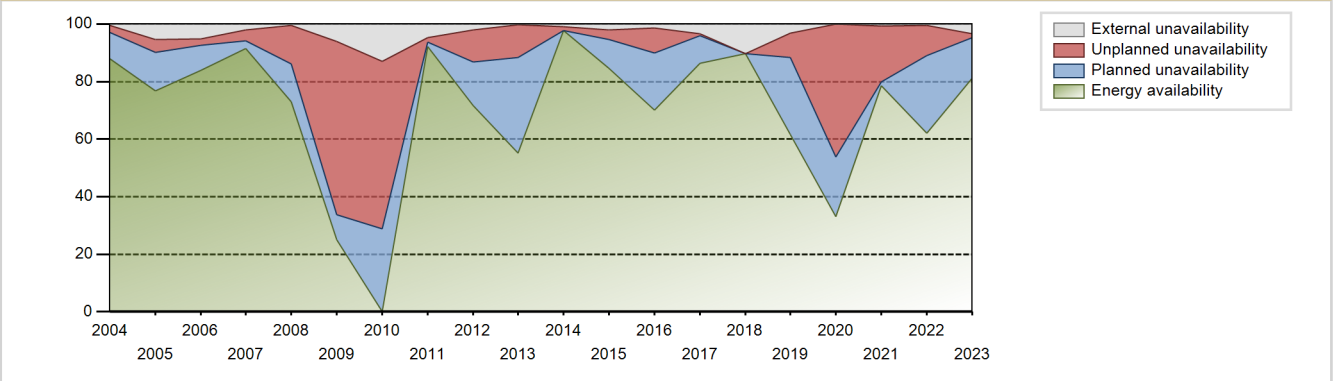


Performance for Years of Commercial Operation

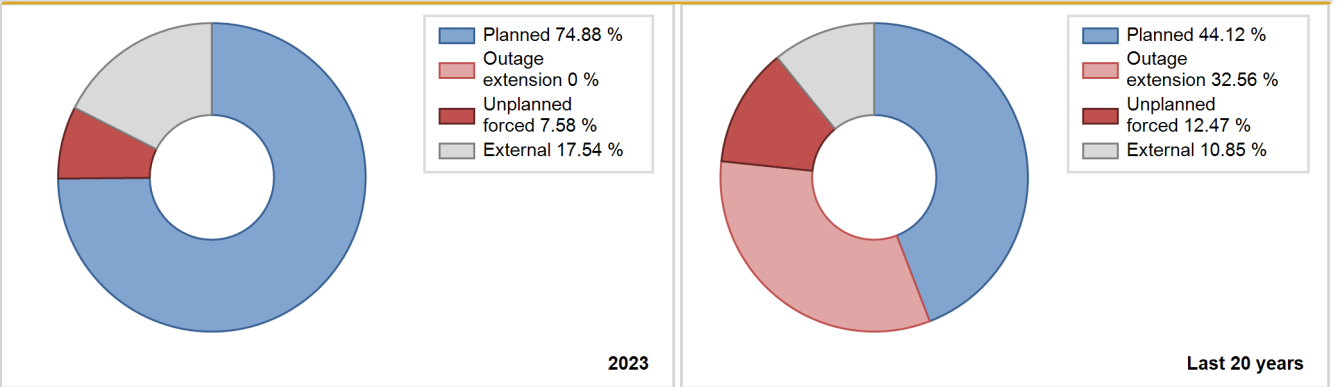
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1979 | 3504.00 | 4389 | 925 | 39.87 | 39.87 | 40.39 | 45.04 | 0.00 | 0.00 | 60.13 | 0.00 |
| 1980 | 5960.00 | 6951 | 920 | 74.66 | 74.66 | 73.75 | 79.13 | 12.90 | 11.05 | 14.28 | 0.00 |
| 1981 | 4849.60 | 5646 | 920 | 61.04 | 61.04 | 60.17 | 64.45 | 7.91 | 5.24 | 33.71 | 0.00 |
| 1982 | 6002.20 | 7661 | 920 | 78.90 | 78.90 | 74.48 | 87.45 | 7.28 | 6.20 | 14.90 | 0.00 |
| 1983 | 5525.00 | 6556 | 920 | 74.04 | 74.04 | 68.56 | 74.84 | 10.03 | 8.25 | 17.71 | 0.00 |
| 1984 | 5793.00 | 6905 | 920 | 77.95 | 77.95 | 71.68 | 78.61 | 10.85 | 9.49 | 12.56 | 0.00 |
| 1985 | 4571.10 | 5235 | 920 | 57.17 | 58.70 | 56.72 | 59.76 | 31.91 | 27.51 | 13.80 | 1.53 |
| 1986 | 6558.10 | 7634 | 920 | 87.13 | 87.65 | 81.37 | 87.15 | 1.89 | 1.69 | 10.66 | 0.52 |
| 1987 | 5482.50 | 6637 | 920 | 76.39 | 78.36 | 68.03 | 75.76 | 10.45 | 9.14 | 12.50 | 1.97 |
| 1988 | 3812.00 | 4935 | 920 | 62.42 | 64.68 | 47.17 | 56.18 | 23.14 | 19.48 | 15.84 | 2.26 |
| 1989 | 4914.26 | 6467 | 920 | 87.37 | 88.72 | 60.98 | 73.82 | 10.86 | 10.81 | 0.47 | 1.35 |
| 1990 | 4538.61 | 5474 | 920 | 62.95 | 68.02 | 56.32 | 62.49 | 14.73 | 11.75 | 20.24 | 5.07 |
| 1991 | 3442.82 | 4168 | 920 | 51.68 | 55.68 | 42.72 | 47.58 | 9.48 | 5.83 | 38.49 | 4.00 |
| 1992 | 2489.99 | 2879 | 910 | 32.19 | 32.50 | 31.15 | 32.78 | 67.39 | 67.17 | 0.33 | 0.31 |
| 1993 | 5954.45 | 7117 | 910 | 76.13 | 80.20 | 74.70 | 81.24 | 3.88 | 3.24 | 16.56 | 4.07 |
| 1994 | 4717.68 | 5872 | 910 | 65.25 | 69.97 | 59.18 | 67.03 | 16.89 | 14.22 | 15.80 | 4.72 |
| 1995 | 5535.71 | 6564 | 910 | 95.21 | 95.93 | 69.44 | 74.93 | 3.60 | 3.59 | 0.48 | 0.72 |
| 1996 | 5652.94 | 7012 | 910 | 76.38 | 78.72 | 70.72 | 79.83 | 10.63 | 9.37 | 11.91 | 2.34 |
| 1997 | 5596.64 | 6561 | 910 | 74.89 | 74.98 | 70.21 | 74.90 | 10.44 | 8.74 | 16.28 | 0.08 |
| 1998 | 6680.36 | 7875 | 910 | 89.04 | 89.13 | 83.80 | 89.90 | 1.44 | 1.30 | 9.56 | 0.09 |
| 1999 | 5786.61 | 7001 | 910 | 77.26 | 77.60 | 72.59 | 79.92 | 10.96 | 9.56 | 12.85 | 0.33 |
| 2000 | 5745.14 | 6765 | 910 | 74.71 | 75.70 | 71.87 | 77.02 | 13.70 | 12.02 | 12.28 | 0.99 |
| 2001 | 6230.61 | 7129 | 910 | 81.20 | 81.80 | 78.16 | 81.38 | 4.21 | 3.60 | 14.60 | 0.60 |
| 2002 | 4634.68 | 5654 | 910 | 63.88 | 66.43 | 58.14 | 64.54 | 4.18 | 2.90 | 30.68 | 2.54 |
| 2003 | 6646.07 | 7924 | 910 | 85.15 | 97.22 | 83.37 | 90.46 | 1.42 | 1.40 | 1.38 | 12.06 |
| 2004 | 6447.31 | 7461 | 910 | 87.85 | 88.23 | 80.66 | 84.94 | 2.89 | 2.62 | 9.15 | 0.37 |
| 2005 | 5805.39 | 7017 | 910 | 76.85 | 82.31 | 72.83 | 80.10 | 4.37 | 4.48 | 13.20 | 5.46 |
| 2006 | 6563.54 | 7624 | 910 | 83.89 | 89.14 | 82.34 | 87.03 | 2.00 | 2.09 | 8.77 | 5.25 |
| 2007 | 7277.78 | 8258 | 910 | 91.39 | 93.44 | 91.30 | 94.27 | 3.85 | 3.74 | 2.82 | 2.05 |
| 2008 | 5807.10 | 7352 | 910 | 72.94 | 73.49 | 72.65 | 83.70 | 14.37 | 13.33 | 13.18 | 0.54 |
| 2009 | 1984.81 | 2676 | 910 | 24.97 | 31.00 | 24.90 | 30.55 | 16.68 | 60.24 | 8.76 | 6.04 |
| 2010 | 0.00 | 0 | 910 | 0.00 | 12.88 | 0.00 | 0.00 | 0.00 | 58.34 | 28.78 | 12.88 |
| 2011 | 7184.55 | 8370 | 910 | 92.08 | 96.70 | 90.13 | 95.55 | 1.77 | 1.75 | 1.55 | 4.62 |
| 2012 | 5696.79 | 6487 | 910 | 71.64 | 73.68 | 71.27 | 73.85 | 5.07 | 11.11 | 15.21 | 2.04 |
| 2013 | 4321.81 | 4929 | 910 | 55.12 | 55.40 | 54.22 | 56.27 | 2.07 | 11.31 | 33.30 | 0.27 |
| 2014 | 7412.21 | 8563 | 910 | 97.69 | 98.52 | 92.98 | 97.75 | 1.43 | 1.43 | 0.06 | 0.83 |
| 2015 | 6656.93 | 7664 | 910 | 84.60 | 86.70 | 83.51 | 87.49 | 3.30 | 3.21 | 10.09 | 2.10 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2016 | 5556.90 | 6516 | 910 | 70.15 | 71.51 | 69.52 | 74.18 | 6.77 | 8.61 | 19.88 | 1.36 |
| 2017 | 6840.57 | 7744 | 910 | 86.28 | 89.66 | 85.81 | 88.40 | 0.80 | 0.72 | 9.62 | 3.38 |
| 2018 | 6993.15 | 8196 | 910 | 89.68 | 99.94 | 87.73 | 93.56 | 0.05 | 0.05 | 0.01 | 10.26 |
| 2019 | 4893.90 | 5806 | 910 | 61.73 | 64.80 | 61.39 | 66.28 | 10.14 | 8.55 | 26.64 | 3.07 |
| 2020 | 2537.87 | 2962 | 910 | 33.18 | 33.18 | 31.75 | 33.72 | 28.80 | 46.21 | 20.61 | 0.00 |
| 2021 | 6181.66 | 7068 | 910 | 78.65 | 79.27 | 77.55 | 80.68 | 0.41 | 19.49 | 1.24 | 0.62 |
| 2022 | 4981.07 | 5653 | 910 | 62.12 | 62.62 | 62.49 | 64.53 | 6.51 | 10.51 | 26.88 | 0.50 |
| 2023 | 6418.38 | 7378 | 910 | 81.27 | 84.56 | 80.52 | 84.22 | 1.65 | 1.42 | 14.02 | 3.28 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1979 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 803 | |
| B. Refuelling without maintenance | | | | 26 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1223 | | | 1062 | 29 | |
| D. Inspection, maintenance or repair without refuelling | | | | 65 | | |
| E. Testing of plant systems or components | | | | 33 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 2 | | |
| H. Nuclear regulatory requirements | | | | | 2 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 10 |
| L. Human factor related | | | | | 10 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 36 | | | 28 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 99 | | 17 | 95 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 1 |
| Z. Other | | | | | 11 | |
| Subtotal | 1223 | 24 | 135 | 1188 | 873 | 135 |
| Total | | 1382 | | | 2196 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1979 to 2023 | |
|--|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 148 |
| 12. Reactor I&C Systems | | | | 12 |
| 13. Reactor Auxiliary Systems | | | | 12 |
| 14. Safety Systems | | | | 19 |
| 15. Reactor Cooling Systems | | | | 30 |
| 16. Steam generation systems | | | | 240 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 0 |
| 31. Turbine and auxiliaries | | | | 63 |
| 32. Feedwater and Main Steam System | | | | 19 |
| 33. Circulating Water System | | | | 1 |
| 34. Miscellaneous Systems | | | | 163 |
| 35. All other I&C Systems | | | | 0 |
| 41. Main Generator Systems | | | 24 | 80 |
| 42. Electrical Power Supply Systems | | | | 17 |
| Total | | | 24 | 804 |

2023 Operating Experience

FR-15

BUGEY-4

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : FRAM (FRAMATOME)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP0 | Construction Date | : 1974-06-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1979-03-08 |
| Gross electrical power | : 917 MWe | Commercial Date | : 1979-07-01 |
| Reference unit power (net) | : 880 MWe | Age at end of year | : 44 years |

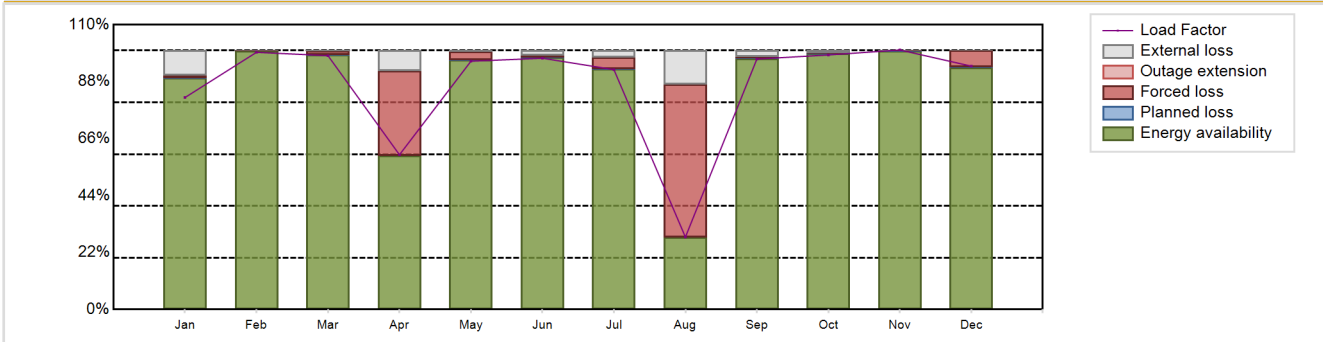
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|------------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.8 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 321 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 5 |
| Refuelling frequency [month] | : 12 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 33735 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Primary means of condenser cooling | : River (once-through) |
| Number of control rod assemblies | : 48 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 6683.66 GW(e).h | Forced Loss Rate (FLR) | : 9.26 % |
| Energy Availability Factor (EAF) | : 87.48 % | Unplanned Capability Loss Factor (UCL) | : 9.25 % |
| Unit Capability Factor (UCF) | : 90.72 % | Planned Unavailability Factor (PUF) | : 0.03 % |
| Load Factor (LF) | : 86.7 % | Externally cause unavailability (XUF) | : 3.24 % |
| Operating Factor (OF) | : 92.75 % | Total off-line time | : 635 hours |

Annual Summary

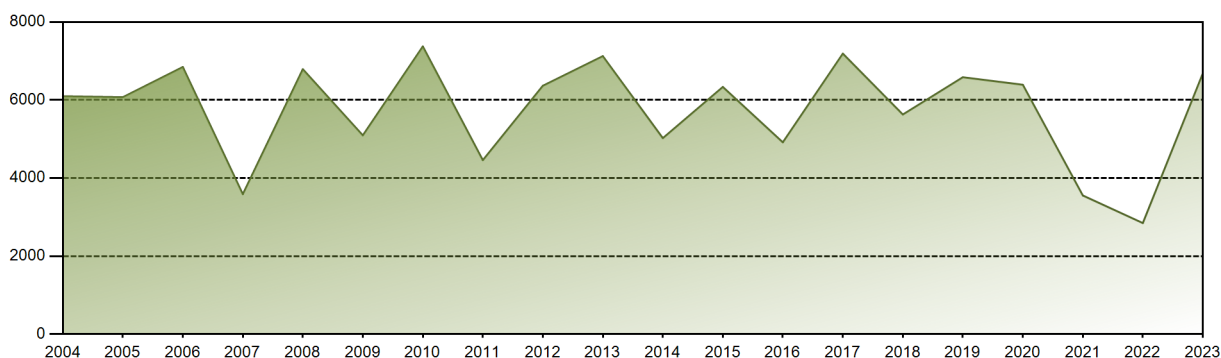


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 536.13 | 587.39 | 641.01 | 378.66 | 627.88 | 614.93 | 606.57 | 183.11 | 613.04 | 644.46 | 635.10 | 615.38 | 6683.66 |
| EAF [%] | 89.50 | 99.99 | 98.39 | 59.44 | 96.33 | 97.34 | 92.89 | 27.99 | 96.98 | 98.79 | 99.95 | 93.52 | 87.48 |
| UCF [%] | 99.03 | 99.99 | 98.45 | 67.22 | 96.82 | 99.13 | 95.45 | 41.11 | 99.34 | 99.60 | 99.95 | 93.52 | 90.72 |
| LF [%] | 81.89 | 99.33 | 98.04 | 59.76 | 95.90 | 97.05 | 92.65 | 27.97 | 96.75 | 98.30 | 100.24 | 93.99 | 86.70 |
| OF [%] | 87.37 | 100.00 | 100.00 | 70.14 | 100.00 | 100.00 | 100.00 | 56.32 | 100.00 | 99.87 | 100.00 | 100.00 | 92.75 |
| FLR [%] | 0.96 | 0.01 | 1.54 | 32.78 | 3.17 | 0.85 | 4.55 | 58.89 | 0.60 | 0.34 | 0.04 | 6.35 | 9.26 |
| UCL [%] | 0.96 | 0.01 | 1.54 | 32.78 | 3.17 | 0.85 | 4.55 | 58.89 | 0.60 | 0.34 | 0.04 | 6.34 | 9.25 |
| PUF [%] | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.06 | 0.06 | 0.01 | 0.14 | 0.03 |
| XUF [%] | 9.52 | 0.00 | 0.06 | 7.78 | 0.50 | 1.80 | 2.56 | 13.12 | 2.36 | 0.81 | 0.00 | 0.00 | 3.24 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 241260.51 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.78 % |
| Cumulative Energy Availability Factor (EAF) | : 73.78 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 9.04 % |
| Cumulative Unit Capability Factor (UCF) | : 75.92 % | Cumulative Planned Unavailability Factor (PUF) | : 15.04 % |
| Cumulative Load Factor (LF) | : 69.61 % | Cumulative Externally cause unavailability (XUF) | : 2.15 % |
| Cumulative Operating Factor (OF) | : 75.26 % | | |

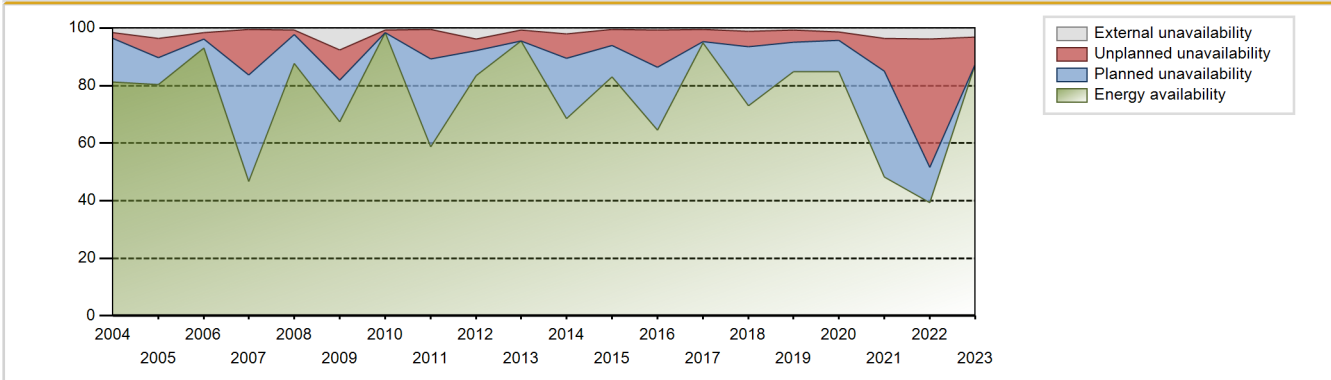
Electricity Production (net) [GWh]



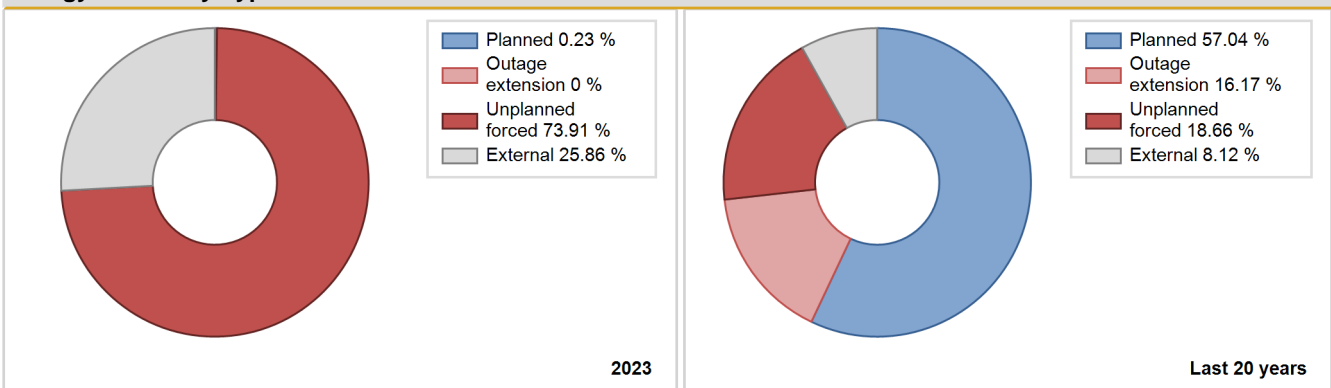
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1979 | 3528.00 | 5030 | 900 | 64.64 | 64.64 | 58.45 | 64.63 | 7.03 | 4.89 | 30.47 | 0.00 |
| 1980 | 5063.00 | 5983 | 900 | 65.84 | 65.84 | 64.04 | 68.11 | 7.76 | 5.54 | 28.63 | 0.00 |
| 1981 | 5671.90 | 6834 | 900 | 75.58 | 75.58 | 71.94 | 78.01 | 7.43 | 6.07 | 18.35 | 0.00 |
| 1982 | 5474.90 | 6276 | 900 | 69.75 | 69.75 | 69.44 | 71.64 | 18.88 | 16.23 | 14.02 | 0.00 |
| 1983 | 6329.00 | 7389 | 900 | 83.23 | 83.28 | 80.28 | 84.35 | 2.40 | 2.05 | 14.67 | 0.05 |
| 1984 | 5882.00 | 6896 | 900 | 75.84 | 75.84 | 74.40 | 78.51 | 8.57 | 7.11 | 17.05 | 0.00 |
| 1985 | 6224.40 | 7696 | 900 | 86.67 | 87.22 | 78.95 | 87.85 | 2.08 | 1.85 | 10.93 | 0.55 |
| 1986 | 5312.70 | 6622 | 900 | 76.12 | 78.72 | 67.39 | 75.59 | 6.46 | 5.44 | 15.84 | 2.60 |
| 1987 | 4670.90 | 6180 | 900 | 78.16 | 79.80 | 59.25 | 70.55 | 6.45 | 5.50 | 14.70 | 1.63 |
| 1988 | 3323.00 | 4524 | 900 | 51.52 | 67.31 | 42.03 | 51.50 | 23.06 | 20.18 | 12.51 | 15.80 |
| 1989 | 5541.34 | 6846 | 900 | 76.16 | 76.69 | 70.29 | 78.15 | 9.60 | 8.14 | 15.17 | 0.53 |
| 1990 | 3186.65 | 4312 | 880 | 53.52 | 56.66 | 41.34 | 49.22 | 4.28 | 2.53 | 40.81 | 3.13 |
| 1991 | 4984.85 | 6317 | 880 | 69.33 | 71.78 | 64.66 | 72.11 | 12.15 | 9.93 | 18.29 | 2.45 |
| 1992 | 1649.11 | 2012 | 880 | 22.25 | 22.25 | 21.33 | 22.91 | 77.11 | 74.94 | 2.82 | 0.00 |
| 1993 | 5748.62 | 7506 | 880 | 74.24 | 82.16 | 74.57 | 85.68 | 5.37 | 4.66 | 13.18 | 7.92 |
| 1994 | 5209.34 | 6619 | 880 | 82.16 | 83.47 | 67.58 | 75.56 | 3.58 | 3.10 | 13.43 | 1.31 |
| 1995 | 3989.94 | 4843 | 880 | 59.14 | 64.32 | 51.76 | 55.29 | 16.92 | 13.10 | 22.57 | 5.19 |
| 1996 | 4188.12 | 5333 | 880 | 62.37 | 62.57 | 54.18 | 60.71 | 34.28 | 32.64 | 4.79 | 0.20 |
| 1997 | 5652.46 | 7420 | 880 | 80.75 | 83.58 | 73.32 | 84.70 | 2.58 | 2.21 | 14.21 | 2.83 |
| 1998 | 6304.00 | 7791 | 880 | 86.32 | 88.31 | 81.78 | 88.94 | 2.09 | 1.88 | 9.81 | 1.99 |
| 1999 | 5591.31 | 7231 | 880 | 77.46 | 81.55 | 72.53 | 82.55 | 0.39 | 0.32 | 18.13 | 4.09 |
| 2000 | 5987.96 | 7544 | 880 | 82.58 | 85.08 | 77.46 | 85.88 | 3.07 | 2.70 | 12.22 | 2.50 |
| 2001 | 4746.00 | 5921 | 880 | 63.43 | 65.82 | 61.57 | 67.59 | 2.47 | 1.66 | 32.52 | 2.39 |
| 2002 | 5590.81 | 7130 | 880 | 83.36 | 83.51 | 72.53 | 81.39 | 0.90 | 0.76 | 15.73 | 0.15 |
| 2003 | 6645.34 | 8192 | 880 | 94.23 | 95.56 | 86.20 | 93.52 | 4.43 | 4.43 | 0.01 | 1.33 |
| 2004 | 6098.32 | 7367 | 880 | 81.31 | 82.97 | 78.89 | 83.87 | 2.42 | 2.05 | 14.98 | 1.66 |
| 2005 | 6073.19 | 7672 | 880 | 80.34 | 83.97 | 78.78 | 87.58 | 7.39 | 6.70 | 9.33 | 3.63 |
| 2006 | 6846.66 | 8341 | 880 | 93.15 | 94.65 | 88.82 | 95.22 | 2.50 | 2.42 | 2.93 | 1.50 |
| 2007 | 3586.19 | 4217 | 880 | 46.76 | 47.20 | 46.52 | 48.14 | 1.14 | 15.77 | 37.03 | 0.44 |
| 2008 | 6790.40 | 7891 | 880 | 87.70 | 88.48 | 87.85 | 89.83 | 1.46 | 1.54 | 9.98 | 0.78 |
| 2009 | 5094.25 | 6262 | 880 | 67.46 | 75.16 | 66.08 | 71.48 | 5.81 | 10.47 | 14.36 | 7.70 |
| 2010 | 7374.14 | 8674 | 880 | 98.36 | 98.95 | 95.66 | 99.02 | 1.03 | 1.02 | 0.02 | 0.59 |
| 2011 | 4458.28 | 5344 | 880 | 58.75 | 59.29 | 57.83 | 61.00 | 1.87 | 10.14 | 30.56 | 0.54 |
| 2012 | 6365.58 | 7529 | 880 | 83.51 | 87.26 | 82.35 | 85.71 | 1.52 | 4.14 | 8.59 | 3.75 |
| 2013 | 7125.79 | 8425 | 880 | 95.40 | 96.19 | 92.44 | 96.18 | 3.79 | 3.79 | 0.02 | 0.79 |
| 2014 | 5022.76 | 6265 | 880 | 68.53 | 70.60 | 65.16 | 71.52 | 1.36 | 8.47 | 20.93 | 2.06 |
| 2015 | 6335.29 | 7448 | 880 | 82.93 | 83.43 | 82.18 | 85.02 | 5.88 | 5.64 | 10.94 | 0.50 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2016 | 4915.52 | 5739 | 880 | 64.52 | 65.19 | 63.59 | 65.33 | 0.11 | 12.89 | 21.92 | 0.67 |
| 2017 | 7189.64 | 8420 | 880 | 94.74 | 95.20 | 93.27 | 96.12 | 0.49 | 4.19 | 0.61 | 0.46 |
| 2018 | 5628.66 | 6625 | 880 | 73.06 | 74.24 | 73.02 | 75.63 | 5.71 | 5.27 | 20.48 | 1.19 |
| 2019 | 6584.52 | 7618 | 880 | 84.80 | 85.47 | 85.42 | 86.96 | 3.25 | 4.26 | 10.27 | 0.67 |
| 2020 | 6391.78 | 7595 | 880 | 84.80 | 86.10 | 82.69 | 86.46 | 3.30 | 2.94 | 10.96 | 1.30 |
| 2021 | 3552.95 | 4434 | 880 | 48.17 | 51.73 | 46.09 | 50.62 | 3.11 | 11.39 | 36.87 | 3.56 |
| 2022 | 2846.18 | 3339 | 880 | 39.25 | 43.11 | 36.92 | 38.12 | 45.87 | 44.54 | 12.35 | 3.86 |
| 2023 | 6683.66 | 8125 | 880 | 87.48 | 90.72 | 86.70 | 92.75 | 9.26 | 9.25 | 0.03 | 3.24 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1979 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 527 | | | 629 | |
| B. Refuelling without maintenance | | | | 23 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1138 | 14 | |
| D. Inspection, maintenance or repair without refuelling | | | | 71 | | |
| E. Testing of plant systems or components | | | | 10 | 0 | |
| H. Nuclear regulatory requirements | | | | | 26 | |
| L. Human factor related | | | | | 9 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 0 | | | 2 |
| O. Load dispatching, prioritization | | | 36 | | | 5 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 49 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 77 | | | 8 |
| Z. Other | | | | | 14 | 0 |
| Subtotal | | 527 | 113 | 1242 | 692 | 64 |
| Total | | 640 | | | 1998 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1979 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 186 |
| 12. Reactor I&C Systems | | 21 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 88 |
| 15. Reactor Cooling Systems | | 16 |
| 16. Steam generation systems | | 66 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 0 |
| 31. Turbine and auxiliaries | 511 | 53 |
| 32. Feedwater and Main Steam System | 15 | 14 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 73 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 27 |
| 42. Electrical Power Supply Systems | | 94 |
| Total | 526 | 647 |

2023 Operating Experience

FR-16
BUGEY-5
FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : FRAM (FRAMATOME)

Reactor Unit Details

Reactor type and model : PWR / CP0
 Thermal power : 2785 MWth
 Gross electrical power : 917 MWe
 Reference unit power (net) : 880 MWe

Key Dates

Construction Date : 1974-07-01
 Grid Date : 1979-07-31
 Commercial Date : 1980-01-03
 Age at end of year : 44 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

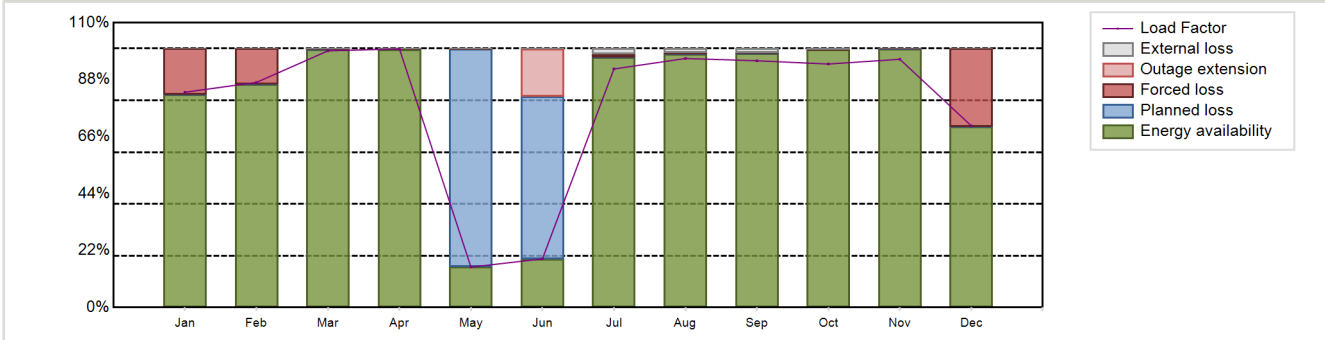
Non-electrical applications

: none

Annual Production Results (2023)

| | | | | | |
|----------------------------------|---|-----------------|--|---|------------|
| Net Energy Production | : | 6081.03 GW(e).h | Forced Loss Rate (FLR) | : | 6.21 % |
| Energy Availability Factor (EAF) | : | 80.3 % | Unplanned Capability Loss Factor (UCL) | : | 6.87 % |
| Unit Capability Factor (UCF) | : | 80.82 % | Planned Unavailability Factor (PUF) | : | 12.31 % |
| Load Factor (LF) | : | 78.88 % | Externally cause unavailability (XUF) | : | 0.52 % |
| Operating Factor (OF) | : | 81.54 % | Total off-line time | : | 1617 hours |

Annual Summary

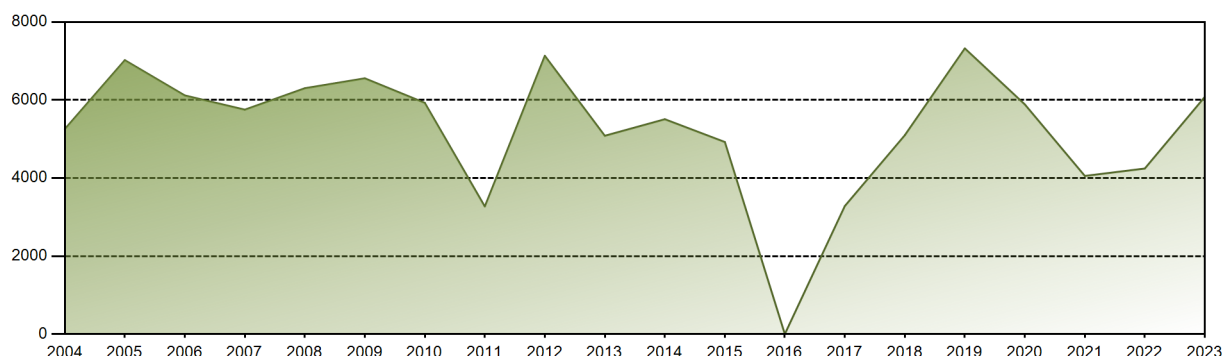


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 544.42 | 514.16 | 648.21 | 632.84 | 102.22 | 119.11 | 603.26 | 629.66 | 603.83 | 616.48 | 607.47 | 459.36 | 6081.03 |
| EAF [%] | 82.28 | 86.18 | 99.56 | 99.71 | 15.62 | 18.80 | 96.64 | 97.81 | 98.11 | 99.54 | 99.94 | 69.79 | 80.30 |
| UCF [%] | 82.28 | 86.18 | 99.60 | 99.78 | 15.74 | 18.83 | 98.79 | 99.50 | 99.81 | 99.95 | 99.94 | 69.79 | 80.82 |
| LF [%] | 83.15 | 86.95 | 99.14 | 99.88 | 15.61 | 18.80 | 92.14 | 96.17 | 95.30 | 94.03 | 95.88 | 70.16 | 78.88 |
| OF [%] | 83.33 | 87.20 | 100.00 | 100.00 | 16.40 | 24.58 | 97.58 | 100.00 | 100.00 | 99.87 | 100.00 | 70.03 | 81.54 |
| FLR [%] | 17.72 | 13.82 | 0.32 | 0.22 | 0.60 | 0.00 | 1.19 | 0.49 | 0.19 | 0.02 | 0.05 | 30.21 | 6.21 |
| UCL [%] | 17.71 | 13.81 | 0.32 | 0.22 | 0.10 | 18.51 | 1.19 | 0.49 | 0.19 | 0.02 | 0.05 | 30.21 | 6.87 |
| PUF [%] | 0.01 | 0.01 | 0.08 | 0.00 | 84.16 | 62.66 | 0.01 | 0.00 | 0.00 | 0.03 | 0.00 | 0.01 | 12.31 |
| XUF [%] | 0.00 | 0.00 | 0.04 | 0.07 | 0.12 | 0.03 | 2.15 | 1.70 | 1.70 | 0.41 | 0.00 | 0.00 | 0.52 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 233063.15 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.53 % |
| Cumulative Energy Availability Factor (EAF) | : 72.19 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 10.39 % |
| Cumulative Unit Capability Factor (UCF) | : 74.5 % | Cumulative Planned Unavailability Factor (PUF) | : 15.11 % |
| Cumulative Load Factor (LF) | : 67.89 % | Cumulative Externally cause unavailability (XUF) | : 2.31 % |
| Cumulative Operating Factor (OF) | : 73.98 % | | |

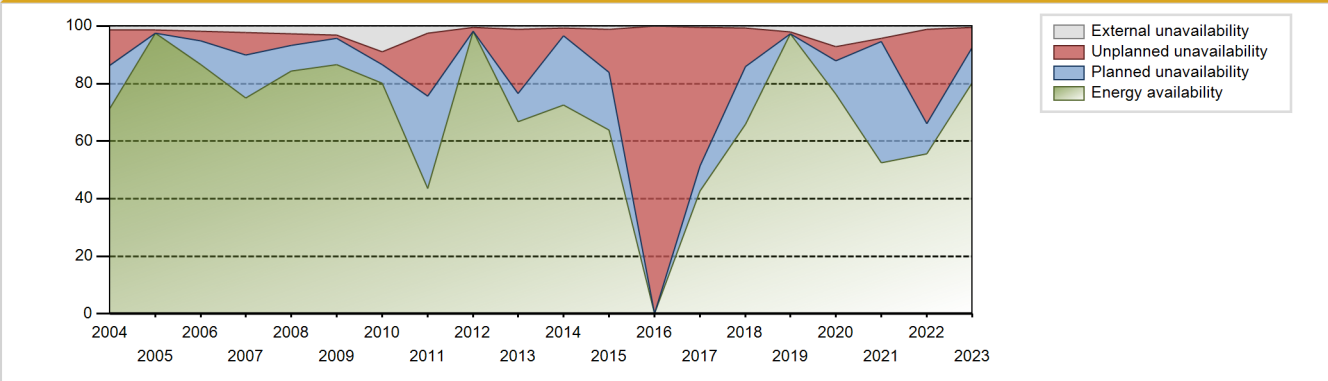
Electricity Production (net) [GWh]



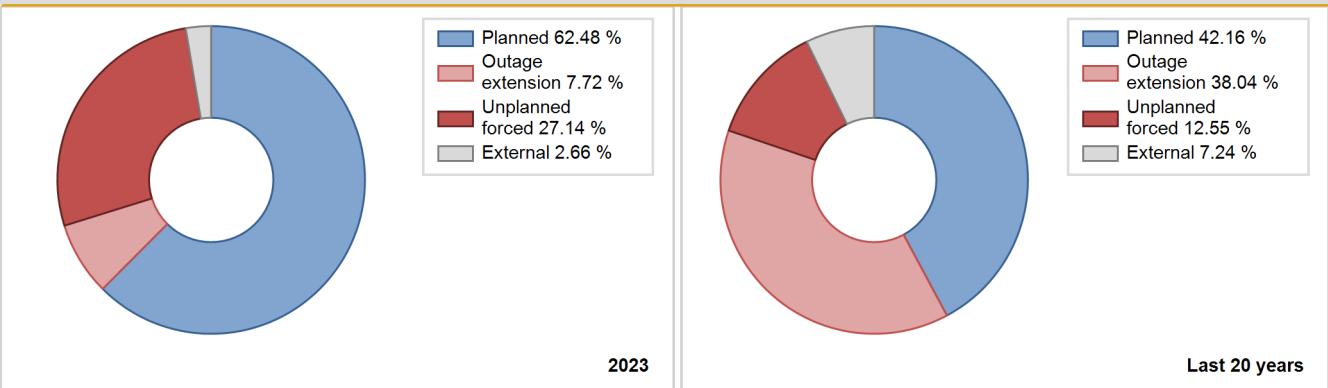
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|--------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | 6589.00 | 8050 | 900 | 84.50 | 84.50 | 83.35 | 91.64 | 5.14 | 4.58 | 10.92 | 0.00 |
| 1981 | 4869.30 | 6061 | 900 | 62.75 | 62.75 | 61.76 | 69.19 | 15.79 | 11.77 | 25.49 | 0.00 |
| 1982 | 5738.50 | 6956 | 900 | 76.38 | 76.38 | 72.79 | 79.41 | 7.50 | 6.20 | 17.43 | 0.00 |
| 1983 | 5578.00 | 6649 | 900 | 73.90 | 73.90 | 70.75 | 75.90 | 6.20 | 4.88 | 21.21 | 0.00 |
| 1984 | 5778.00 | 6884 | 900 | 74.10 | 74.10 | 73.09 | 78.37 | 8.03 | 6.47 | 19.43 | 0.00 |
| 1985 | 6079.70 | 7314 | 900 | 80.50 | 84.57 | 77.11 | 83.49 | 5.26 | 4.69 | 10.74 | 4.07 |
| 1986 | 5465.50 | 6493 | 900 | 75.53 | 75.70 | 69.32 | 74.12 | 9.49 | 7.94 | 16.36 | 0.17 |
| 1987 | 5015.90 | 6044 | 900 | 66.65 | 67.77 | 63.62 | 69.00 | 19.07 | 15.97 | 16.26 | 1.12 |
| 1988 | 5466.00 | 6465 | 900 | 84.64 | 89.74 | 69.14 | 73.60 | 10.26 | 10.26 | 0.00 | 5.10 |
| 1989 | 4757.98 | 6185 | 900 | 64.71 | 68.78 | 60.35 | 70.61 | 17.71 | 14.80 | 16.42 | 4.06 |
| 1990 | 5585.97 | 7156 | 880 | 74.85 | 80.74 | 72.46 | 81.69 | 3.54 | 2.97 | 16.29 | 5.88 |
| 1991 | 3358.36 | 4258 | 880 | 43.96 | 47.88 | 43.57 | 48.61 | 18.91 | 11.16 | 40.95 | 3.92 |
| 1992 | 4034.99 | 5003 | 880 | 52.52 | 56.39 | 52.20 | 56.96 | 15.49 | 10.33 | 33.28 | 3.87 |
| 1993 | 4416.61 | 5329 | 880 | 57.37 | 60.55 | 57.29 | 60.83 | 4.76 | 3.03 | 36.42 | 3.18 |
| 1994 | 4487.33 | 6311 | 880 | 85.68 | 85.91 | 58.21 | 72.04 | 1.40 | 1.22 | 12.87 | 0.22 |
| 1995 | 5582.80 | 7060 | 880 | 77.97 | 79.88 | 72.42 | 80.59 | 8.08 | 7.02 | 13.11 | 1.91 |
| 1996 | 5361.36 | 6844 | 880 | 77.53 | 79.00 | 69.36 | 77.91 | 4.57 | 3.78 | 17.22 | 1.47 |
| 1997 | 5592.90 | 7302 | 880 | 84.27 | 87.99 | 72.55 | 83.36 | 1.27 | 1.13 | 10.89 | 3.72 |
| 1998 | 5320.37 | 6844 | 880 | 80.46 | 83.94 | 69.02 | 78.13 | 4.52 | 3.97 | 12.08 | 3.48 |
| 1999 | 6108.75 | 7679 | 880 | 82.66 | 86.75 | 79.24 | 87.66 | 1.02 | 0.89 | 12.35 | 4.09 |
| 2000 | 5403.24 | 6889 | 880 | 74.63 | 77.30 | 69.90 | 78.43 | 11.53 | 10.08 | 12.63 | 2.67 |
| 2001 | 4358.59 | 5604 | 880 | 72.09 | 77.89 | 56.54 | 63.97 | 0.26 | 0.20 | 21.91 | 5.80 |
| 2002 | 6146.94 | 7925 | 880 | 90.98 | 90.98 | 79.74 | 90.47 | 3.60 | 3.40 | 5.62 | 0.00 |
| 2003 | 5711.09 | 7220 | 880 | 80.03 | 83.52 | 74.09 | 82.42 | 6.30 | 5.62 | 10.86 | 3.49 |
| 2004 | 5256.10 | 6438 | 880 | 71.42 | 72.70 | 68.00 | 73.29 | 14.46 | 12.29 | 15.01 | 1.28 |
| 2005 | 7022.84 | 8573 | 880 | 97.55 | 98.85 | 91.09 | 97.85 | 1.13 | 1.13 | 0.02 | 1.30 |
| 2006 | 6118.12 | 7765 | 880 | 86.64 | 88.48 | 79.37 | 88.64 | 3.43 | 3.33 | 8.20 | 1.84 |
| 2007 | 5752.87 | 7051 | 880 | 75.07 | 77.36 | 74.63 | 80.49 | 4.33 | 7.74 | 14.90 | 2.29 |
| 2008 | 6302.49 | 7822 | 880 | 84.34 | 86.98 | 81.53 | 89.05 | 4.17 | 4.08 | 8.94 | 2.64 |
| 2009 | 6556.83 | 7935 | 880 | 86.60 | 89.78 | 85.06 | 90.58 | 1.13 | 1.02 | 9.20 | 3.18 |
| 2010 | 5927.46 | 7457 | 880 | 80.13 | 89.11 | 76.89 | 85.13 | 2.82 | 4.35 | 6.54 | 8.98 |
| 2011 | 3271.68 | 4079 | 880 | 43.46 | 45.86 | 42.44 | 46.56 | 2.41 | 22.04 | 32.10 | 2.39 |
| 2012 | 7133.76 | 8569 | 880 | 98.27 | 98.68 | 92.29 | 97.55 | 1.31 | 1.31 | 0.01 | 0.41 |
| 2013 | 5083.50 | 5997 | 880 | 66.73 | 67.79 | 65.94 | 68.46 | 18.44 | 22.38 | 9.83 | 1.05 |
| 2014 | 5508.01 | 6492 | 880 | 72.44 | 73.04 | 71.45 | 74.11 | 3.11 | 2.74 | 24.22 | 0.60 |
| 2015 | 4924.48 | 5693 | 880 | 63.94 | 65.20 | 63.88 | 64.99 | 1.07 | 14.91 | 19.89 | 1.26 |
| 2016 | 0.00 | 0 | 880 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2017 | 3282.27 | 3887 | 880 | 42.74 | 43.19 | 42.58 | 44.37 | 0.44 | 48.14 | 8.67 | 0.45 |
| 2018 | 5098.42 | 5902 | 880 | 65.87 | 66.62 | 66.14 | 67.37 | 9.11 | 13.37 | 20.02 | 0.75 |
| 2019 | 7323.23 | 8655 | 880 | 97.31 | 99.34 | 95.00 | 98.80 | 0.63 | 0.63 | 0.04 | 2.03 |
| 2020 | 5887.45 | 6900 | 880 | 76.33 | 83.59 | 76.16 | 78.55 | 1.68 | 4.88 | 11.53 | 7.26 |
| 2021 | 4054.52 | 4822 | 880 | 52.51 | 56.83 | 52.60 | 55.05 | 1.66 | 0.96 | 42.21 | 4.32 |
| 2022 | 4244.17 | 5623 | 880 | 55.52 | 56.63 | 55.06 | 64.19 | 17.70 | 32.73 | 10.64 | 1.11 |
| 2023 | 6081.03 | 7143 | 880 | 80.30 | 80.82 | 78.88 | 81.54 | 6.21 | 6.87 | 12.31 | 0.52 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 400 | | | 434 | |
| B. Refuelling without maintenance | 1032 | | | 23 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1215 | 8 | |
| D. Inspection, maintenance or repair without refuelling | | | | 21 | | |
| E. Testing of plant systems or components | | | | 8 | 1 | |
| H. Nuclear regulatory requirements | | | | | 315 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 10 |
| L. Human factor related | | 167 | | | 17 | 0 |
| M. Governmental requirements or court decisions | | | | | | 0 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 14 |
| O. Load dispatching, prioritization | | | 4 | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 7 | 21 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 10 |
| Z. Other | | | | | 38 | 9 |
| Subtotal | 1032 | 567 | 4 | 1267 | 820 | 67 |
| Total | | 1603 | | | 2154 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1980 to 2023 | |
|--|------------|-----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 55 | | 18 |
| 12. Reactor I&C Systems | | | | 43 |
| 13. Reactor Auxiliary Systems | | | | 10 |
| 14. Safety Systems | | 0 | | 8 |
| 15. Reactor Cooling Systems | | | | 20 |
| 16. Steam generation systems | | | | 413 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 2 |
| 21. Fuel Handling and Storage Facilities | | | | 1 |
| 31. Turbine and auxiliaries | | | | 79 |
| 32. Feedwater and Main Steam System | | 124 | | 13 |
| 33. Circulating Water System | | | | 2 |
| 34. Miscellaneous Systems | | 134 | | 94 |
| 41. Main Generator Systems | | | | 44 |
| 42. Electrical Power Supply Systems | | 86 | | 9 |
| Total | | 399 | | 756 |

2023 Operating Experience

FR-50

CATTENOM-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1362 MWe
 Reference unit power (net) : 1300 MWe

Key Dates

Construction Date : 1979-10-29
 Grid Date : 1986-11-13
 Commercial Date : 1987-04-01
 Age at end of year : 37 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.2
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 323.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

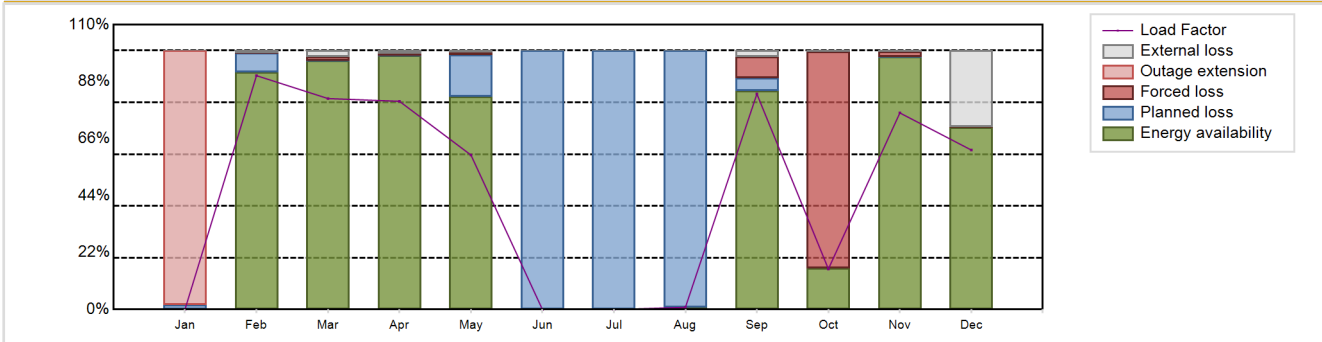
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5152.34 GW(e).h
 Energy Availability Factor (EAF) : 52.63 %
 Unit Capability Factor (UCF) : 55.77 %
 Load Factor (LF) : 45.24 %
 Operating Factor (OF) : 55.49 %
 Forced Loss Rate (FLR) : 12.86 %
 Unplanned Capability Loss Factor (UCL) : 16.57 %
 Planned Unavailability Factor (PUF) : 27.66 %
 Externally cause unavailability (XUF) : 3.14 %
 Total off-line time : 3899 hours

Annual Summary

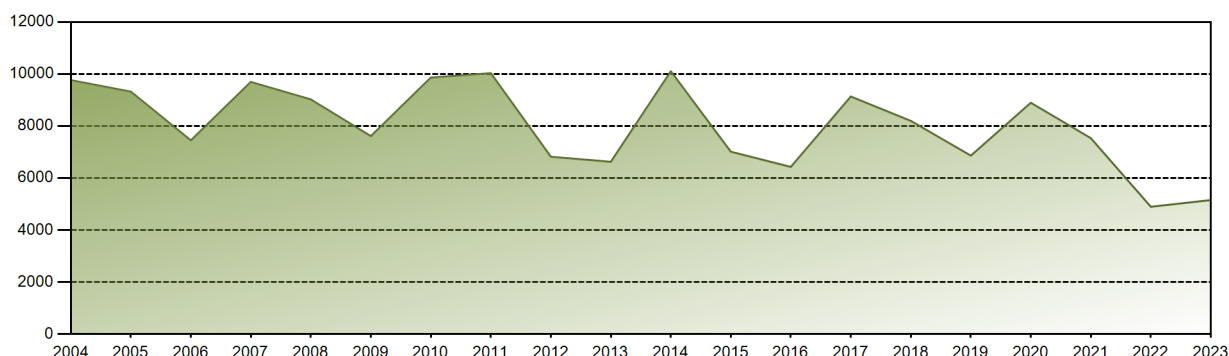


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.63 | 789.10 | 787.03 | 752.72 | 577.12 | 0.00 | 0.00 | 8.31 | 779.31 | 151.73 | 710.68 | 595.70 | 5152.34 |
| EAF [%] | 0.07 | 91.79 | 96.20 | 98.06 | 82.27 | 0.00 | 0.00 | 0.87 | 84.41 | 16.08 | 97.60 | 70.40 | 52.63 |
| UCF [%] | 0.07 | 92.57 | 98.63 | 99.08 | 82.91 | 0.00 | 0.00 | 0.87 | 86.71 | 16.36 | 97.93 | 99.74 | 55.77 |
| LF [%] | 0.06 | 90.33 | 81.48 | 80.42 | 59.67 | 0.00 | 0.00 | 0.86 | 83.26 | 15.67 | 75.93 | 61.59 | 45.24 |
| OF [%] | 1.75 | 100.00 | 100.00 | 100.00 | 83.87 | 0.00 | 0.00 | 2.69 | 96.81 | 16.64 | 100.00 | 70.97 | 55.49 |
| FLR [%] | 0.00 | 0.00 | 1.34 | 0.78 | 1.15 | 0.00 | 0.00 | 0.00 | 8.67 | 83.64 | 2.02 | 0.20 | 12.86 |
| UCL [%] | 98.19 | 0.00 | 1.34 | 0.77 | 0.96 | 0.00 | 0.00 | 0.00 | 8.23 | 83.64 | 2.02 | 0.20 | 16.57 |
| PUF [%] | 1.74 | 7.43 | 0.03 | 0.15 | 16.13 | 100.00 | 100.00 | 99.13 | 5.06 | 0.00 | 0.05 | 0.06 | 27.66 |
| XUF [%] | 0.00 | 0.77 | 2.43 | 1.02 | 0.64 | 0.00 | 0.00 | 0.00 | 2.31 | 0.28 | 0.32 | 29.34 | 3.14 |

Historical Summary

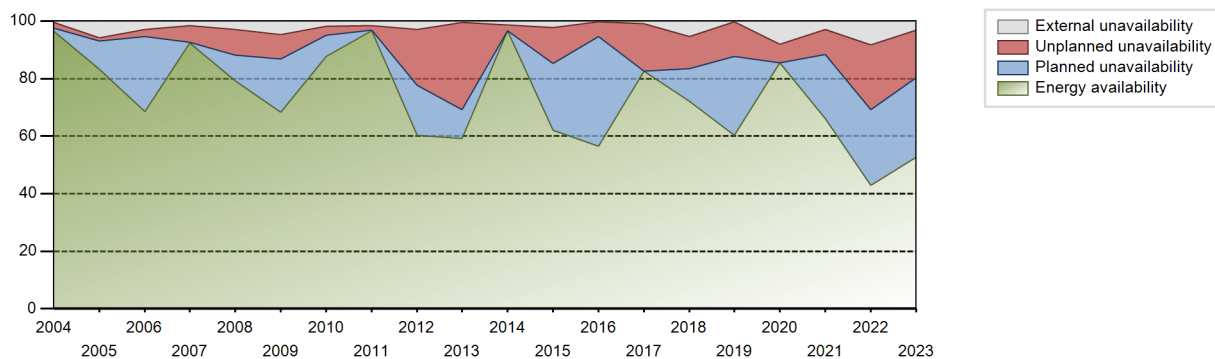
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 286697.51 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 11.79 % |
| Cumulative Energy Availability Factor (EAF) | : 71.73 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 12.21 % |
| Cumulative Unit Capability Factor (UCF) | : 73.76 % | Cumulative Planned Unavailability Factor (PUF) | : 14.04 % |
| Cumulative Load Factor (LF) | : 68.21 % | Cumulative Externally cause unavailability (XUF) | : 2.02 % |
| Cumulative Operating Factor (OF) | : 74.81 % | | |

Electricity Production (net) [GWh]

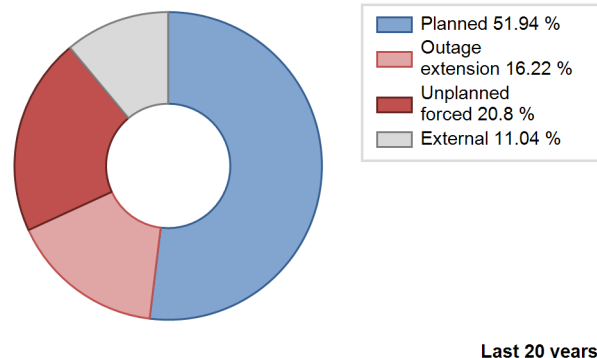
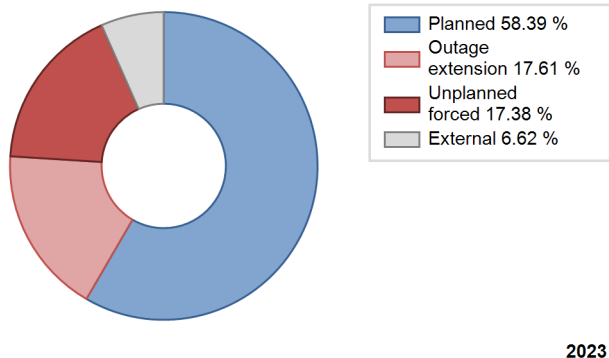


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 7429.80 | 6393 | 1265 | 68.80 | 69.47 | 65.53 | 68.38 | 30.53 | 30.53 | 0.00 | 0.67 |
| 1988 | 5283.00 | 4369 | 1300 | 47.40 | 47.80 | 46.26 | 49.74 | 32.01 | 22.51 | 29.70 | 0.39 |
| 1989 | 6802.43 | 5548 | 1300 | 60.28 | 60.28 | 59.73 | 63.33 | 24.40 | 19.46 | 20.26 | 0.00 |
| 1990 | 7781.88 | 6710 | 1300 | 75.29 | 75.71 | 68.33 | 76.60 | 11.10 | 9.46 | 14.84 | 0.42 |
| 1991 | 1509.28 | 1336 | 1300 | 13.48 | 13.48 | 13.25 | 15.25 | 84.22 | 71.92 | 14.61 | 0.00 |
| 1992 | 7933.30 | 6595 | 1300 | 71.02 | 71.46 | 69.47 | 75.08 | 12.28 | 10.00 | 18.54 | 0.44 |
| 1993 | 6956.55 | 5608 | 1300 | 61.46 | 63.47 | 61.09 | 64.02 | 25.00 | 21.15 | 15.37 | 2.01 |
| 1994 | 6775.45 | 6006 | 1300 | 64.04 | 64.06 | 59.50 | 68.56 | 35.14 | 34.71 | 1.22 | 0.02 |
| 1995 | 6634.25 | 6346 | 1300 | 59.54 | 59.84 | 58.26 | 72.44 | 27.42 | 22.60 | 17.55 | 0.30 |
| 1996 | 9539.24 | 7783 | 1300 | 87.29 | 87.48 | 83.54 | 88.60 | 0.58 | 0.51 | 12.01 | 0.19 |
| 1997 | 8688.94 | 7374 | 1300 | 81.38 | 84.07 | 76.30 | 84.18 | 0.75 | 0.64 | 15.29 | 2.69 |
| 1998 | 9365.85 | 7644 | 1300 | 85.65 | 85.89 | 82.24 | 87.26 | 5.54 | 5.04 | 9.07 | 0.23 |
| 1999 | 8273.01 | 7028 | 1300 | 76.29 | 79.76 | 72.65 | 80.23 | 1.45 | 1.17 | 19.07 | 3.46 |
| 2000 | 8053.79 | 6873 | 1300 | 78.09 | 81.03 | 70.53 | 78.24 | 0.87 | 0.71 | 18.26 | 2.94 |
| 2001 | 9220.15 | 8094 | 1300 | 96.42 | 96.44 | 80.96 | 92.40 | 1.60 | 1.57 | 1.99 | 0.02 |
| 2002 | 8270.16 | 7011 | 1300 | 79.18 | 79.38 | 72.62 | 80.03 | 8.52 | 7.39 | 13.23 | 0.19 |
| 2003 | 8530.97 | 7150 | 1300 | 78.44 | 80.35 | 74.91 | 81.62 | 0.89 | 0.72 | 18.92 | 1.91 |
| 2004 | 9764.16 | 8583 | 1300 | 96.38 | 96.94 | 85.51 | 97.71 | 1.94 | 1.91 | 1.15 | 0.56 |
| 2005 | 9323.78 | 7919 | 1300 | 83.23 | 89.12 | 81.86 | 90.39 | 0.25 | 1.05 | 9.83 | 5.89 |
| 2006 | 7448.99 | 6480 | 1300 | 68.59 | 71.55 | 65.41 | 73.97 | 2.32 | 2.45 | 26.00 | 2.96 |
| 2007 | 9696.23 | 8426 | 1300 | 92.42 | 93.96 | 85.14 | 96.19 | 5.90 | 5.89 | 0.15 | 1.54 |
| 2008 | 9022.88 | 7881 | 1300 | 79.19 | 82.22 | 79.02 | 89.72 | 7.91 | 8.73 | 9.05 | 3.03 |
| 2009 | 7612.66 | 6261 | 1300 | 68.35 | 73.14 | 66.85 | 71.47 | 2.20 | 8.29 | 18.56 | 4.79 |
| 2010 | 9864.05 | 7948 | 1300 | 87.65 | 89.44 | 86.62 | 90.73 | 1.81 | 3.20 | 7.36 | 1.79 |
| 2011 | 10033.88 | 8538 | 1300 | 96.69 | 98.22 | 88.11 | 97.47 | 1.63 | 1.63 | 0.15 | 1.54 |
| 2012 | 6818.80 | 5738 | 1300 | 60.27 | 63.12 | 59.71 | 65.32 | 4.83 | 19.50 | 17.38 | 2.85 |
| 2013 | 6624.72 | 5440 | 1300 | 59.23 | 59.70 | 58.17 | 62.10 | 33.56 | 30.33 | 9.97 | 0.47 |
| 2014 | 10106.20 | 8421 | 1300 | 96.54 | 97.98 | 88.74 | 96.13 | 1.97 | 1.97 | 0.05 | 1.44 |
| 2015 | 7013.40 | 5683 | 1300 | 61.96 | 64.19 | 61.59 | 64.87 | 2.94 | 12.59 | 23.22 | 2.23 |
| 2016 | 6428.77 | 5371 | 1300 | 56.57 | 56.93 | 56.30 | 61.15 | 1.84 | 5.10 | 37.97 | 0.36 |
| 2017 | 9134.86 | 7393 | 1300 | 82.49 | 83.34 | 80.21 | 84.39 | 16.58 | 16.56 | 0.10 | 0.85 |
| 2018 | 8198.29 | 6694 | 1300 | 72.02 | 77.35 | 71.99 | 76.42 | 9.64 | 11.24 | 11.41 | 5.33 |
| 2019 | 6861.87 | 5497 | 1300 | 60.39 | 60.74 | 60.26 | 62.75 | 3.11 | 11.99 | 27.26 | 0.35 |
| 2020 | 8894.78 | 7835 | 1300 | 85.47 | 93.64 | 77.89 | 89.20 | 6.33 | 6.33 | 0.03 | 8.17 |
| 2021 | 7533.87 | 6204 | 1300 | 66.17 | 69.10 | 66.16 | 70.82 | 11.09 | 8.62 | 22.28 | 2.93 |
| 2022 | 4896.26 | 3863 | 1300 | 43.00 | 51.38 | 42.99 | 44.10 | 0.84 | 22.53 | 26.09 | 8.38 |
| 2023 | 5152.34 | 4861 | 1300 | 52.63 | 55.77 | 45.24 | 55.49 | 12.86 | 16.57 | 27.66 | 3.14 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|-------------|-------------|------------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1374 | | | 873 | |
| B. Refuelling without maintenance | 2195 | | | 189 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 915 | 10 | |
| D. Inspection, maintenance or repair without refuelling | 96 | | | 36 | 5 | |
| E. Testing of plant systems or components | 17 | | | 42 | | |
| H. Nuclear regulatory requirements | | | | | 5 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 5 |
| L. Human factor related | | | | | 9 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 0 | 35 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 216 | | | 18 |
| Z. Other | | | | | 43 | 6 |
| Subtotal | 2308 | 1374 | 216 | 1182 | 945 | 68 |
| Total | | 3898 | | | 2195 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 22 |
| 12. Reactor I&C Systems | | 56 |
| 13. Reactor Auxiliary Systems | | 31 |
| 14. Safety Systems | 0 | 8 |
| 15. Reactor Cooling Systems | | 58 |
| 16. Steam generation systems | | 28 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 7 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 55 |
| 32. Feedwater and Main Steam System | | 66 |
| 33. Circulating Water System | | 20 |
| 34. Miscellaneous Systems | 731 | 157 |
| 35. All other I&C Systems | | 6 |
| 41. Main Generator Systems | | 233 |
| 42. Electrical Power Supply Systems | 643 | 116 |
| Total | 1374 | 864 |

2023 Operating Experience

FR-53

CATTENOM-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1362 MWe
 Reference unit power (net) : 1300 MWe

Key Dates

Construction Date : 1980-07-28
 Grid Date : 1987-09-17
 Commercial Date : 1988-02-01
 Age at end of year : 36 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.2
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

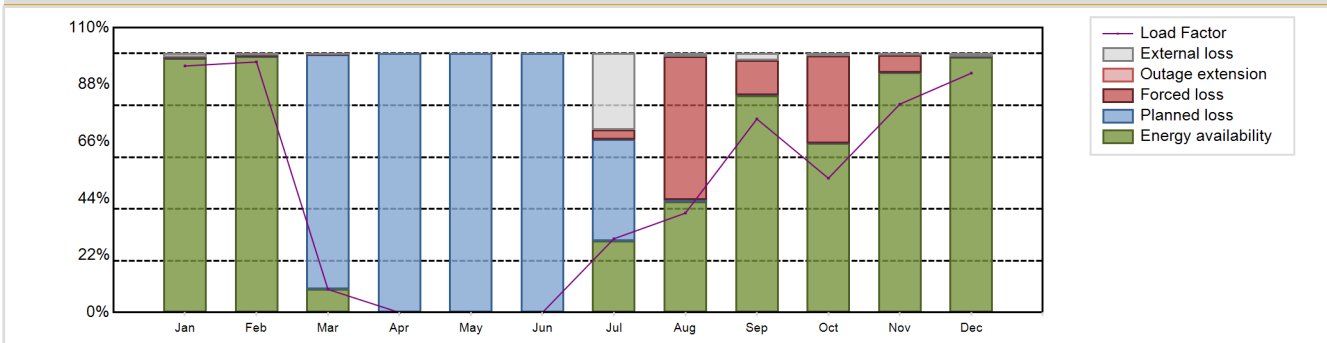
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5348.61 GW(e).h
 Energy Availability Factor (EAF) : 51.09 %
 Unit Capability Factor (UCF) : 54.34 %
 Load Factor (LF) : 46.97 %
 Operating Factor (OF) : 53.63 %
 Forced Loss Rate (FLR) : 15.05 %
 Unplanned Capability Loss Factor (UCL) : 9.62 %
 Planned Unavailability Factor (PUF) : 36.03 %
 Externally cause unavailability (XUF) : 3.25 %
 Total off-line time : 4062 hours

Annual Summary

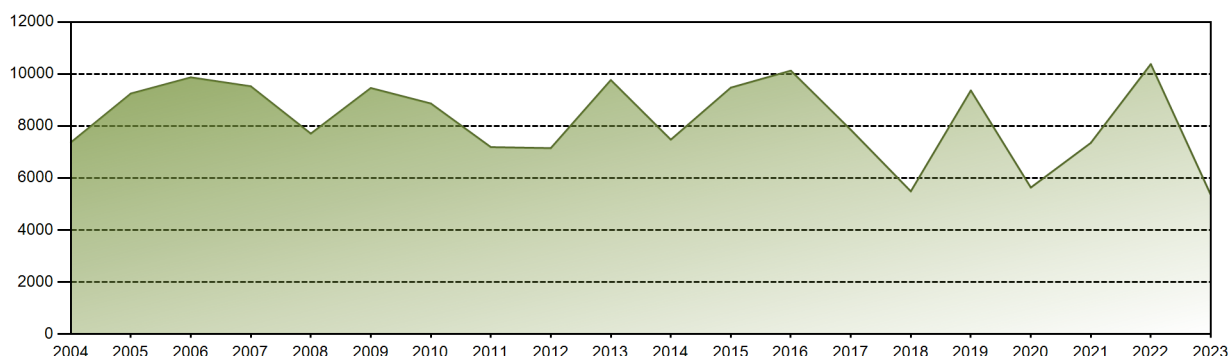


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 920.95 | 845.36 | 86.43 | 0.00 | 0.00 | 0.00 | 275.57 | 371.23 | 699.60 | 502.24 | 753.15 | 894.07 | 5348.61 |
| EAF [%] | 98.15 | 98.84 | 8.95 | 0.00 | 0.00 | 0.00 | 27.55 | 42.85 | 83.77 | 65.29 | 92.74 | 98.58 | 51.09 |
| UCF [%] | 99.61 | 99.49 | 9.36 | 0.00 | 0.00 | 0.00 | 57.05 | 43.94 | 86.50 | 66.18 | 93.40 | 99.68 | 54.34 |
| LF [%] | 95.22 | 96.77 | 8.95 | 0.00 | 0.00 | 0.00 | 28.49 | 38.38 | 74.74 | 51.86 | 80.47 | 92.44 | 46.97 |
| OF [%] | 100.00 | 100.00 | 9.56 | 0.00 | 0.00 | 0.00 | 38.17 | 51.88 | 89.17 | 63.76 | 94.44 | 100.00 | 53.63 |
| FLR [%] | 0.35 | 0.46 | 0.91 | 0.00 | 0.00 | 0.00 | 5.97 | 55.81 | 13.35 | 33.80 | 6.59 | 0.24 | 15.05 |
| UCL [%] | 0.35 | 0.46 | 0.09 | 0.00 | 0.00 | 0.00 | 3.62 | 55.50 | 13.33 | 33.79 | 6.59 | 0.24 | 9.62 |
| PUF [%] | 0.04 | 0.05 | 90.55 | 100.00 | 100.00 | 100.00 | 39.33 | 0.56 | 0.17 | 0.03 | 0.01 | 0.08 | 36.03 |
| XUF [%] | 1.46 | 0.65 | 0.42 | 0.00 | 0.00 | 0.00 | 29.50 | 1.09 | 2.73 | 0.89 | 0.65 | 1.09 | 3.25 |

Historical Summary

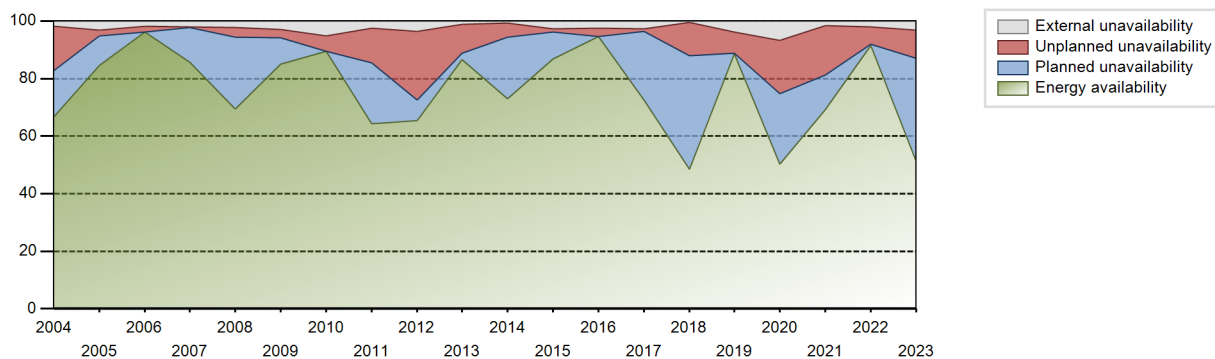
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 296168.56 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.76 % |
| Cumulative Energy Availability Factor (EAF) | : 76.45 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.8 % |
| Cumulative Unit Capability Factor (UCF) | : 78.79 % | Cumulative Planned Unavailability Factor (PUF) | : 13.41 % |
| Cumulative Load Factor (LF) | : 71.8 % | Cumulative Externally cause unavailability (XUF) | : 2.34 % |
| Cumulative Operating Factor (OF) | : 78.45 % | | |

Electricity Production (net) [GWh]

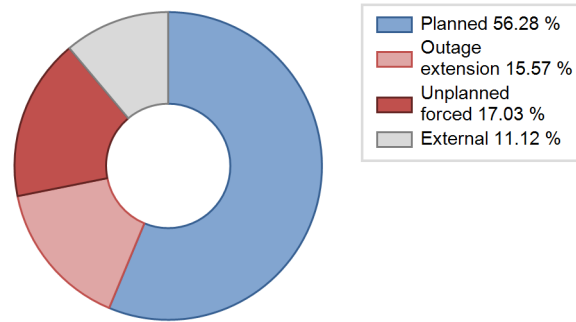
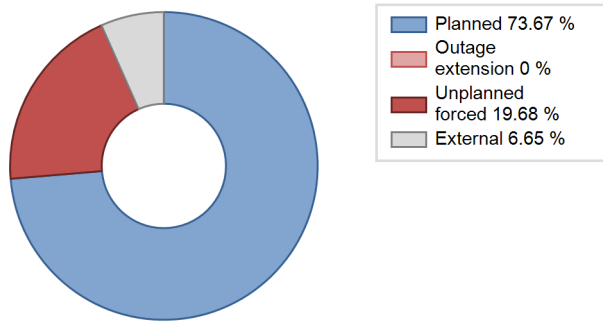


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 8138.00 | 7156 | 1300 | 90.80 | 91.04 | 71.35 | 81.94 | 5.24 | 5.03 | 3.93 | 0.24 |
| 1989 | 1765.48 | 1452 | 1300 | 15.48 | 16.51 | 15.50 | 16.58 | 77.27 | 56.12 | 27.37 | 1.03 |
| 1990 | 8137.59 | 6670 | 1300 | 82.70 | 82.98 | 71.46 | 76.14 | 6.39 | 5.66 | 11.36 | 0.27 |
| 1991 | 7543.13 | 6472 | 1300 | 68.21 | 71.75 | 66.24 | 73.88 | 11.68 | 9.49 | 18.77 | 3.54 |
| 1992 | 8134.30 | 6752 | 1300 | 72.38 | 75.63 | 71.23 | 76.87 | 7.25 | 5.91 | 18.46 | 3.26 |
| 1993 | 8626.96 | 6990 | 1300 | 76.22 | 78.82 | 75.75 | 79.79 | 6.36 | 5.36 | 15.83 | 2.60 |
| 1994 | 8526.27 | 7158 | 1300 | 77.69 | 80.49 | 74.87 | 81.71 | 3.61 | 3.01 | 16.50 | 2.80 |
| 1995 | 8603.72 | 7138 | 1300 | 78.31 | 79.93 | 75.55 | 81.48 | 7.42 | 6.40 | 13.67 | 1.62 |
| 1996 | 9018.10 | 7804 | 1300 | 98.09 | 99.57 | 78.97 | 88.84 | 0.38 | 0.38 | 0.04 | 1.49 |
| 1997 | 8487.38 | 7503 | 1300 | 82.21 | 84.39 | 74.53 | 85.65 | 4.23 | 3.73 | 11.88 | 2.19 |
| 1998 | 7259.47 | 6144 | 1300 | 67.96 | 68.96 | 63.75 | 70.14 | 7.64 | 5.71 | 25.34 | 1.00 |
| 1999 | 9367.49 | 7781 | 1300 | 87.28 | 90.19 | 82.26 | 88.82 | 0.22 | 0.20 | 9.61 | 2.91 |
| 2000 | 9164.30 | 7868 | 1300 | 88.57 | 88.61 | 80.25 | 89.57 | 7.45 | 7.14 | 4.25 | 0.05 |
| 2001 | 8649.04 | 7033 | 1300 | 77.53 | 79.41 | 75.95 | 80.29 | 2.80 | 2.28 | 18.30 | 1.88 |
| 2002 | 8288.00 | 6918 | 1300 | 76.87 | 76.92 | 72.78 | 78.97 | 8.18 | 6.85 | 16.23 | 0.05 |
| 2003 | 10197.46 | 8217 | 1300 | 93.45 | 99.30 | 89.55 | 93.80 | 0.63 | 0.63 | 0.07 | 5.84 |
| 2004 | 7368.16 | 6183 | 1300 | 66.80 | 68.70 | 64.52 | 70.39 | 18.24 | 15.33 | 15.97 | 1.90 |
| 2005 | 9247.81 | 7845 | 1300 | 84.65 | 87.87 | 81.21 | 89.55 | 1.12 | 2.04 | 10.09 | 3.22 |
| 2006 | 9870.28 | 8626 | 1300 | 96.14 | 97.96 | 86.67 | 98.47 | 1.97 | 1.97 | 0.07 | 1.82 |
| 2007 | 9526.50 | 7758 | 1300 | 85.72 | 87.82 | 83.65 | 88.56 | 0.07 | 0.06 | 12.11 | 2.10 |
| 2008 | 7707.77 | 6356 | 1300 | 69.45 | 71.67 | 67.50 | 72.36 | 0.45 | 3.47 | 24.86 | 2.22 |
| 2009 | 9460.92 | 7845 | 1300 | 85.12 | 88.12 | 83.08 | 89.55 | 1.47 | 2.88 | 9.00 | 3.00 |
| 2010 | 8866.22 | 8001 | 1300 | 89.41 | 94.65 | 77.86 | 91.34 | 5.32 | 5.32 | 0.03 | 5.24 |
| 2011 | 7188.84 | 5995 | 1300 | 64.26 | 66.64 | 63.13 | 68.44 | 2.91 | 12.06 | 21.30 | 2.38 |
| 2012 | 7149.60 | 5981 | 1300 | 65.49 | 69.16 | 62.61 | 68.09 | 10.21 | 23.70 | 7.14 | 3.67 |
| 2013 | 9766.15 | 7830 | 1300 | 86.59 | 87.79 | 85.76 | 89.38 | 2.78 | 9.93 | 2.28 | 1.20 |
| 2014 | 7475.58 | 6535 | 1300 | 72.92 | 73.61 | 65.64 | 74.60 | 6.20 | 4.86 | 21.52 | 0.69 |
| 2015 | 9474.83 | 7870 | 1300 | 86.81 | 89.49 | 83.20 | 89.84 | 1.18 | 1.07 | 9.44 | 2.68 |
| 2016 | 10129.04 | 8664 | 1300 | 94.52 | 97.10 | 88.70 | 98.63 | 2.87 | 2.86 | 0.04 | 2.58 |
| 2017 | 7853.19 | 6649 | 1300 | 72.48 | 75.10 | 68.96 | 75.90 | 1.23 | 0.93 | 23.96 | 2.62 |
| 2018 | 5487.63 | 4386 | 1300 | 48.54 | 49.10 | 48.19 | 50.07 | 18.90 | 11.44 | 39.45 | 0.56 |
| 2019 | 9366.77 | 8046 | 1300 | 88.69 | 92.57 | 82.25 | 91.85 | 7.39 | 7.39 | 0.04 | 3.88 |
| 2020 | 5634.04 | 4699 | 1300 | 50.31 | 57.06 | 49.34 | 53.49 | 1.48 | 18.56 | 24.38 | 6.74 |
| 2021 | 7351.90 | 6220 | 1300 | 69.09 | 70.79 | 64.56 | 71.00 | 0.46 | 17.04 | 12.17 | 1.70 |
| 2022 | 10380.51 | 8319 | 1300 | 91.51 | 93.46 | 91.15 | 94.97 | 4.84 | 6.04 | 0.50 | 1.95 |
| 2023 | 5348.61 | 4698 | 1300 | 51.09 | 54.34 | 46.97 | 53.63 | 15.05 | 9.62 | 36.03 | 3.25 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|-------------|-------------|------------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 710 | | | 544 | |
| B. Refuelling without maintenance | | | | 89 | | |
| C. Inspection, maintenance or repair combined with refuelling | 3093 | | | 995 | 5 | |
| D. Inspection, maintenance or repair without refuelling | | | | 38 | 13 | |
| E. Testing of plant systems or components | 0 | | | 34 | 0 | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 2 |
| L. Human factor related | | | | | 21 | |
| M. Governmental requirements or court decisions | | | | | | 2 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 11 |
| O. Load dispatching, prioritization | | | 36 | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 222 | | | 19 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 18 |
| Z. Other | | | | | 24 | 18 |
| Subtotal | 3093 | 710 | 258 | 1156 | 607 | 73 |
| Total | | 4061 | | | 1836 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 8 |
| 12. Reactor I&C Systems | | 17 |
| 13. Reactor Auxiliary Systems | | 4 |
| 14. Safety Systems | | 49 |
| 15. Reactor Cooling Systems | | 114 |
| 16. Steam generation systems | | 54 |
| 31. Turbine and auxiliaries | 406 | 24 |
| 32. Feedwater and Main Steam System | 25 | 13 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | 279 | 189 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 49 |
| 42. Electrical Power Supply Systems | | 18 |
| Total | 710 | 542 |

2023 Operating Experience

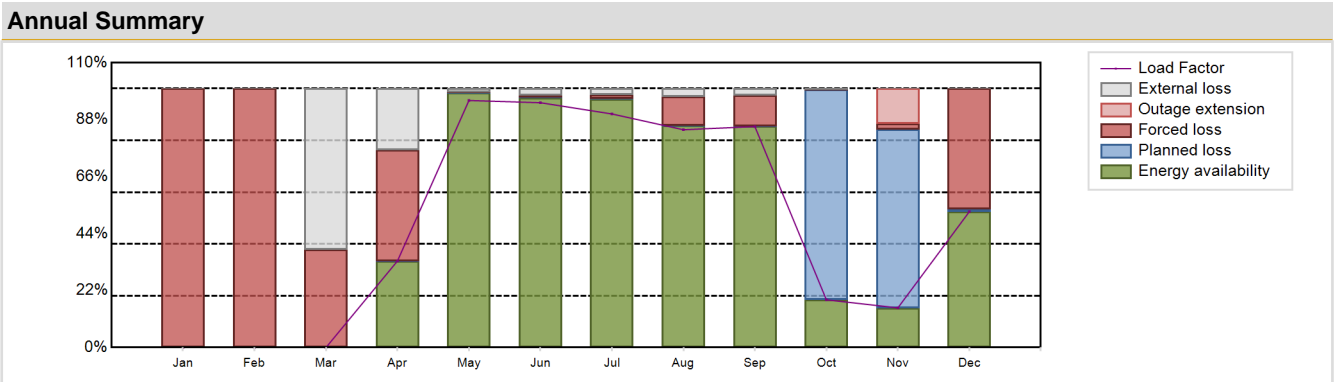
FR-60 **CATTENOM-3** **FRANCE**

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PWR / P4 REP 1300 | Construction Date | : 1982-06-15 |
| Thermal power | : 3817 MWth | Grid Date | : 1990-07-06 |
| Gross electrical power | : 1362 MWe | Commercial Date | : 1991-02-01 |
| Reference unit power (net) | : 1300 MWe | Age at end of year | : 33 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 328.7 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 4.1 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 16 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.37 | HP cylinder inlet steam pressure [MPa] | : 6.95 |
| Active core height/length [m] | : 4.267 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 193 | Primary means of condenser cooling | : Cooling towers |
| Fuel linear heat generation rate [kW/m] | : 17.2 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 53 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 5434.54 GW(e).h | Forced Loss Rate (FLR) | : 33.87 % |
| Energy Availability Factor (EAF) | : 48.76 % | Unplanned Capability Loss Factor (UCL) | : 30.3 % |
| Unit Capability Factor (UCF) | : 57.01 % | Planned Unavailability Factor (PUF) | : 12.69 % |
| Load Factor (LF) | : 47.72 % | Externally cause unavailability (XUF) | : 8.25 % |
| Operating Factor (OF) | : 52.64 % | Total off-line time | : 4149 hours |

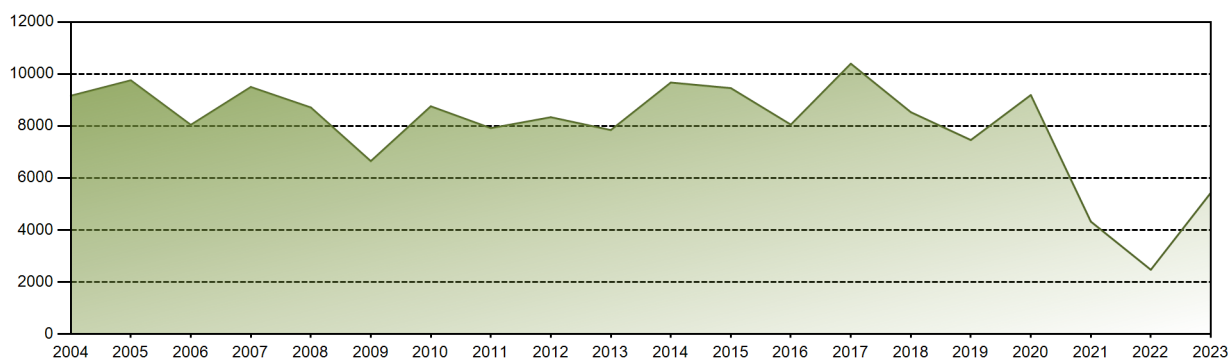


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 312.71 | 922.67 | 885.02 | 872.47 | 813.50 | 798.80 | 178.45 | 143.36 | 507.57 | 5434.54 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 33.42 | 98.34 | 96.47 | 95.92 | 85.67 | 85.41 | 18.43 | 15.32 | 52.51 | 48.76 |
| UCF [%] | 0.00 | 0.00 | 62.13 | 57.03 | 99.73 | 99.18 | 98.28 | 88.69 | 87.98 | 18.79 | 15.32 | 52.51 | 57.01 |
| LF [%] | 0.00 | 0.00 | 0.00 | 33.41 | 95.40 | 94.55 | 90.21 | 84.11 | 85.34 | 18.43 | 15.32 | 52.48 | 47.72 |
| OF [%] | 0.00 | 0.00 | 0.00 | 41.94 | 100.00 | 100.00 | 100.00 | 92.07 | 95.42 | 19.19 | 25.69 | 53.90 | 52.64 |
| FLR [%] | 100.00 | 100.00 | 37.87 | 42.94 | 0.20 | 0.70 | 1.57 | 11.20 | 11.90 | 0.70 | 13.75 | 46.94 | 33.87 |
| UCL [%] | 100.00 | 100.00 | 37.87 | 42.92 | 0.20 | 0.70 | 1.57 | 11.19 | 11.88 | 0.13 | 15.88 | 46.45 | 30.30 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.05 | 0.07 | 0.12 | 0.15 | 0.12 | 0.13 | 81.08 | 68.80 | 1.04 | 12.69 |
| XUF [%] | 0.00 | 0.00 | 62.13 | 23.61 | 1.39 | 2.71 | 2.36 | 3.02 | 2.57 | 0.36 | 0.00 | 0.00 | 8.25 |

Historical Summary

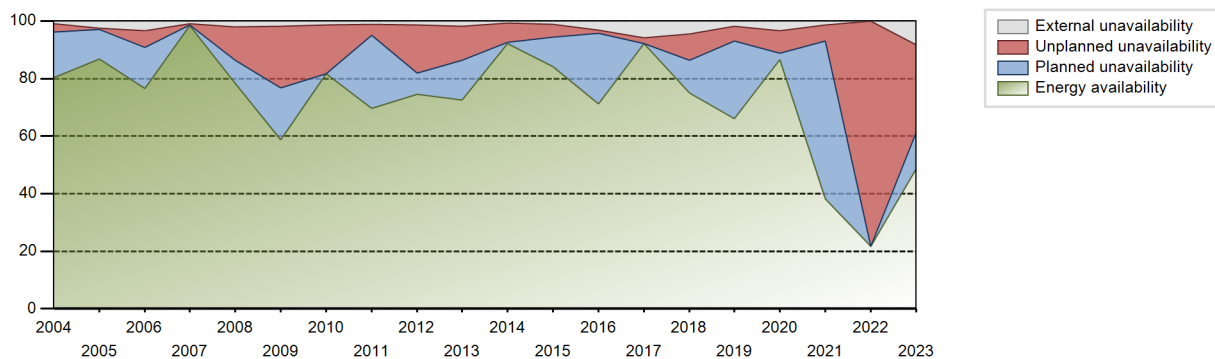
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 269621.98 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 9.16 % |
| Cumulative Energy Availability Factor (EAF) | : 75.29 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 9.6 % |
| Cumulative Unit Capability Factor (UCF) | : 77.55 % | Cumulative Planned Unavailability Factor (PUF) | : 12.84 % |
| Cumulative Load Factor (LF) | : 71.34 % | Cumulative Externally cause unavailability (XUF) | : 2.26 % |
| Cumulative Operating Factor (OF) | : 77.31 % | | |

Electricity Production (net) [GWh]

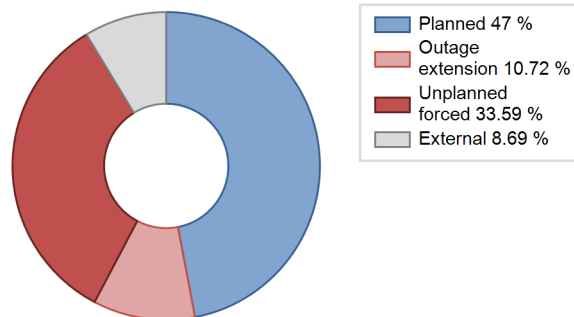
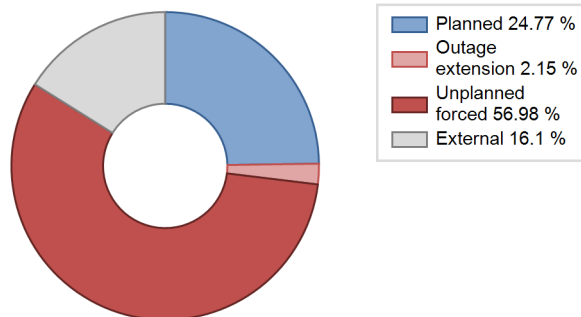


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1991 | 9683.15 | 7897 | 1300 | 88.20 | 89.61 | 85.70 | 90.51 | 10.29 | 10.27 | 0.12 | 1.41 |
| 1992 | 7145.04 | 5903 | 1300 | 65.61 | 67.00 | 62.57 | 67.20 | 3.95 | 2.76 | 30.24 | 1.40 |
| 1993 | 8035.13 | 6858 | 1300 | 75.86 | 81.16 | 70.56 | 78.29 | 1.87 | 1.55 | 17.30 | 5.29 |
| 1994 | 8613.33 | 7464 | 1300 | 84.36 | 85.71 | 75.64 | 85.21 | 1.30 | 1.13 | 13.16 | 1.35 |
| 1995 | 8344.31 | 7269 | 1300 | 78.93 | 82.24 | 73.27 | 82.98 | 5.14 | 4.46 | 13.30 | 3.31 |
| 1996 | 8264.73 | 7184 | 1300 | 77.27 | 80.56 | 72.38 | 81.79 | 3.75 | 3.14 | 16.29 | 3.29 |
| 1997 | 9504.06 | 8097 | 1300 | 93.25 | 94.46 | 83.46 | 92.43 | 1.79 | 1.72 | 3.82 | 1.22 |
| 1998 | 8054.93 | 7175 | 1300 | 80.15 | 83.51 | 70.73 | 81.91 | 2.52 | 2.16 | 14.33 | 3.36 |
| 1999 | 8237.00 | 7169 | 1300 | 79.73 | 83.51 | 72.33 | 81.84 | 1.57 | 1.34 | 15.15 | 3.78 |
| 2000 | 8933.53 | 7984 | 1300 | 98.71 | 99.15 | 78.23 | 90.89 | 0.57 | 0.57 | 0.29 | 0.43 |
| 2001 | 3171.47 | 2739 | 1300 | 29.74 | 29.81 | 27.85 | 31.27 | 58.95 | 42.80 | 27.39 | 0.07 |
| 2002 | 9402.46 | 7443 | 1300 | 82.50 | 83.63 | 82.56 | 84.97 | 3.03 | 2.62 | 13.75 | 1.13 |
| 2003 | 11254.01 | 8715 | 1300 | 98.37 | 99.34 | 98.82 | 99.49 | 0.18 | 0.18 | 0.47 | 0.97 |
| 2004 | 9162.73 | 7274 | 1300 | 80.35 | 81.37 | 80.24 | 82.81 | 3.34 | 2.81 | 15.82 | 1.02 |
| 2005 | 9757.05 | 7944 | 1300 | 86.70 | 89.23 | 85.67 | 90.67 | 0.52 | 0.47 | 10.30 | 2.53 |
| 2006 | 8045.34 | 7088 | 1300 | 76.49 | 79.94 | 70.65 | 80.91 | 1.63 | 5.67 | 14.39 | 3.45 |
| 2007 | 9500.56 | 8559 | 1300 | 98.46 | 99.27 | 83.43 | 97.71 | 0.65 | 0.65 | 0.07 | 0.81 |
| 2008 | 8712.70 | 7145 | 1300 | 78.40 | 80.48 | 76.30 | 81.34 | 1.04 | 11.62 | 7.90 | 2.08 |
| 2009 | 6649.76 | 5277 | 1300 | 58.66 | 60.45 | 58.39 | 60.24 | 20.99 | 21.49 | 18.06 | 1.79 |
| 2010 | 8756.81 | 6966 | 1300 | 81.71 | 82.99 | 76.90 | 79.52 | 17.00 | 16.99 | 0.01 | 1.28 |
| 2011 | 7918.57 | 6306 | 1300 | 69.59 | 70.83 | 69.53 | 71.99 | 2.78 | 3.73 | 25.44 | 1.24 |
| 2012 | 8337.71 | 6760 | 1300 | 74.49 | 75.86 | 73.01 | 76.96 | 1.63 | 16.80 | 7.34 | 1.36 |
| 2013 | 7844.56 | 6552 | 1300 | 72.57 | 74.29 | 68.88 | 74.79 | 1.69 | 11.91 | 13.80 | 1.72 |
| 2014 | 9671.58 | 8049 | 1300 | 92.06 | 92.80 | 84.93 | 91.88 | 3.56 | 6.74 | 0.46 | 0.74 |
| 2015 | 9456.96 | 7813 | 1300 | 84.04 | 85.30 | 83.04 | 89.19 | 4.80 | 4.30 | 10.41 | 1.26 |
| 2016 | 8053.88 | 6821 | 1300 | 71.20 | 74.31 | 70.53 | 77.65 | 1.43 | 1.08 | 24.62 | 3.11 |
| 2017 | 10396.60 | 8390 | 1300 | 92.19 | 97.96 | 91.29 | 95.78 | 1.97 | 1.97 | 0.07 | 5.78 |
| 2018 | 8531.74 | 7038 | 1300 | 75.07 | 79.59 | 74.92 | 80.34 | 9.36 | 9.07 | 11.34 | 4.52 |
| 2019 | 7460.81 | 6029 | 1300 | 65.97 | 67.85 | 65.51 | 68.82 | 0.31 | 5.06 | 27.09 | 1.88 |
| 2020 | 9190.97 | 7711 | 1300 | 86.57 | 89.88 | 80.49 | 87.78 | 7.95 | 7.76 | 2.35 | 3.31 |
| 2021 | 4325.56 | 3519 | 1300 | 38.12 | 39.49 | 37.98 | 40.17 | 12.43 | 5.63 | 54.88 | 1.37 |
| 2022 | 2472.54 | 1942 | 1300 | 21.66 | 21.66 | 21.71 | 22.17 | 78.34 | 78.33 | 0.01 | 0.00 |
| 2023 | 5434.54 | 4611 | 1300 | 48.76 | 57.01 | 47.72 | 52.64 | 33.87 | 30.30 | 12.69 | 8.25 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1991 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 2441 | | | 690 | |
| B. Refuelling without maintenance | 1035 | | | 84 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 966 | 12 | |
| D. Inspection, maintenance or repair without refuelling | | | | 43 | | |
| E. Testing of plant systems or components | | | | 11 | | |
| H. Nuclear regulatory requirements | | | | | 70 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 12 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 13 |
| L. Human factor related | | 41 | | | 7 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 5 |
| O. Load dispatching, prioritization | | | | | | 3 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 631 | | 1 | 33 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 7 |
| Z. Other | | | | | 23 | |
| Subtotal | 1035 | 2482 | 631 | 1104 | 803 | 73 |
| Total | | 4148 | | | 1980 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1991 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 73 |
| 12. Reactor I&C Systems | 53 | 31 |
| 13. Reactor Auxiliary Systems | | 34 |
| 14. Safety Systems | 1946 | 284 |
| 15. Reactor Cooling Systems | | 16 |
| 16. Steam generation systems | | 24 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | 51 | 22 |
| 32. Feedwater and Main Steam System | | 12 |
| 33. Circulating Water System | 295 | 9 |
| 34. Miscellaneous Systems | 97 | 72 |
| 41. Main Generator Systems | | 76 |
| 42. Electrical Power Supply Systems | | 21 |
| Total | 2442 | 682 |

2023 Operating Experience

FR-65

CATTENOM-4

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1362 MWe
 Reference unit power (net) : 1300 MWe

Key Dates

Construction Date : 1983-09-28
 Grid Date : 1991-05-27
 Commercial Date : 1992-01-01
 Age at end of year : 32 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.2
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

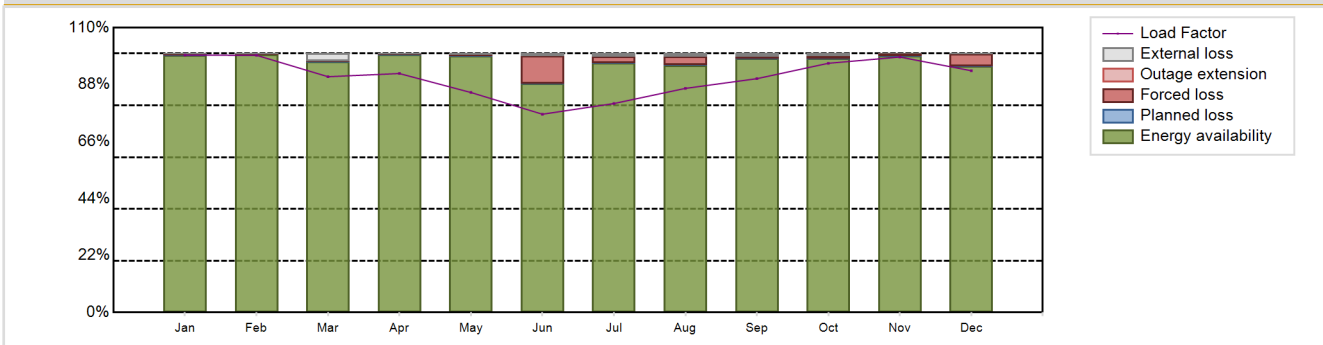
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 10334.09 GW(e).h
 Energy Availability Factor (EAF) : 97.07 %
 Unit Capability Factor (UCF) : 97.83 %
 Load Factor (LF) : 90.75 %
 Operating Factor (OF) : 98.69 %
 Forced Loss Rate (FLR) : 2.11 %
 Unplanned Capability Loss Factor (UCL) : 2.11 %
 Planned Unavailability Factor (PUF) : 0.06 %
 Externally cause unavailability (XUF) : 0.76 %
 Total off-line time : 115 hours

Annual Summary

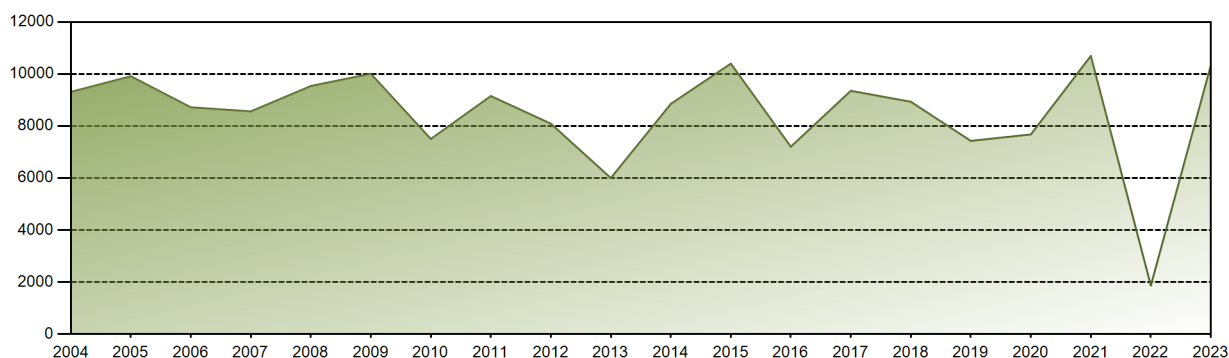


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 961.54 | 867.87 | 879.75 | 863.88 | 821.90 | 716.88 | 780.66 | 837.28 | 845.35 | 932.31 | 923.49 | 903.18 | 10334.09 |
| EAF [%] | 99.30 | 99.70 | 96.85 | 99.55 | 99.15 | 88.43 | 96.31 | 95.45 | 98.12 | 98.01 | 99.08 | 95.03 | 97.07 |
| UCF [%] | 99.36 | 99.75 | 99.72 | 99.66 | 99.53 | 89.43 | 97.52 | 96.61 | 99.18 | 98.99 | 99.08 | 95.21 | 97.83 |
| LF [%] | 99.41 | 99.34 | 91.08 | 92.30 | 84.98 | 76.59 | 80.71 | 86.57 | 90.32 | 96.26 | 98.66 | 93.38 | 90.75 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.47 | 98.39 | 100.00 | 100.00 | 99.87 | 100.00 | 97.45 | 98.69 |
| FLR [%] | 0.55 | 0.21 | 0.22 | 0.32 | 0.41 | 10.54 | 2.41 | 3.31 | 0.73 | 0.89 | 0.89 | 4.74 | 2.11 |
| UCL [%] | 0.55 | 0.21 | 0.22 | 0.32 | 0.41 | 10.53 | 2.41 | 3.31 | 0.73 | 0.89 | 0.89 | 4.73 | 2.11 |
| PUF [%] | 0.09 | 0.04 | 0.06 | 0.02 | 0.06 | 0.04 | 0.07 | 0.09 | 0.08 | 0.12 | 0.03 | 0.05 | 0.06 |
| XUF [%] | 0.05 | 0.05 | 2.87 | 0.11 | 0.39 | 0.99 | 1.21 | 1.15 | 1.07 | 0.98 | 0.00 | 0.18 | 0.76 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 277229.4 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.16 % |
| Cumulative Energy Availability Factor (EAF) | : 80.19 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.63 % |
| Cumulative Unit Capability Factor (UCF) | : 82.67 % | Cumulative Planned Unavailability Factor (PUF) | : 11.69 % |
| Cumulative Load Factor (LF) | : 75.46 % | Cumulative Externally cause unavailability (XUF) | : 2.48 % |
| Cumulative Operating Factor (OF) | : 82.27 % | | |

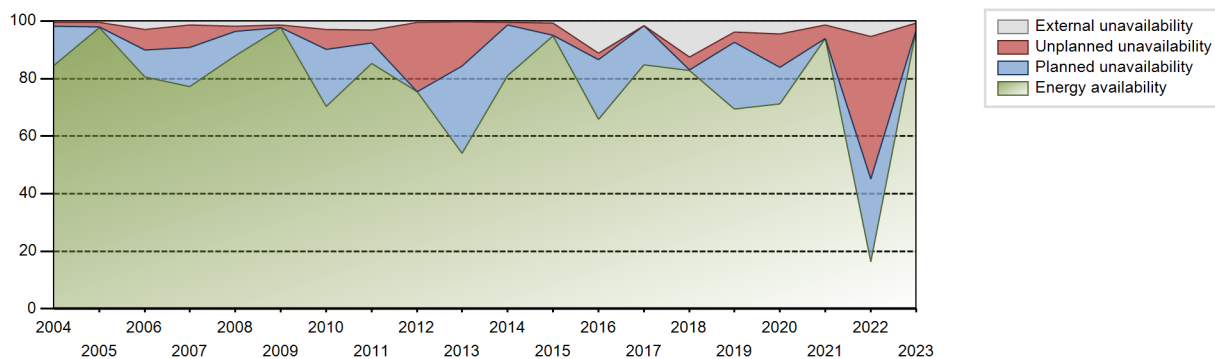
Electricity Production (net) [GWh]



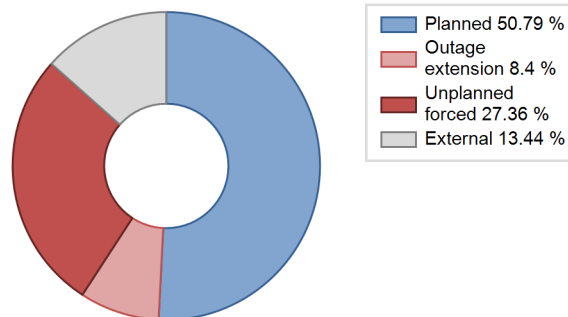
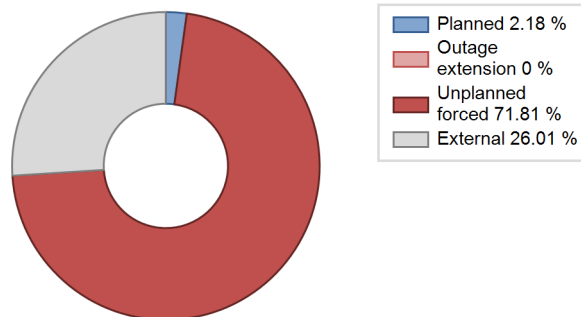
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1992 | 9355.95 | 7649 | 1300 | 85.83 | 88.01 | 81.93 | 87.08 | 0.88 | 0.78 | 11.21 | 2.18 |
| 1993 | 7736.44 | 6251 | 1300 | 77.98 | 79.09 | 67.94 | 71.36 | 6.27 | 5.29 | 15.62 | 1.11 |
| 1994 | 7828.78 | 6866 | 1300 | 80.42 | 81.90 | 68.75 | 78.38 | 2.35 | 1.97 | 16.13 | 1.48 |
| 1995 | 8942.43 | 7563 | 1300 | 82.80 | 85.53 | 78.53 | 86.34 | 3.24 | 2.87 | 11.60 | 2.73 |
| 1996 | 8897.57 | 7399 | 1300 | 81.35 | 82.59 | 77.92 | 84.23 | 5.41 | 4.73 | 12.69 | 1.24 |
| 1997 | 8690.54 | 7382 | 1300 | 79.28 | 82.61 | 76.31 | 84.27 | 1.84 | 1.55 | 15.84 | 3.33 |
| 1998 | 10000.14 | 8476 | 1300 | 94.49 | 96.06 | 87.81 | 96.76 | 2.40 | 2.37 | 1.58 | 1.56 |
| 1999 | 8131.93 | 7164 | 1300 | 80.77 | 82.85 | 71.41 | 81.78 | 5.31 | 4.65 | 12.50 | 2.08 |
| 2000 | 9139.01 | 7692 | 1300 | 85.08 | 86.59 | 80.03 | 87.57 | 0.18 | 0.15 | 13.25 | 1.51 |
| 2001 | 8593.18 | 7375 | 1300 | 84.84 | 86.55 | 75.46 | 84.19 | 0.30 | 0.26 | 13.19 | 1.71 |
| 2002 | 10598.80 | 8467 | 1300 | 95.10 | 95.29 | 93.07 | 96.66 | 0.33 | 0.31 | 4.40 | 0.19 |
| 2003 | 7708.34 | 6406 | 1300 | 69.75 | 72.09 | 67.69 | 73.13 | 1.34 | 0.98 | 26.93 | 2.34 |
| 2004 | 9311.78 | 7560 | 1300 | 84.51 | 85.02 | 81.54 | 86.07 | 1.40 | 1.21 | 13.77 | 0.51 |
| 2005 | 9913.85 | 8520 | 1300 | 97.83 | 98.32 | 87.06 | 97.26 | 1.66 | 1.66 | 0.02 | 0.49 |
| 2006 | 8719.60 | 7440 | 1300 | 80.57 | 83.51 | 76.57 | 84.93 | 0.60 | 7.05 | 9.44 | 2.95 |
| 2007 | 8562.21 | 6999 | 1300 | 77.13 | 78.42 | 75.19 | 79.90 | 1.59 | 7.80 | 13.78 | 1.29 |
| 2008 | 9538.78 | 7975 | 1300 | 87.89 | 89.83 | 83.53 | 90.79 | 0.71 | 1.70 | 8.48 | 1.93 |
| 2009 | 10010.11 | 8733 | 1300 | 97.73 | 99.13 | 87.90 | 99.69 | 0.85 | 0.85 | 0.02 | 1.39 |
| 2010 | 7502.23 | 6677 | 1300 | 70.36 | 73.24 | 65.88 | 76.22 | 2.52 | 7.05 | 19.71 | 2.87 |
| 2011 | 9152.84 | 7786 | 1300 | 85.24 | 88.38 | 80.37 | 88.88 | 0.70 | 4.37 | 7.25 | 3.15 |
| 2012 | 8090.85 | 6692 | 1300 | 75.41 | 76.00 | 70.85 | 76.18 | 23.98 | 23.98 | 0.02 | 0.59 |
| 2013 | 6000.78 | 4913 | 1300 | 53.96 | 54.34 | 52.69 | 56.08 | 8.92 | 15.38 | 30.29 | 0.38 |
| 2014 | 8851.37 | 7240 | 1300 | 81.05 | 81.55 | 77.73 | 82.65 | 0.46 | 0.82 | 17.63 | 0.50 |
| 2015 | 10400.59 | 8451 | 1300 | 94.92 | 95.61 | 91.33 | 96.47 | 4.36 | 4.36 | 0.03 | 0.69 |
| 2016 | 7204.81 | 6164 | 1300 | 65.79 | 77.06 | 63.09 | 70.17 | 2.82 | 2.24 | 20.70 | 11.27 |
| 2017 | 9354.28 | 7629 | 1300 | 84.84 | 86.39 | 82.14 | 87.09 | 0.16 | 0.14 | 13.47 | 1.55 |
| 2018 | 8932.66 | 7525 | 1300 | 82.90 | 95.41 | 78.44 | 85.90 | 4.52 | 4.52 | 0.06 | 12.51 |
| 2019 | 7428.66 | 6266 | 1300 | 69.53 | 73.44 | 65.23 | 71.53 | 3.00 | 3.43 | 23.13 | 3.91 |
| 2020 | 7676.68 | 6751 | 1300 | 71.29 | 75.68 | 67.23 | 76.86 | 11.78 | 11.70 | 12.62 | 4.39 |
| 2021 | 10695.07 | 8439 | 1300 | 93.92 | 95.33 | 93.92 | 96.34 | 4.58 | 4.58 | 0.09 | 1.41 |
| 2022 | 1865.96 | 1687 | 1300 | 16.38 | 21.84 | 16.39 | 19.26 | 69.37 | 49.46 | 28.70 | 5.46 |
| 2023 | 10334.09 | 8645 | 1300 | 97.07 | 97.83 | 90.75 | 98.69 | 2.11 | 2.11 | 0.06 | 0.76 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1992 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 96 | | | 421 | 1 |
| B. Refuelling without maintenance | | | | 110 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 834 | 21 | |
| D. Inspection, maintenance or repair without refuelling | | | | 40 | | |
| E. Testing of plant systems or components | | | | 40 | | |
| I. Grid capacity limitation | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 21 |
| L. Human factor related | | | | | 13 | 8 |
| M. Governmental requirements or court decisions | | | | | | 0 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| O. Load dispatching, prioritization | | | 9 | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 2 | 49 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 32 |
| Z. Other | | | | | 6 | 1 |
| Subtotal | | 96 | 9 | 1024 | 463 | 115 |
| Total | | 105 | | | 1602 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1992 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 9 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 164 |
| 15. Reactor Cooling Systems | | 10 |
| 16. Steam generation systems | | 34 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | 19 | 35 |
| 32. Feedwater and Main Steam System | | 20 |
| 33. Circulating Water System | 12 | 2 |
| 34. Miscellaneous Systems | | 38 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 86 |
| 42. Electrical Power Supply Systems | 65 | 16 |
| Total | 96 | 440 |

2023 Operating Experience

FR-40

CHINON B-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP2
 Thermal power : 2785 MWth
 Gross electrical power : 954 MWe
 Reference unit power (net) : 905 MWe

Key Dates

Construction Date : 1977-03-01
 Grid Date : 1982-11-30
 Commercial Date : 1984-02-01
 Age at end of year : 41 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 38
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

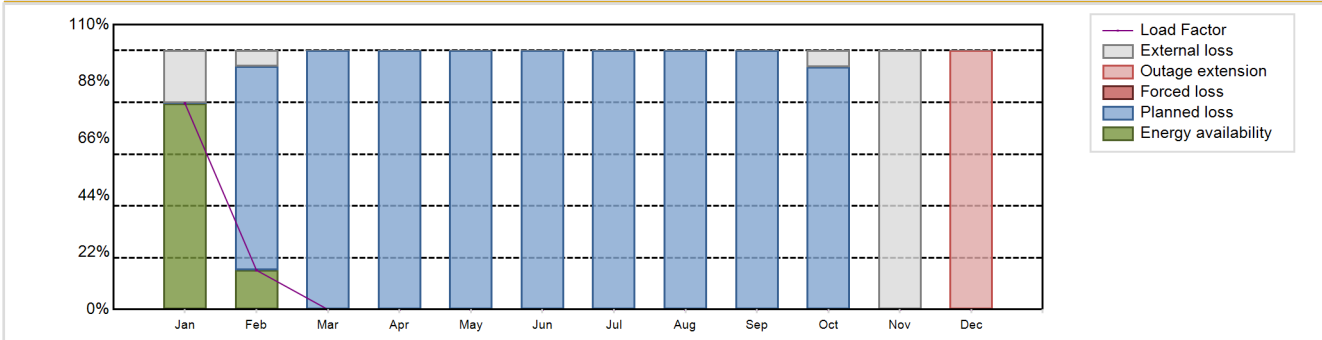
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 628.22 GW(e).h
 Energy Availability Factor (EAF) : 7.93 %
 Unit Capability Factor (UCF) : 18.88 %
 Load Factor (LF) : 7.92 %
 Operating Factor (OF) : 10.15 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 8.49 %
 Planned Unavailability Factor (PUF) : 72.63 %
 Externally cause unavailability (XUF) : 10.96 %
 Total off-line time : 7871 hours

Annual Summary

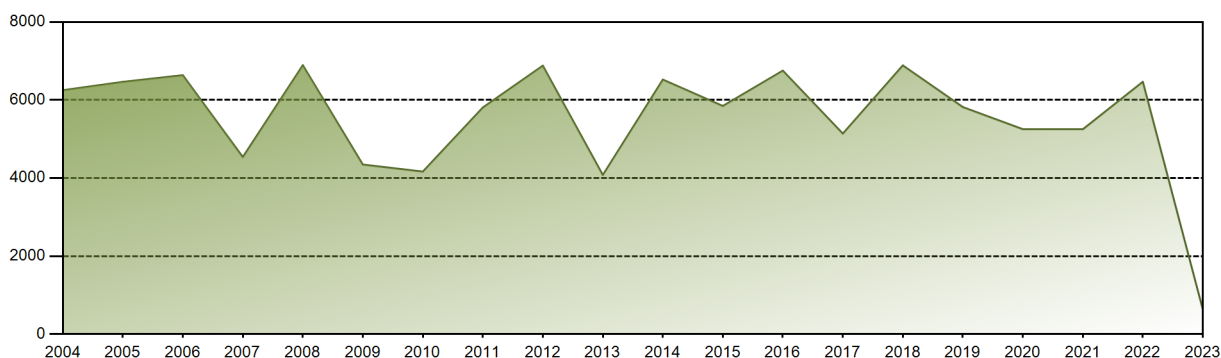


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|-------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|
| GW(e)-h | 535.95 | 92.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 628.22 |
| EAF [%] | 79.60 | 15.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.93 |
| UCF [%] | 99.87 | 21.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.44 | 100.00 | 0.00 | 18.88 |
| LF [%] | 79.60 | 15.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.92 |
| OF [%] | 100.00 | 21.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.15 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 8.49 |
| PUF [%] | 0.13 | 78.73 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.56 | 0.00 | 0.00 | 72.63 |
| XUF [%] | 20.27 | 6.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.44 | 100.00 | 0.00 | 10.96 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 229683.74 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.98 % |
| Cumulative Energy Availability Factor (EAF) | : 74.78 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.13 % |
| Cumulative Unit Capability Factor (UCF) | : 77.08 % | Cumulative Planned Unavailability Factor (PUF) | : 15.79 % |
| Cumulative Load Factor (LF) | : 71.52 % | Cumulative Externally cause unavailability (XUF) | : 2.3 % |
| Cumulative Operating Factor (OF) | : 76.79 % | | |

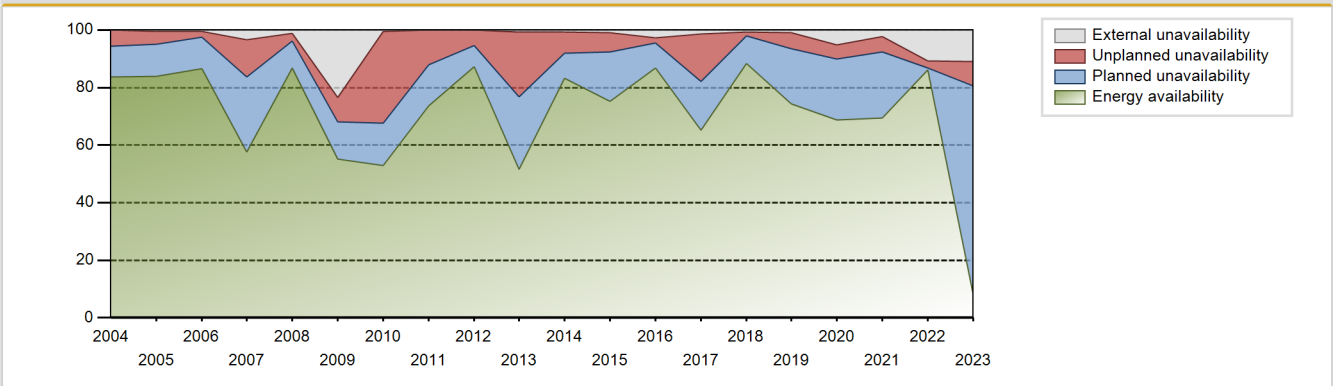
Electricity Production (net) [GWh]



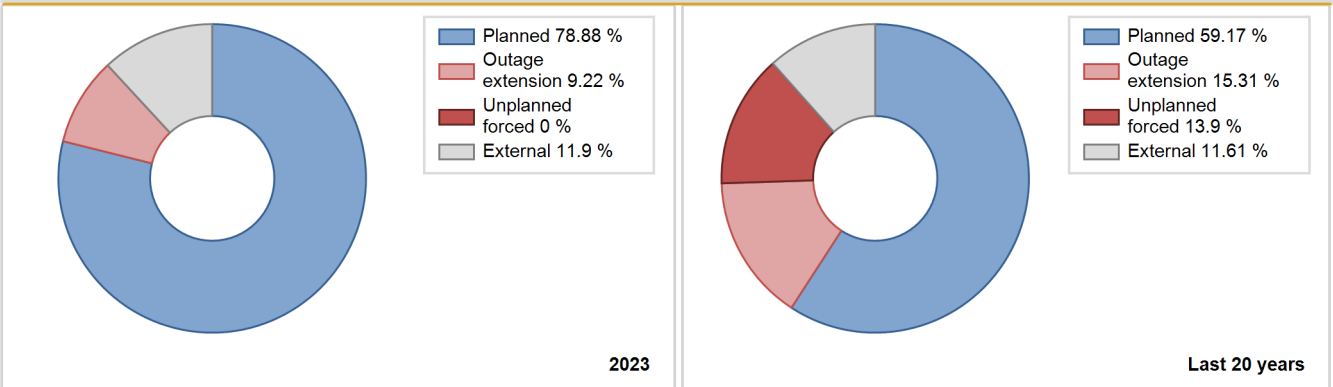
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 4568.00 | 5570 | 870 | 57.57 | 57.57 | 56.11 | 60.14 | 16.20 | 11.13 | 31.30 | 0.00 |
| 1985 | 5978.20 | 7402 | 870 | 82.12 | 84.46 | 78.44 | 84.50 | 2.46 | 2.13 | 13.41 | 2.34 |
| 1986 | 6322.20 | 7609 | 870 | 86.06 | 86.08 | 82.96 | 86.86 | 3.52 | 3.14 | 10.77 | 0.02 |
| 1987 | 4914.10 | 6438 | 870 | 72.92 | 73.65 | 64.48 | 73.49 | 16.21 | 14.25 | 12.10 | 0.73 |
| 1988 | 5271.00 | 7195 | 870 | 96.18 | 97.40 | 68.97 | 81.91 | 2.50 | 2.50 | 0.10 | 1.22 |
| 1989 | 4734.28 | 5724 | 870 | 63.62 | 64.41 | 62.12 | 65.34 | 19.35 | 15.45 | 20.14 | 0.78 |
| 1990 | 5912.97 | 7043 | 870 | 79.14 | 79.34 | 77.59 | 80.40 | 9.15 | 7.99 | 12.67 | 0.20 |
| 1991 | 5339.25 | 6033 | 905 | 67.66 | 67.96 | 67.35 | 68.87 | 20.43 | 17.45 | 14.60 | 0.30 |
| 1992 | 5972.02 | 7133 | 905 | 80.59 | 80.94 | 75.12 | 81.20 | 3.98 | 3.35 | 15.70 | 0.36 |
| 1993 | 5651.68 | 6914 | 905 | 73.26 | 77.71 | 71.29 | 78.93 | 10.64 | 9.25 | 13.05 | 4.45 |
| 1994 | 5366.30 | 6347 | 905 | 71.36 | 71.91 | 67.69 | 72.45 | 4.52 | 3.41 | 24.68 | 0.55 |
| 1995 | 6333.93 | 7573 | 905 | 84.39 | 85.60 | 79.90 | 86.45 | 4.43 | 3.97 | 10.44 | 1.21 |
| 1996 | 6295.23 | 7476 | 905 | 83.36 | 83.58 | 79.19 | 85.11 | 5.07 | 4.46 | 11.96 | 0.22 |
| 1997 | 6093.31 | 7268 | 905 | 81.84 | 81.94 | 76.86 | 82.97 | 1.47 | 1.22 | 16.84 | 0.10 |
| 1998 | 6631.27 | 7759 | 905 | 85.68 | 87.12 | 83.65 | 88.57 | 1.47 | 1.30 | 11.59 | 1.44 |
| 1999 | 6214.03 | 7483 | 905 | 82.06 | 84.31 | 78.38 | 85.42 | 5.73 | 5.12 | 10.57 | 2.25 |
| 2000 | 6166.79 | 7416 | 905 | 82.68 | 83.64 | 77.57 | 84.43 | 5.27 | 4.65 | 11.71 | 0.96 |
| 2001 | 5769.00 | 7260 | 905 | 81.16 | 82.61 | 72.77 | 82.88 | 1.95 | 1.65 | 15.75 | 1.45 |
| 2002 | 6229.34 | 7671 | 905 | 85.55 | 88.86 | 78.58 | 87.57 | 2.02 | 1.83 | 9.30 | 3.31 |
| 2003 | 5181.70 | 6357 | 905 | 68.36 | 71.01 | 65.36 | 72.57 | 4.62 | 3.44 | 25.55 | 2.65 |
| 2004 | 6252.57 | 7536 | 905 | 83.66 | 83.66 | 78.65 | 85.79 | 6.40 | 5.72 | 10.63 | 0.00 |
| 2005 | 6465.82 | 7611 | 905 | 83.93 | 84.49 | 81.55 | 86.87 | 2.05 | 4.40 | 11.11 | 0.56 |
| 2006 | 6637.84 | 7873 | 905 | 86.67 | 87.25 | 83.73 | 89.87 | 2.14 | 1.91 | 10.84 | 0.59 |
| 2007 | 4538.82 | 5559 | 905 | 57.66 | 61.04 | 57.25 | 63.46 | 15.66 | 12.83 | 26.13 | 3.38 |
| 2008 | 6893.10 | 7862 | 905 | 86.87 | 88.07 | 86.71 | 89.50 | 1.53 | 2.65 | 9.28 | 1.20 |
| 2009 | 4345.75 | 5003 | 905 | 55.12 | 78.46 | 54.82 | 57.11 | 1.51 | 8.58 | 12.95 | 23.34 |
| 2010 | 4165.79 | 4893 | 905 | 52.82 | 53.23 | 52.55 | 55.86 | 35.70 | 31.96 | 14.81 | 0.42 |
| 2011 | 5808.26 | 6601 | 905 | 73.65 | 73.66 | 73.26 | 75.35 | 2.27 | 12.09 | 14.26 | 0.01 |
| 2012 | 6881.62 | 7766 | 905 | 87.31 | 87.31 | 86.57 | 88.41 | 1.89 | 5.39 | 7.30 | 0.00 |
| 2013 | 4078.88 | 4634 | 905 | 51.55 | 52.27 | 51.45 | 52.90 | 6.40 | 22.45 | 25.29 | 0.71 |
| 2014 | 6524.18 | 7473 | 905 | 83.17 | 83.90 | 82.29 | 85.31 | 3.68 | 7.30 | 8.80 | 0.73 |
| 2015 | 5847.76 | 6812 | 905 | 75.28 | 76.17 | 73.76 | 77.76 | 5.56 | 6.73 | 17.10 | 0.89 |
| 2016 | 6754.06 | 7846 | 905 | 86.81 | 89.53 | 84.96 | 89.32 | 0.44 | 1.74 | 8.73 | 2.72 |
| 2017 | 5139.16 | 5867 | 905 | 65.25 | 66.72 | 64.82 | 66.97 | 5.36 | 16.47 | 16.81 | 1.48 |
| 2018 | 6888.18 | 7949 | 905 | 88.47 | 89.27 | 86.89 | 90.74 | 0.76 | 1.17 | 9.56 | 0.79 |
| 2019 | 5820.16 | 6750 | 905 | 74.38 | 75.25 | 73.41 | 77.05 | 2.81 | 5.65 | 19.11 | 0.87 |
| 2020 | 5253.27 | 6335 | 905 | 68.67 | 73.73 | 66.08 | 72.12 | 4.39 | 5.02 | 21.25 | 5.06 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|-------|
| 2021 | 5250.72 | 6240 | 905 | 69.43 | 71.70 | 66.23 | 71.23 | 0.55 | 5.25 | 23.06 | 2.27 |
| 2022 | 6467.62 | 8247 | 905 | 86.15 | 96.97 | 81.58 | 94.14 | 1.66 | 2.27 | 0.77 | 10.82 |
| 2023 | 628.22 | 889 | 905 | 7.93 | 18.88 | 7.92 | 10.15 | 0.00 | 8.49 | 72.63 | 10.96 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|-------------|-------------|------------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 744 | | | 501 | |
| B. Refuelling without maintenance | | | | 153 | | |
| C. Inspection, maintenance or repair combined with refuelling | 6358 | | | 1162 | 43 | |
| E. Testing of plant systems or components | | | | 5 | 1 | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| I. Grid capacity limitation | | | | | | 0 |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 11 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 768 | | 25 | 85 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 7 | 15 |
| Z. Other | | | | | 19 | 1 |
| Subtotal | 6358 | 744 | 768 | 1320 | 610 | 110 |
| Total | | 7870 | | | 2040 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 5 |
| 12. Reactor I&C Systems | | 8 |
| 13. Reactor Auxiliary Systems | | 25 |
| 14. Safety Systems | | 9 |
| 15. Reactor Cooling Systems | | 26 |
| 16. Steam generation systems | | 13 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 21. Fuel Handling and Storage Facilities | | 12 |
| 31. Turbine and auxiliaries | | 118 |
| 32. Feedwater and Main Steam System | | 17 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | 744 | 122 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 100 |
| 42. Electrical Power Supply Systems | | 27 |
| Total | 744 | 490 |

2023 Operating Experience

FR-41

CHINON B-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP2
 Thermal power : 2785 MWth
 Gross electrical power : 954 MWe
 Reference unit power (net) : 905 MWe

Key Dates

Construction Date : 1977-03-01
 Grid Date : 1983-11-29
 Commercial Date : 1984-08-01
 Age at end of year : 40 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 38
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

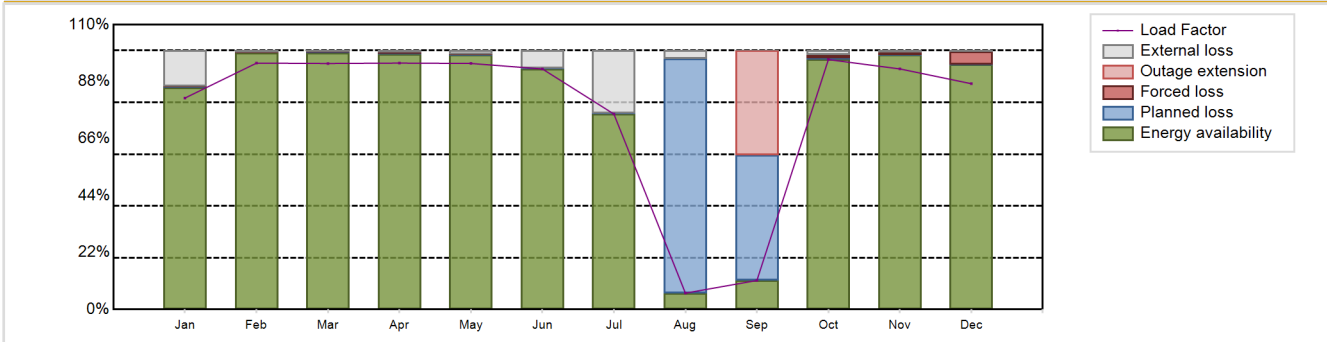
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 6100.43 GW(e).h
 Energy Availability Factor (EAF) : 79.58 %
 Unit Capability Factor (UCF) : 84.12 %
 Load Factor (LF) : 76.95 %
 Operating Factor (OF) : 84.89 %
 Forced Loss Rate (FLR) : 0.85 %
 Unplanned Capability Loss Factor (UCL) : 4.04 %
 Planned Unavailability Factor (PUF) : 11.83 %
 Externally cause unavailability (XUF) : 4.55 %
 Total off-line time : 1324 hours

Annual Summary

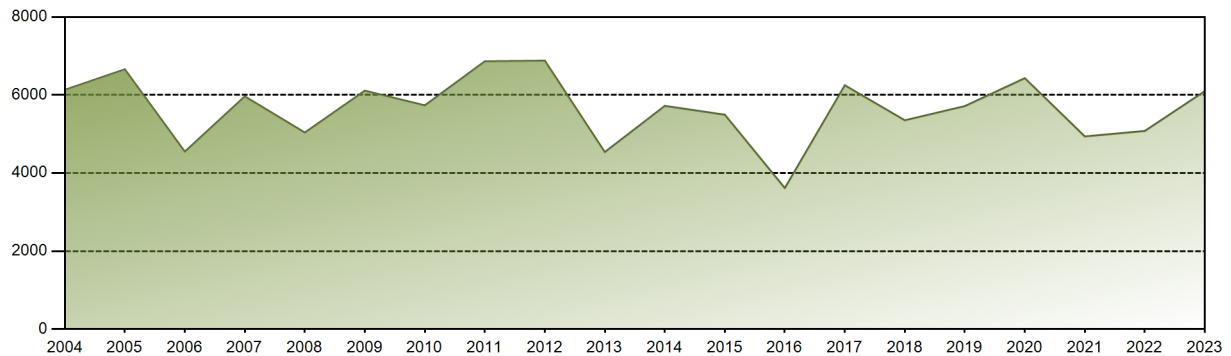


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|-------|-------|--------|--------|--------|---------|
| GW(e)-h | 549.97 | 578.70 | 638.85 | 620.13 | 639.85 | 605.36 | 508.30 | 42.66 | 73.10 | 650.81 | 605.49 | 587.21 | 6100.43 |
| EAF [%] | 85.63 | 99.08 | 99.19 | 98.53 | 98.39 | 92.93 | 75.49 | 6.34 | 11.22 | 96.56 | 98.31 | 94.58 | 79.58 |
| UCF [%] | 99.42 | 99.70 | 99.70 | 99.22 | 99.68 | 99.89 | 99.78 | 9.44 | 11.22 | 98.25 | 98.94 | 94.87 | 84.12 |
| LF [%] | 81.68 | 95.16 | 95.01 | 95.17 | 95.03 | 92.90 | 75.49 | 6.34 | 11.22 | 96.53 | 92.92 | 87.21 | 76.95 |
| OF [%] | 89.92 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 9.81 | 19.86 | 99.87 | 100.00 | 100.00 | 84.89 |
| FLR [%] | 0.35 | 0.12 | 0.21 | 0.56 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 1.20 | 0.94 | 4.99 | 0.85 |
| UCL [%] | 0.35 | 0.12 | 0.21 | 0.56 | 0.24 | 0.00 | 0.00 | 0.00 | 40.35 | 1.19 | 0.94 | 4.98 | 4.04 |
| PUF [%] | 0.22 | 0.19 | 0.09 | 0.22 | 0.08 | 0.11 | 0.22 | 90.56 | 48.43 | 0.56 | 0.12 | 0.15 | 11.83 |
| XUF [%] | 13.79 | 0.61 | 0.51 | 0.69 | 1.30 | 6.95 | 24.29 | 3.11 | 0.00 | 1.69 | 0.64 | 0.30 | 4.55 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 227549.49 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.28 % |
| Cumulative Energy Availability Factor (EAF) | : 76.32 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.8 % |
| Cumulative Unit Capability Factor (UCF) | : 78.47 % | Cumulative Planned Unavailability Factor (PUF) | : 13.72 % |
| Cumulative Load Factor (LF) | : 72.42 % | Cumulative Externally cause unavailability (XUF) | : 2.16 % |
| Cumulative Operating Factor (OF) | : 77.73 % | | |

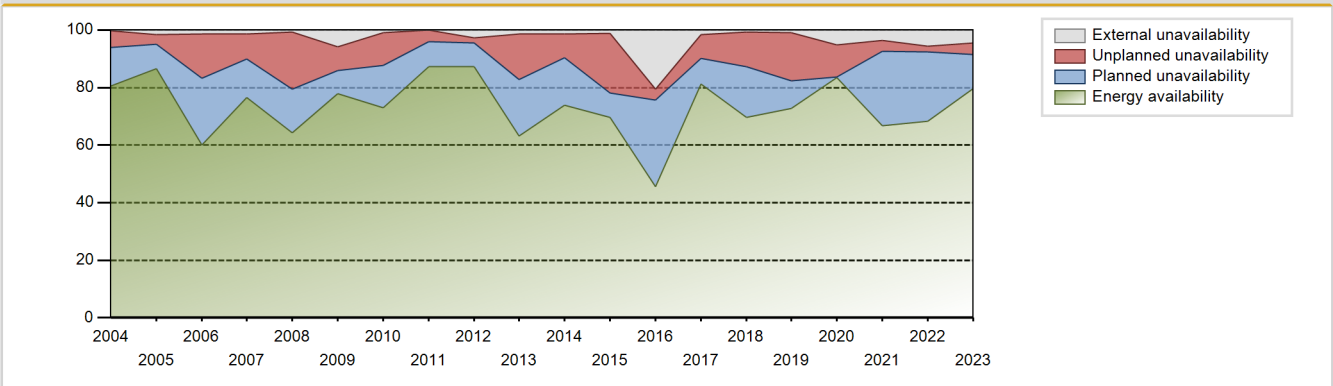
Electricity Production (net) [GWh]



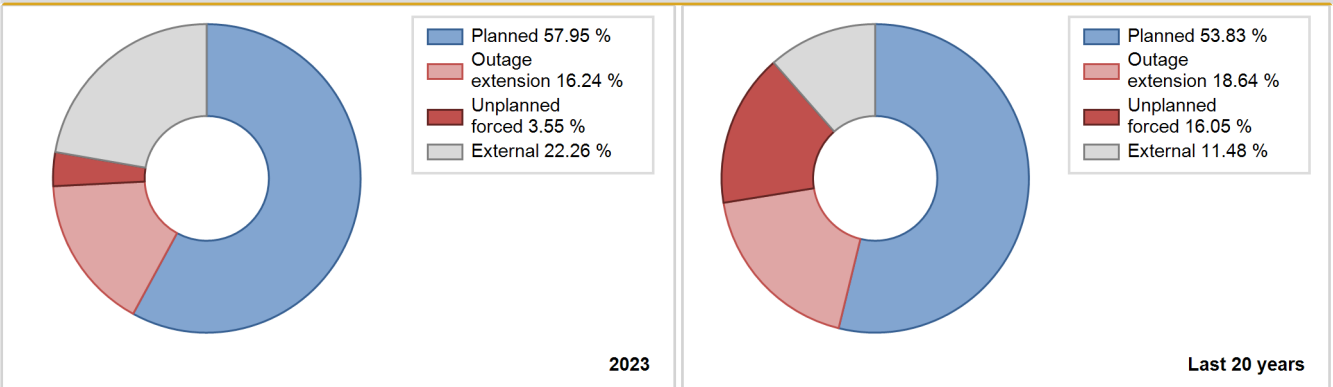
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 5394.00 | 7226 | 870 | 91.69 | 91.69 | 75.83 | 81.27 | 8.31 | 8.31 | 0.00 | 0.00 |
| 1985 | 5037.40 | 6201 | 870 | 67.88 | 69.30 | 66.10 | 70.79 | 4.44 | 3.22 | 27.48 | 1.42 |
| 1986 | 6215.10 | 7639 | 870 | 86.02 | 86.42 | 81.55 | 87.20 | 3.85 | 3.46 | 10.11 | 0.40 |
| 1987 | 5618.80 | 7171 | 870 | 80.73 | 81.14 | 73.73 | 81.86 | 9.38 | 8.40 | 10.46 | 0.41 |
| 1988 | 4425.00 | 5731 | 870 | 67.26 | 68.40 | 57.90 | 65.24 | 23.79 | 21.36 | 10.25 | 1.14 |
| 1989 | 6043.40 | 7873 | 870 | 91.22 | 94.36 | 79.30 | 89.87 | 1.27 | 1.21 | 4.43 | 3.15 |
| 1990 | 5216.99 | 6714 | 870 | 84.12 | 84.42 | 68.45 | 76.64 | 7.80 | 7.14 | 8.44 | 0.30 |
| 1991 | 3142.20 | 3921 | 870 | 53.19 | 55.79 | 41.23 | 44.76 | 29.04 | 22.83 | 21.38 | 2.59 |
| 1992 | 6295.44 | 7321 | 870 | 80.76 | 81.98 | 82.38 | 83.34 | 2.05 | 1.72 | 16.30 | 1.23 |
| 1993 | 5491.59 | 6867 | 870 | 76.25 | 81.41 | 72.06 | 78.39 | 6.53 | 5.68 | 12.90 | 5.17 |
| 1994 | 6174.63 | 7407 | 905 | 83.94 | 84.73 | 77.89 | 84.55 | 4.32 | 3.82 | 11.45 | 0.79 |
| 1995 | 6356.32 | 7741 | 905 | 85.98 | 86.08 | 80.18 | 88.37 | 3.28 | 2.92 | 11.01 | 0.09 |
| 1996 | 5287.61 | 6206 | 905 | 69.38 | 69.62 | 66.51 | 70.65 | 7.32 | 5.49 | 24.89 | 0.24 |
| 1997 | 6637.94 | 7622 | 905 | 85.20 | 86.50 | 83.73 | 87.01 | 1.86 | 1.64 | 11.86 | 1.30 |
| 1998 | 6186.39 | 7136 | 905 | 79.85 | 80.36 | 78.03 | 81.46 | 7.20 | 6.24 | 13.40 | 0.51 |
| 1999 | 5900.93 | 7075 | 905 | 78.96 | 79.10 | 74.43 | 80.76 | 10.24 | 9.03 | 11.87 | 0.15 |
| 2000 | 6177.00 | 7260 | 905 | 80.81 | 81.16 | 77.70 | 82.65 | 5.21 | 4.46 | 14.37 | 0.35 |
| 2001 | 6646.20 | 7846 | 905 | 87.52 | 88.49 | 83.83 | 89.57 | 2.09 | 1.89 | 9.63 | 0.97 |
| 2002 | 6155.60 | 7404 | 905 | 85.35 | 86.22 | 77.65 | 84.52 | 0.87 | 0.76 | 13.02 | 0.86 |
| 2003 | 5746.23 | 7163 | 905 | 78.72 | 81.28 | 72.48 | 81.77 | 9.09 | 8.13 | 10.59 | 2.56 |
| 2004 | 6133.37 | 7252 | 905 | 80.62 | 80.94 | 77.15 | 82.56 | 6.56 | 5.68 | 13.38 | 0.31 |
| 2005 | 6659.58 | 7882 | 905 | 86.50 | 88.00 | 84.00 | 89.98 | 1.73 | 3.38 | 8.62 | 1.50 |
| 2006 | 4548.84 | 5503 | 905 | 60.11 | 61.45 | 57.38 | 62.82 | 12.98 | 15.37 | 23.19 | 1.34 |
| 2007 | 5965.94 | 7023 | 905 | 76.58 | 77.85 | 75.25 | 80.17 | 4.21 | 8.74 | 13.41 | 1.27 |
| 2008 | 5038.27 | 5852 | 905 | 64.24 | 64.95 | 63.38 | 66.62 | 2.43 | 19.75 | 15.30 | 0.71 |
| 2009 | 6111.50 | 7485 | 905 | 77.93 | 83.83 | 77.09 | 85.45 | 3.97 | 8.11 | 8.05 | 5.90 |
| 2010 | 5735.14 | 6561 | 905 | 72.95 | 73.96 | 72.34 | 74.90 | 3.67 | 11.20 | 14.85 | 1.01 |
| 2011 | 6863.39 | 7733 | 905 | 87.23 | 87.30 | 86.57 | 88.28 | 1.00 | 3.94 | 8.77 | 0.07 |
| 2012 | 6880.86 | 7965 | 905 | 87.34 | 90.04 | 86.56 | 90.68 | 2.01 | 1.85 | 8.11 | 2.69 |
| 2013 | 4538.32 | 5483 | 905 | 63.15 | 64.52 | 57.25 | 62.59 | 2.30 | 15.85 | 19.63 | 1.37 |
| 2014 | 5721.41 | 6565 | 905 | 73.83 | 75.14 | 72.17 | 74.94 | 3.86 | 8.28 | 16.58 | 1.31 |
| 2015 | 5495.29 | 6235 | 905 | 69.57 | 70.62 | 69.32 | 71.18 | 22.10 | 20.79 | 8.59 | 1.06 |
| 2016 | 3614.86 | 4251 | 905 | 45.53 | 65.98 | 45.47 | 48.39 | 0.50 | 3.78 | 30.24 | 20.45 |
| 2017 | 6249.36 | 7345 | 905 | 81.21 | 82.73 | 78.83 | 83.85 | 3.64 | 8.43 | 8.84 | 1.52 |
| 2018 | 5352.55 | 6303 | 905 | 69.60 | 70.32 | 67.52 | 71.95 | 0.69 | 12.09 | 17.59 | 0.73 |
| 2019 | 5716.24 | 6607 | 905 | 72.70 | 73.62 | 72.10 | 75.42 | 13.61 | 16.80 | 9.59 | 0.91 |
| 2020 | 6431.85 | 7452 | 905 | 83.51 | 88.72 | 80.91 | 84.84 | 11.15 | 11.13 | 0.15 | 5.21 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 4938.64 | 6083 | 905 | 66.64 | 70.25 | 62.30 | 69.44 | 2.89 | 3.68 | 26.07 | 3.62 |
| 2022 | 5078.62 | 6285 | 905 | 68.32 | 73.94 | 64.06 | 71.75 | 1.31 | 1.97 | 24.09 | 5.62 |
| 2023 | 6100.43 | 7436 | 905 | 79.58 | 84.12 | 76.95 | 84.89 | 0.85 | 4.04 | 11.83 | 4.55 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 291 | | | 550 | |
| B. Refuelling without maintenance | 957 | | | 160 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 975 | 7 | |
| D. Inspection, maintenance or repair without refuelling | | | | 2 | | |
| E. Testing of plant systems or components | | | | 11 | 1 | |
| H. Nuclear regulatory requirements | | | | | 13 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 33 |
| L. Human factor related | | | | | 15 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 4 | 59 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 75 | | 9 | 19 |
| Z. Other | | | | | 17 | 2 |
| Subtotal | 957 | 291 | 75 | 1148 | 616 | 116 |
| Total | | 1323 | | | 1880 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 13 |
| 12. Reactor I&C Systems | | 17 |
| 13. Reactor Auxiliary Systems | | 29 |
| 14. Safety Systems | | 28 |
| 15. Reactor Cooling Systems | | 40 |
| 16. Steam generation systems | | 88 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 5 |
| 21. Fuel Handling and Storage Facilities | | 19 |
| 31. Turbine and auxiliaries | | 58 |
| 32. Feedwater and Main Steam System | | 22 |
| 33. Circulating Water System | | 4 |
| 34. Miscellaneous Systems | 291 | 119 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 104 |
| 42. Electrical Power Supply Systems | | 40 |
| Total | 291 | 588 |

2023 Operating Experience

FR-56 **CHINON B-3** **FRANCE**

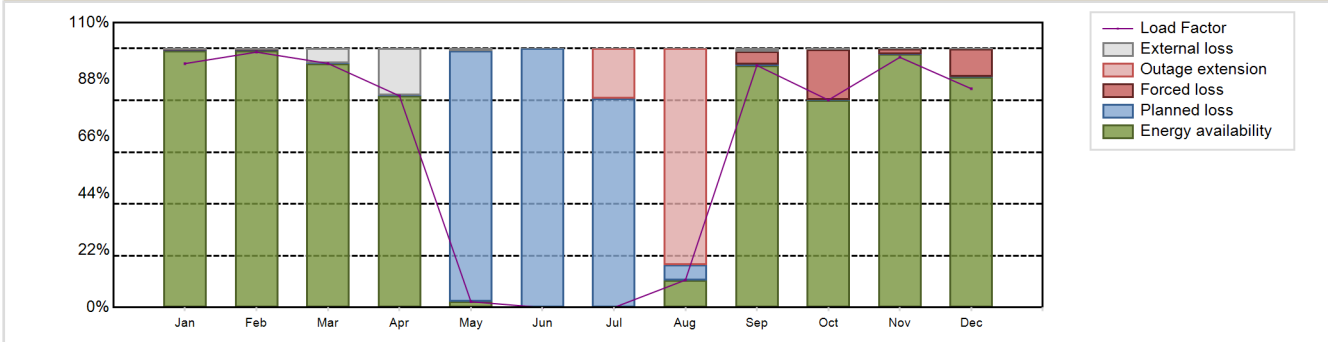
Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP2 | Construction Date | : 1980-10-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1986-10-20 |
| Gross electrical power | : 954 MWe | Commercial Date | : 1987-03-04 |
| Reference unit power (net) | : 905 MWe | Age at end of year | : 37 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.4 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 321 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33735 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Cooling towers |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 38 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4835.37 GW(e).h | Forced Loss Rate (FLR) | : 4.7 % |
| Energy Availability Factor (EAF) | : 61.94 % | Unplanned Capability Loss Factor (UCL) | : 11.9 % |
| Unit Capability Factor (UCF) | : 64.19 % | Planned Unavailability Factor (PUF) | : 23.91 % |
| Load Factor (LF) | : 60.99 % | Externally cause unavailability (XUF) | : 2.25 % |
| Operating Factor (OF) | : 65.32 % | Total off-line time | : 3038 hours |

Annual Summary

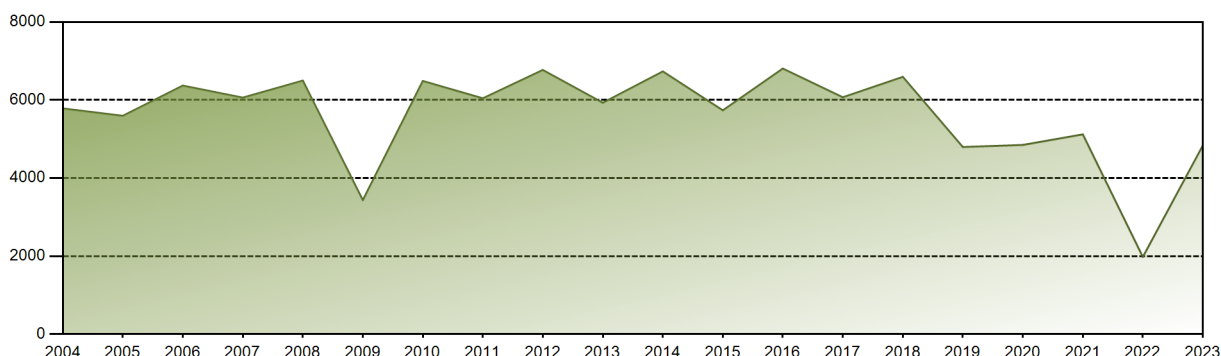


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|-------|-------|--------|--------|--------|--------|---------|
| GW(e)-h | 634.34 | 599.83 | 633.86 | 532.69 | 15.16 | 0.00 | 0.00 | 71.41 | 609.22 | 540.24 | 629.69 | 568.94 | 4835.37 |
| EAF [%] | 99.14 | 99.17 | 94.26 | 81.75 | 2.25 | 0.00 | 0.00 | 10.61 | 93.53 | 80.09 | 97.85 | 89.03 | 61.94 |
| UCF [%] | 99.53 | 99.57 | 99.91 | 99.73 | 3.17 | 0.00 | 0.00 | 10.61 | 94.63 | 80.59 | 98.05 | 89.06 | 64.19 |
| LF [%] | 94.21 | 98.63 | 94.27 | 81.75 | 2.25 | 0.00 | 0.00 | 10.61 | 93.50 | 80.13 | 96.64 | 84.50 | 60.99 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 3.49 | 0.00 | 0.00 | 16.26 | 100.00 | 80.81 | 98.61 | 89.25 | 65.32 |
| FLR [%] | 0.28 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.96 | 19.35 | 1.86 | 10.83 | 4.70 |
| UCL [%] | 0.28 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 19.35 | 83.53 | 4.94 | 19.33 | 1.85 | 10.82 | 11.90 |
| PUF [%] | 0.19 | 0.15 | 0.09 | 0.27 | 96.83 | 100.00 | 80.64 | 5.86 | 0.43 | 0.08 | 0.10 | 0.12 | 23.91 |
| XUF [%] | 0.38 | 0.40 | 5.64 | 17.98 | 0.92 | 0.00 | 0.00 | 0.00 | 1.10 | 0.50 | 0.20 | 0.03 | 2.25 |

Historical Summary

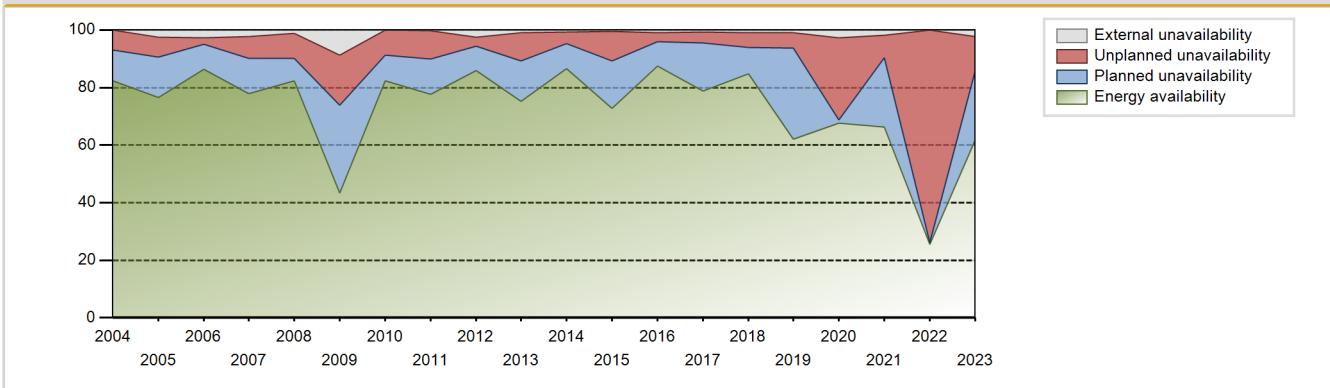
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 210653.95 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.55 % |
| Cumulative Energy Availability Factor (EAF) | : 75.77 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 9.24 % |
| Cumulative Unit Capability Factor (UCF) | : 77.44 % | Cumulative Planned Unavailability Factor (PUF) | : 13.32 % |
| Cumulative Load Factor (LF) | : 71.81 % | Cumulative Externally cause unavailability (XUF) | : 1.67 % |
| Cumulative Operating Factor (OF) | : 77.58 % | | |

Electricity Production (net) [GWh]

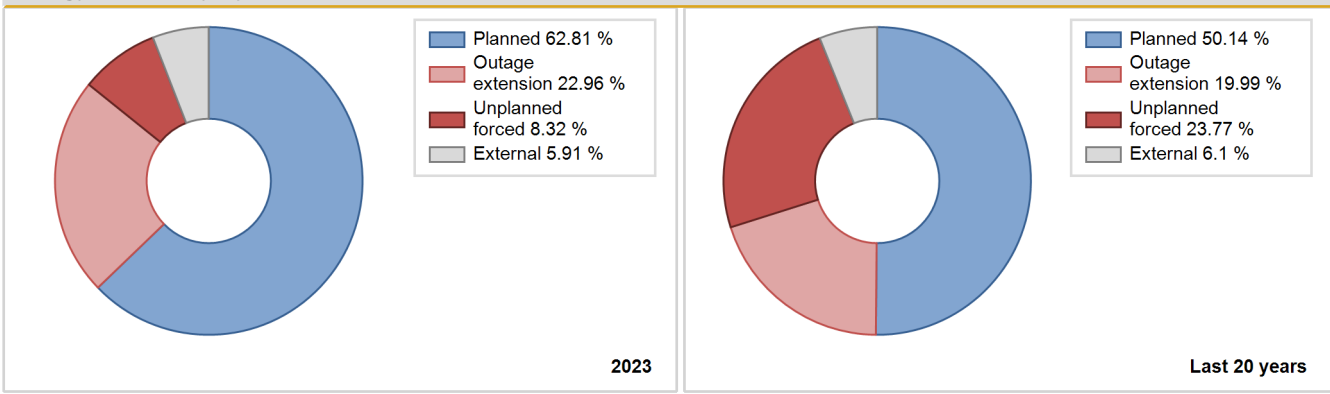


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 4120.60 | 5311 | 870 | 67.61 | 67.61 | 52.00 | 59.68 | 24.66 | 22.13 | 10.26 | 0.00 |
| 1988 | 4413.00 | 5354 | 905 | 58.90 | 61.48 | 55.51 | 60.95 | 21.77 | 17.11 | 21.41 | 2.58 |
| 1989 | 5028.58 | 6125 | 905 | 77.81 | 81.19 | 63.43 | 69.92 | 6.64 | 5.77 | 13.04 | 3.38 |
| 1990 | 5417.63 | 6274 | 905 | 69.12 | 69.18 | 68.34 | 71.62 | 16.51 | 13.68 | 17.15 | 0.06 |
| 1991 | 7026.39 | 8204 | 905 | 90.66 | 92.91 | 88.63 | 93.65 | 4.00 | 3.87 | 3.22 | 2.25 |
| 1992 | 6091.45 | 7468 | 905 | 85.62 | 87.48 | 76.63 | 85.02 | 2.98 | 2.69 | 9.83 | 1.86 |
| 1993 | 5600.75 | 6827 | 905 | 72.61 | 78.35 | 70.65 | 77.93 | 3.69 | 3.00 | 18.65 | 5.74 |
| 1994 | 5064.02 | 6325 | 905 | 75.45 | 76.21 | 63.88 | 72.20 | 15.56 | 14.04 | 9.75 | 0.76 |
| 1995 | 6005.65 | 7177 | 905 | 82.54 | 83.34 | 75.75 | 81.93 | 7.56 | 6.82 | 9.84 | 0.81 |
| 1996 | 6277.96 | 7761 | 905 | 86.86 | 87.18 | 78.97 | 88.35 | 1.56 | 1.38 | 11.44 | 0.31 |
| 1997 | 5816.77 | 7249 | 905 | 85.07 | 85.10 | 73.37 | 82.75 | 0.96 | 0.82 | 14.08 | 0.03 |
| 1998 | 6345.64 | 7472 | 905 | 81.32 | 84.10 | 80.04 | 85.30 | 0.65 | 0.55 | 15.35 | 2.77 |
| 1999 | 5601.97 | 6656 | 905 | 72.19 | 74.80 | 70.66 | 75.98 | 4.22 | 3.30 | 21.90 | 2.62 |
| 2000 | 6330.11 | 7386 | 905 | 82.52 | 83.12 | 79.63 | 84.08 | 3.89 | 3.36 | 13.52 | 0.60 |
| 2001 | 6318.00 | 7665 | 905 | 84.76 | 87.05 | 79.69 | 87.50 | 1.29 | 1.14 | 11.82 | 2.29 |
| 2002 | 6720.45 | 7971 | 905 | 87.57 | 90.03 | 84.77 | 90.99 | 0.43 | 0.39 | 9.58 | 2.46 |
| 2003 | 5807.75 | 6954 | 905 | 77.57 | 77.72 | 73.26 | 79.38 | 11.07 | 9.68 | 12.60 | 0.15 |
| 2004 | 5784.36 | 7444 | 905 | 82.34 | 82.47 | 72.76 | 84.74 | 7.64 | 6.82 | 10.70 | 0.14 |
| 2005 | 5595.37 | 7287 | 905 | 76.52 | 79.10 | 70.58 | 83.18 | 7.97 | 6.85 | 14.05 | 2.58 |
| 2006 | 6369.75 | 7930 | 905 | 86.29 | 89.00 | 80.35 | 90.53 | 1.62 | 2.28 | 8.72 | 2.71 |
| 2007 | 6061.29 | 7310 | 905 | 77.89 | 80.19 | 76.46 | 83.45 | 4.04 | 7.56 | 12.25 | 2.30 |
| 2008 | 6498.11 | 7760 | 905 | 82.30 | 83.51 | 81.74 | 88.34 | 5.36 | 8.73 | 7.76 | 1.21 |
| 2009 | 3433.46 | 4114 | 905 | 43.40 | 52.08 | 43.31 | 46.96 | 7.88 | 17.47 | 30.45 | 8.68 |
| 2010 | 6488.82 | 7485 | 905 | 82.45 | 82.48 | 81.85 | 85.45 | 4.78 | 8.66 | 8.87 | 0.03 |
| 2011 | 6043.83 | 6906 | 905 | 77.58 | 77.78 | 76.24 | 78.84 | 2.04 | 9.83 | 12.40 | 0.20 |
| 2012 | 6770.53 | 7662 | 905 | 85.87 | 88.39 | 85.17 | 87.23 | 1.65 | 3.15 | 8.46 | 2.52 |
| 2013 | 5930.23 | 6823 | 905 | 75.27 | 76.20 | 74.80 | 77.89 | 3.07 | 9.76 | 14.04 | 0.93 |
| 2014 | 6733.16 | 7711 | 905 | 86.59 | 87.34 | 84.93 | 88.03 | 2.77 | 3.91 | 8.75 | 0.75 |
| 2015 | 5735.52 | 6515 | 905 | 72.75 | 73.26 | 72.35 | 74.37 | 0.72 | 10.27 | 16.47 | 0.51 |
| 2016 | 6806.55 | 7949 | 905 | 87.43 | 88.25 | 85.62 | 90.49 | 1.28 | 3.19 | 8.56 | 0.82 |
| 2017 | 6070.41 | 7079 | 905 | 78.88 | 79.62 | 76.57 | 80.81 | 0.51 | 3.70 | 16.68 | 0.74 |
| 2018 | 6593.67 | 7668 | 905 | 84.70 | 85.60 | 83.17 | 87.53 | 3.35 | 5.09 | 9.31 | 0.90 |
| 2019 | 4795.66 | 5526 | 905 | 62.11 | 63.02 | 60.49 | 63.08 | 2.45 | 5.42 | 31.56 | 0.91 |
| 2020 | 4848.50 | 6046 | 905 | 67.64 | 70.39 | 60.99 | 68.83 | 4.58 | 28.44 | 1.17 | 2.75 |
| 2021 | 5119.31 | 6022 | 905 | 66.21 | 67.93 | 64.57 | 68.74 | 1.00 | 7.87 | 24.20 | 1.72 |
| 2022 | 1976.92 | 2323 | 905 | 25.54 | 25.62 | 24.94 | 26.52 | 74.23 | 73.79 | 0.60 | 0.08 |
| 2023 | 4835.37 | 5722 | 905 | 61.94 | 64.19 | 60.99 | 65.32 | 4.70 | 11.90 | 23.91 | 2.25 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|--|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 997 | | | 617 | |
| B. Refuelling without maintenance | | | | 116 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2038 | | | 963 | 21 | |
| D. Inspection, maintenance or repair without refuelling | | | | 25 | | |
| E. Testing of plant systems or components | 2 | | | 22 | 1 | |
| H. Nuclear regulatory requirements | | | | | 12 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 13 | |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant , spare part delivery problems etc.) | | | | | 2 | 27 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 7 | 5 |
| Z. Other | | | | | 40 | 1 |
| Subtotal | 2040 | 997 | | 1126 | 713 | 37 |
| Total | | 3037 | | | 1876 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 23 |
| 12. Reactor I&C Systems | | 9 |
| 13. Reactor Auxiliary Systems | | 32 |
| 14. Safety Systems | | 177 |
| 15. Reactor Cooling Systems | | 22 |
| 16. Steam generation systems | | 23 |
| 21. Fuel Handling and Storage Facilities | | 20 |
| 31. Turbine and auxiliaries | 151 | 66 |
| 32. Feedwater and Main Steam System | 80 | 29 |
| 33. Circulating Water System | | 3 |
| 34. Miscellaneous Systems | 765 | 177 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 28 |
| 42. Electrical Power Supply Systems | | 7 |
| Total | 996 | 617 |

2023 Operating Experience

FR-57

CHINON B-4

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP2
 Thermal power : 2785 MWth
 Gross electrical power : 954 MWe
 Reference unit power (net) : 905 MWe

Key Dates

Construction Date : 1981-02-01
 Grid Date : 1987-11-14
 Commercial Date : 1988-04-01
 Age at end of year : 36 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 38
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

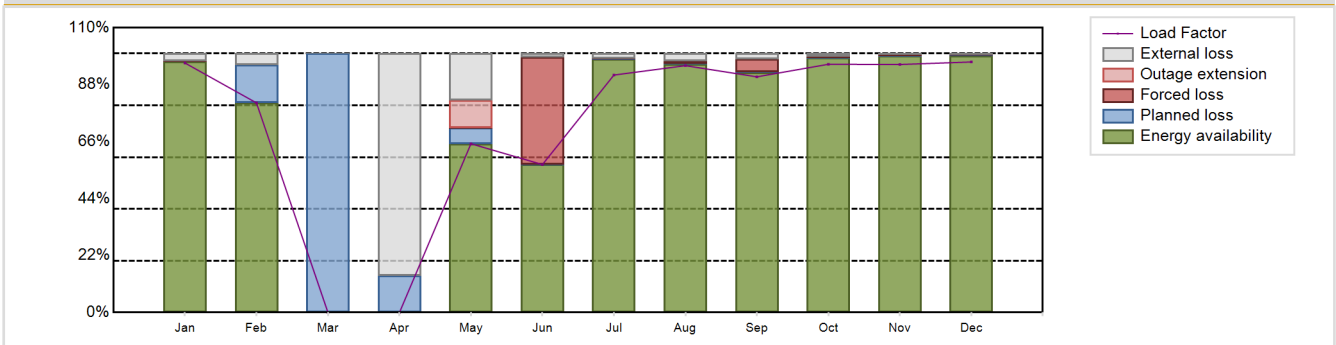
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 5727.02 GW(e).h
 Energy Availability Factor (EAF) : 73.68 %
 Unit Capability Factor (UCF) : 83.72 %
 Load Factor (LF) : 72.24 %
 Operating Factor (OF) : 76.08 %
 Forced Loss Rate (FLR) : 4.57 %
 Unplanned Capability Loss Factor (UCL) : 4.91 %
 Planned Unavailability Factor (PUF) : 11.37 %
 Externally cause unavailability (XUF) : 10.04 %
 Total off-line time : 2095 hours

Annual Summary

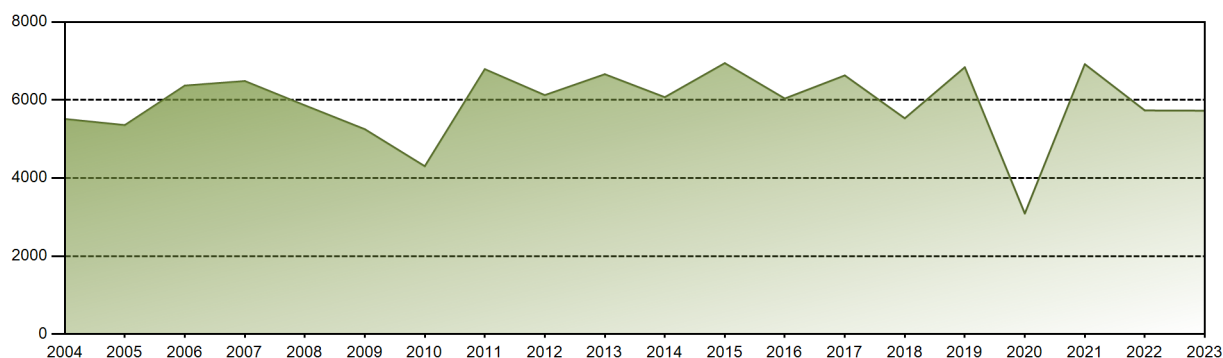


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 648.80 | 492.39 | 0.00 | 0.00 | 438.84 | 372.37 | 617.48 | 641.95 | 593.14 | 646.41 | 624.14 | 651.51 | 5727.02 |
| EAF [%] | 96.92 | 80.96 | 0.00 | 0.00 | 65.15 | 57.17 | 97.89 | 95.93 | 92.71 | 98.32 | 99.13 | 99.12 | 73.68 |
| UCF [%] | 99.85 | 85.37 | 0.00 | 85.83 | 83.14 | 58.55 | 99.77 | 98.89 | 94.88 | 99.54 | 99.60 | 99.41 | 83.72 |
| LF [%] | 96.36 | 80.96 | 0.00 | 0.00 | 65.18 | 57.15 | 91.71 | 95.34 | 91.03 | 95.87 | 95.79 | 96.76 | 72.24 |
| OF [%] | 97.58 | 85.86 | 0.00 | 0.00 | 71.64 | 60.14 | 100.00 | 100.00 | 97.22 | 99.87 | 100.00 | 100.00 | 76.08 |
| FLR [%] | 0.06 | 0.00 | 0.00 | 0.00 | 0.07 | 41.42 | 0.12 | 1.00 | 4.99 | 0.35 | 0.33 | 0.42 | 4.57 |
| UCL [%] | 0.06 | 0.00 | 0.00 | 0.00 | 10.68 | 41.39 | 0.12 | 1.00 | 4.98 | 0.35 | 0.33 | 0.42 | 4.91 |
| PUF [%] | 0.09 | 14.63 | 100.00 | 14.17 | 6.18 | 0.06 | 0.11 | 0.12 | 0.14 | 0.12 | 0.07 | 0.17 | 11.37 |
| XUF [%] | 2.92 | 4.41 | 0.00 | 85.83 | 17.99 | 1.38 | 1.88 | 2.96 | 2.17 | 1.22 | 0.47 | 0.29 | 10.04 |

Historical Summary

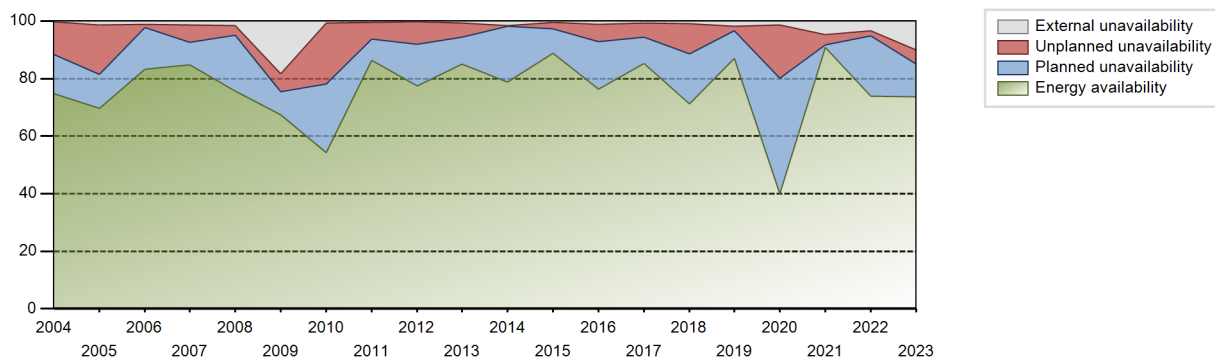
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 212869.24 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.56 % |
| Cumulative Energy Availability Factor (EAF) | : 78.39 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.04 % |
| Cumulative Unit Capability Factor (UCF) | : 80.66 % | Cumulative Planned Unavailability Factor (PUF) | : 13.29 % |
| Cumulative Load Factor (LF) | : 74.65 % | Cumulative Externally cause unavailability (XUF) | : 2.27 % |
| Cumulative Operating Factor (OF) | : 80.49 % | | |

Electricity Production (net) [GWh]

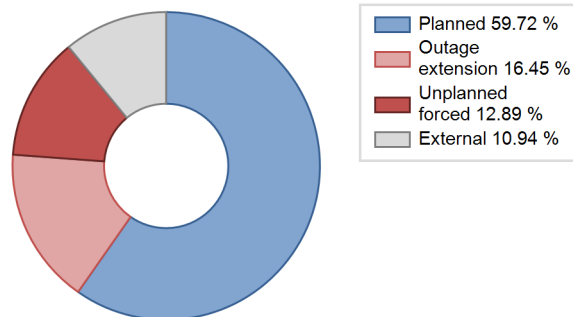
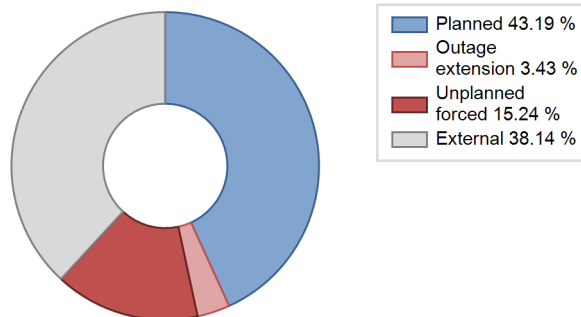


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 4410.00 | 5897 | 905 | 86.17 | 89.04 | 56.36 | 67.79 | 10.96 | 10.96 | 0.00 | 2.86 |
| 1989 | 4688.12 | 5664 | 905 | 60.39 | 63.58 | 59.14 | 64.66 | 13.81 | 10.18 | 26.24 | 3.19 |
| 1990 | 6098.01 | 7003 | 905 | 77.01 | 77.22 | 76.92 | 79.94 | 11.20 | 9.74 | 13.04 | 0.21 |
| 1991 | 6339.97 | 7204 | 905 | 79.24 | 79.96 | 79.97 | 82.24 | 7.12 | 6.13 | 13.91 | 0.71 |
| 1992 | 6387.95 | 7544 | 905 | 82.80 | 85.03 | 80.36 | 85.88 | 0.66 | 0.56 | 14.40 | 2.23 |
| 1993 | 6016.91 | 7359 | 905 | 80.12 | 85.77 | 75.90 | 84.01 | 3.60 | 3.20 | 11.03 | 5.65 |
| 1994 | 5935.09 | 7196 | 905 | 81.25 | 82.44 | 74.86 | 82.15 | 2.73 | 2.31 | 15.25 | 1.19 |
| 1995 | 6566.02 | 7805 | 905 | 87.88 | 88.17 | 82.82 | 89.10 | 1.73 | 1.55 | 10.28 | 0.29 |
| 1996 | 6574.24 | 7764 | 905 | 87.03 | 87.64 | 82.70 | 88.39 | 1.90 | 1.70 | 10.66 | 0.61 |
| 1997 | 6345.37 | 7795 | 905 | 85.64 | 88.73 | 80.04 | 88.98 | 1.09 | 0.98 | 10.29 | 3.09 |
| 1998 | 5940.13 | 7326 | 905 | 80.18 | 83.14 | 74.93 | 83.63 | 2.98 | 2.56 | 14.31 | 2.96 |
| 1999 | 5596.27 | 7059 | 905 | 88.17 | 89.89 | 70.59 | 80.58 | 9.99 | 9.98 | 0.13 | 1.72 |
| 2000 | 5110.70 | 6445 | 905 | 72.91 | 74.09 | 64.29 | 73.37 | 5.72 | 4.49 | 21.42 | 1.18 |
| 2001 | 5764.99 | 7078 | 905 | 79.91 | 81.33 | 72.72 | 80.80 | 10.39 | 9.43 | 9.24 | 1.42 |
| 2002 | 6321.31 | 7584 | 905 | 84.03 | 85.53 | 79.74 | 86.58 | 2.58 | 2.27 | 12.20 | 1.50 |
| 2003 | 6431.76 | 7811 | 905 | 86.62 | 87.71 | 81.13 | 89.17 | 3.61 | 3.29 | 9.00 | 1.10 |
| 2004 | 5513.22 | 6883 | 905 | 74.88 | 75.12 | 69.35 | 78.36 | 13.19 | 11.41 | 13.47 | 0.24 |
| 2005 | 5356.45 | 7030 | 905 | 69.72 | 71.15 | 67.57 | 80.25 | 19.49 | 17.23 | 11.63 | 1.43 |
| 2006 | 6368.95 | 7558 | 905 | 83.27 | 84.36 | 80.34 | 86.28 | 0.89 | 1.15 | 14.48 | 1.09 |
| 2007 | 6485.73 | 7691 | 905 | 84.82 | 86.11 | 81.81 | 87.80 | 2.22 | 6.15 | 7.74 | 1.29 |
| 2008 | 5863.53 | 6881 | 905 | 75.65 | 77.15 | 73.76 | 78.34 | 0.74 | 3.33 | 19.52 | 1.50 |
| 2009 | 5250.85 | 6232 | 905 | 67.43 | 85.76 | 66.23 | 71.14 | 4.16 | 6.30 | 7.94 | 18.33 |
| 2010 | 4302.57 | 4902 | 905 | 54.34 | 54.98 | 54.27 | 55.96 | 1.78 | 21.24 | 23.78 | 0.64 |
| 2011 | 6790.85 | 7868 | 905 | 86.40 | 86.81 | 85.66 | 89.82 | 3.56 | 5.85 | 7.34 | 0.42 |
| 2012 | 6125.00 | 6958 | 905 | 77.51 | 77.81 | 77.05 | 79.21 | 1.15 | 7.80 | 14.38 | 0.31 |
| 2013 | 6660.90 | 7573 | 905 | 84.94 | 85.68 | 84.02 | 86.45 | 1.50 | 4.93 | 9.39 | 0.74 |
| 2014 | 6071.89 | 7092 | 905 | 78.89 | 80.42 | 76.59 | 80.96 | 0.30 | 0.24 | 19.34 | 1.53 |
| 2015 | 6944.68 | 7944 | 905 | 88.88 | 89.44 | 87.60 | 90.68 | 2.37 | 2.18 | 8.38 | 0.56 |
| 2016 | 6037.90 | 7119 | 905 | 76.24 | 77.46 | 75.95 | 81.05 | 0.45 | 5.88 | 16.66 | 1.22 |
| 2017 | 6630.00 | 7624 | 905 | 85.17 | 85.78 | 83.63 | 87.03 | 4.57 | 4.90 | 9.31 | 0.61 |
| 2018 | 5530.08 | 6388 | 905 | 71.13 | 72.10 | 69.76 | 72.92 | 2.86 | 10.34 | 17.56 | 0.97 |
| 2019 | 6839.72 | 7843 | 905 | 86.97 | 88.70 | 86.28 | 89.53 | 0.94 | 1.64 | 9.67 | 1.72 |
| 2020 | 3089.77 | 3583 | 905 | 40.03 | 41.33 | 38.87 | 40.79 | 0.21 | 18.66 | 40.01 | 1.29 |
| 2021 | 6917.88 | 8441 | 905 | 90.91 | 95.72 | 87.26 | 96.36 | 3.45 | 3.42 | 0.86 | 4.81 |
| 2022 | 5732.97 | 6868 | 905 | 73.98 | 77.25 | 72.31 | 78.40 | 2.37 | 1.88 | 20.87 | 3.27 |
| 2023 | 5727.02 | 6665 | 905 | 73.68 | 83.72 | 72.24 | 76.08 | 4.57 | 4.91 | 11.37 | 10.04 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-------------|------------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 386 | | | 374 | |
| B. Refuelling without maintenance | 940 | | | 159 | | |
| C. Inspection, maintenance or repair combined with refuelling | 0 | | | 930 | 11 | |
| E. Testing of plant systems or components | | | | 23 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 3 |
| L. Human factor related | | | | | 4 | |
| M. Governmental requirements or court decisions | | | | | | 1 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| O. Load dispatching, prioritization | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 750 | | 5 | 67 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 18 | | 7 | 6 |
| Z. Other | | | | | 33 | 14 |
| Subtotal | 940 | 386 | 768 | 1112 | 435 | 93 |
| Total | | 2094 | | | 1640 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 44 |
| 12. Reactor I&C Systems | 68 | 16 |
| 13. Reactor Auxiliary Systems | | 25 |
| 14. Safety Systems | | 11 |
| 15. Reactor Cooling Systems | | 37 |
| 16. Steam generation systems | | 10 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 14 |
| 31. Turbine and auxiliaries | 20 | 37 |
| 32. Feedwater and Main Steam System | | 11 |
| 33. Circulating Water System | | 3 |
| 34. Miscellaneous Systems | 79 | 104 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 26 |
| 42. Electrical Power Supply Systems | 219 | 30 |
| Total | 386 | 370 |

2023 Operating Experience

FR-62

CHOOZ B-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : FRAM (FRAMATOME)

Reactor Unit Details

Reactor type and model : PWR / N4 REP 1450
 Thermal power : 4270 MWth
 Gross electrical power : 1560 MWe
 Reference unit power (net) : 1500 MWe

Key Dates

Construction Date : 1984-01-01
 Grid Date : 1996-08-30
 Commercial Date : 2000-05-15
 Age at end of year : 27 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 39000
 Active core diameter [m] : 3.47
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 205
 Fuel linear heat generation rate [kW/m] : 17.92
 Number of control rod assemblies : 25
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 329.5
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.3

Secondary systems

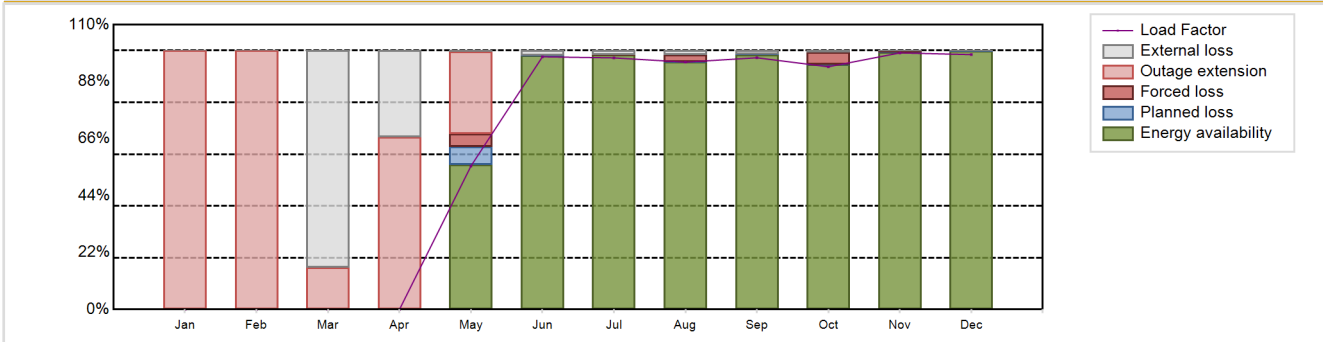
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 7.1
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8089.97 GW(e).h
 Energy Availability Factor (EAF) : 62.09 %
 Unit Capability Factor (UCF) : 72.62 %
 Load Factor (LF) : 61.57 %
 Operating Factor (OF) : 63.8 %
 Forced Loss Rate (FLR) : 1.44 %
 Unplanned Capability Loss Factor (UCL) : 26.78 %
 Planned Unavailability Factor (PUF) : 0.61 %
 Externally cause unavailability (XUF) : 10.53 %
 Total off-line time : 3171 hours

Annual Summary

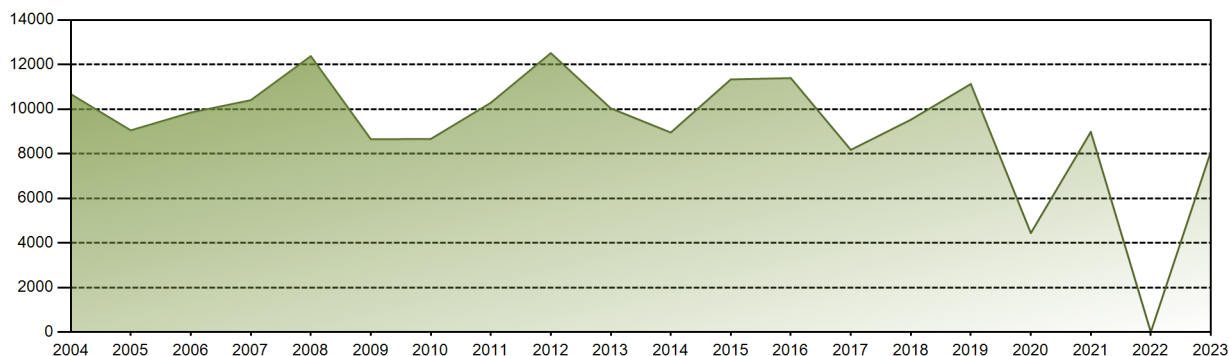


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|-------|--------|---------|---------|---------|---------|---------|---------|---------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 618.38 | 1054.09 | 1084.62 | 1066.23 | 1050.10 | 1047.63 | 1070.38 | 1098.55 | 8089.97 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 56.01 | 98.05 | 98.34 | 95.63 | 98.47 | 94.74 | 99.44 | 99.78 | 62.09 |
| UCF [%] | 0.00 | 0.00 | 83.85 | 33.33 | 56.39 | 99.94 | 99.91 | 97.30 | 99.92 | 95.43 | 99.67 | 99.99 | 72.62 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 55.41 | 97.60 | 97.19 | 95.54 | 97.23 | 93.75 | 99.11 | 98.44 | 61.57 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 64.52 | 100.00 | 100.00 | 100.00 | 100.00 | 96.24 | 100.00 | 100.00 | 63.80 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 8.04 | 0.00 | 0.07 | 2.63 | 0.00 | 4.55 | 0.31 | 0.00 | 1.44 |
| UCL [%] | 100.00 | 100.00 | 16.15 | 66.67 | 36.75 | 0.00 | 0.07 | 2.63 | 0.00 | 4.55 | 0.31 | 0.00 | 26.78 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 6.86 | 0.06 | 0.02 | 0.07 | 0.08 | 0.02 | 0.02 | 0.01 | 0.61 |
| XUF [%] | 0.00 | 0.00 | 83.85 | 33.33 | 0.38 | 1.89 | 1.57 | 1.67 | 1.44 | 0.69 | 0.23 | 0.21 | 10.53 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 233373.25 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.54 % |
| Cumulative Energy Availability Factor (EAF) | : 73.69 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 9.26 % |
| Cumulative Unit Capability Factor (UCF) | : 77.25 % | Cumulative Planned Unavailability Factor (PUF) | : 13.48 % |
| Cumulative Load Factor (LF) | : 71.57 % | Cumulative Externally cause unavailability (XUF) | : 3.56 % |
| Cumulative Operating Factor (OF) | : 75.1 % | | |

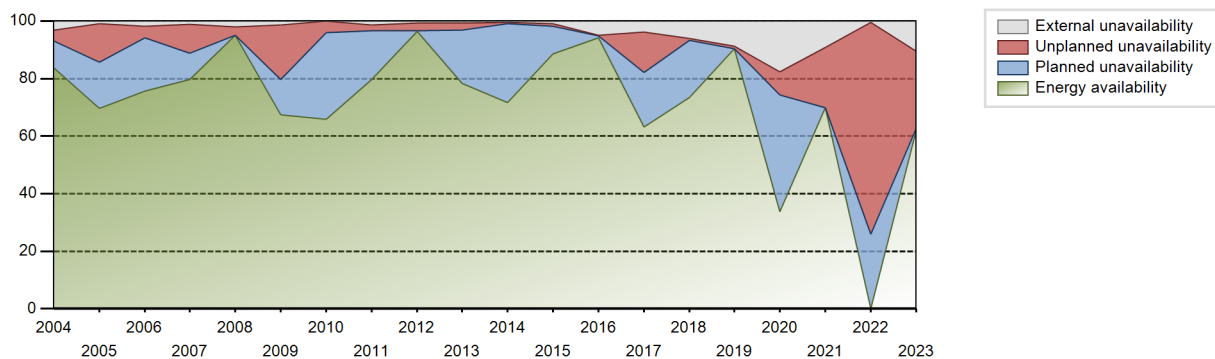
Electricity Production (net) [GWh]



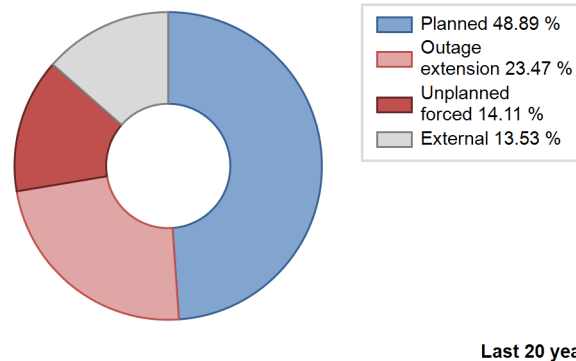
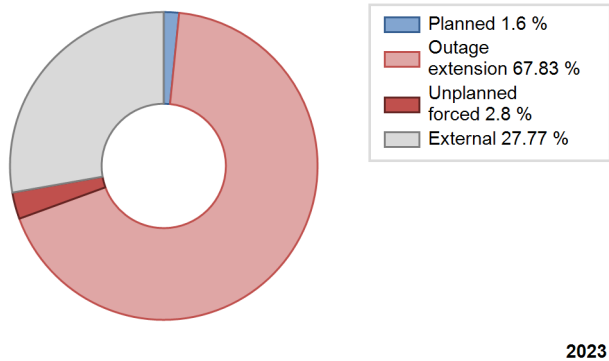
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2000 | 8429.16 | 5877 | 1455 | 96.94 | 96.94 | 98.43 | 97.13 | 1.64 | 1.62 | 1.43 | 0.00 |
| 2001 | 9524.35 | 6800 | 1455 | 75.00 | 78.03 | 74.73 | 77.63 | 6.98 | 5.85 | 16.11 | 3.03 |
| 2002 | 9515.08 | 6807 | 1455 | 80.96 | 82.39 | 74.65 | 77.71 | 0.08 | 0.07 | 17.54 | 1.43 |
| 2003 | 10021.89 | 7219 | 1500 | 85.61 | 89.41 | 76.27 | 82.41 | 0.76 | 0.68 | 9.91 | 3.79 |
| 2004 | 10671.09 | 7657 | 1500 | 83.59 | 86.67 | 80.99 | 87.17 | 4.38 | 3.97 | 9.36 | 3.08 |
| 2005 | 9047.67 | 6285 | 1500 | 69.59 | 70.47 | 68.85 | 71.74 | 14.26 | 13.36 | 16.17 | 0.88 |
| 2006 | 9845.73 | 6885 | 1500 | 75.64 | 77.56 | 74.93 | 78.60 | 2.14 | 3.95 | 18.49 | 1.92 |
| 2007 | 10402.28 | 7154 | 1500 | 79.60 | 80.70 | 79.16 | 81.67 | 0.33 | 10.12 | 9.18 | 1.10 |
| 2008 | 12376.75 | 8572 | 1500 | 95.03 | 97.01 | 93.93 | 97.59 | 2.98 | 2.98 | 0.01 | 1.98 |
| 2009 | 8649.52 | 6307 | 1500 | 67.49 | 68.96 | 65.83 | 72.00 | 5.83 | 18.93 | 12.11 | 1.47 |
| 2010 | 8663.04 | 5962 | 1500 | 65.89 | 65.98 | 65.93 | 68.06 | 3.16 | 3.94 | 30.09 | 0.09 |
| 2011 | 10285.74 | 7044 | 1500 | 79.66 | 81.08 | 78.28 | 80.41 | 0.75 | 2.02 | 16.90 | 1.43 |
| 2012 | 12512.93 | 8496 | 1500 | 96.49 | 97.16 | 94.97 | 96.72 | 2.82 | 2.82 | 0.02 | 0.67 |
| 2013 | 10034.78 | 6905 | 1500 | 78.25 | 78.86 | 76.37 | 78.82 | 0.91 | 2.49 | 18.65 | 0.62 |
| 2014 | 8950.47 | 6279 | 1500 | 71.66 | 72.24 | 68.12 | 71.68 | 0.49 | 0.35 | 27.40 | 0.58 |
| 2015 | 11334.11 | 7835 | 1500 | 88.55 | 89.52 | 86.26 | 89.44 | 0.13 | 0.94 | 9.55 | 0.97 |
| 2016 | 11392.17 | 8671 | 1500 | 94.26 | 99.16 | 86.46 | 98.71 | 0.26 | 0.25 | 0.58 | 4.90 |
| 2017 | 8172.98 | 5760 | 1500 | 63.27 | 66.99 | 62.20 | 65.75 | 9.41 | 14.03 | 18.97 | 3.72 |
| 2018 | 9526.45 | 6522 | 1500 | 73.38 | 79.46 | 72.50 | 74.45 | 0.81 | 0.65 | 19.89 | 6.08 |
| 2019 | 11128.09 | 7952 | 1500 | 90.33 | 98.97 | 84.69 | 90.78 | 1.01 | 1.01 | 0.02 | 8.64 |
| 2020 | 4440.81 | 3206 | 1500 | 33.73 | 51.27 | 33.70 | 36.50 | 9.13 | 8.19 | 40.54 | 17.54 |
| 2021 | 8981.37 | 6209 | 1500 | 69.79 | 78.98 | 68.35 | 70.88 | 20.98 | 20.98 | 0.04 | 9.20 |
| 2022 | 0.00 | 0 | 1500 | 0.00 | 0.55 | 0.00 | 0.00 | 95.43 | 73.40 | 26.05 | 0.55 |
| 2023 | 8089.97 | 5589 | 1500 | 62.09 | 72.62 | 61.57 | 63.80 | 1.44 | 26.78 | 0.61 | 10.53 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2000 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 2307 | | | 1030 | |
| B. Refuelling without maintenance | | | | 228 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 849 | | |
| E. Testing of plant systems or components | | | | 79 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 9 |
| L. Human factor related | | | | | 46 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 88 |
| O. Load dispatching, prioritization | | | | | | 10 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 863 | | | 59 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 76 |
| Z. Other | | | | | 75 | |
| Subtotal | | 2307 | 863 | 1156 | 1152 | 242 |
| Total | | 3170 | | | 2550 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2000 to 2023 |
|-------------------------------------|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 106 |
| 13. Reactor Auxiliary Systems | | 11 |
| 14. Safety Systems | | 48 |
| 15. Reactor Cooling Systems | | 33 |
| 16. Steam generation systems | | 6 |
| 31. Turbine and auxiliaries | 54 | 276 |
| 32. Feedwater and Main Steam System | | 16 |
| 34. Miscellaneous Systems | 2253 | 347 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 55 |
| Total | 2307 | 904 |

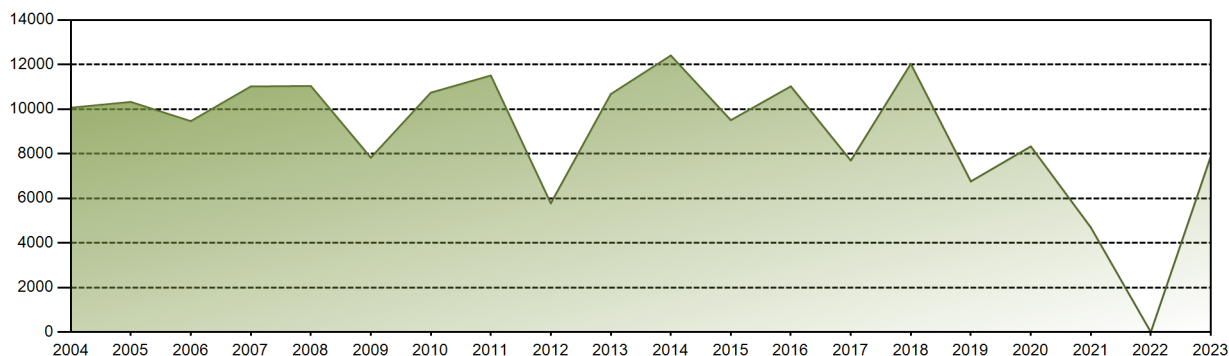
2023 Operating Experience

| FR-70 | | CHOOZ B-2 | | FRANCE | | | | | | | | | |
|---|-------------------------------|-------------------|--|---------------|------------|--------|---------|---------|--------|--------|---------|---------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : EDF (ÉLECTRICITÉ DE FRANCE) | | | | | | | | | | | | |
| Owner | : EDF (ÉLECTRICITÉ DE FRANCE) | | | | | | | | | | | | |
| Reactor Supplier | : FRAM (FRAMATOME) | | | | | | | | | | | | |
| Turbine Supplier | : FRAM (FRAMATOME) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PWR / N4 REP 1450 | Construction Date | : | 1985-12-31 | | | | | | | | |
| Thermal power | : | 4270 MWth | Grid Date | : | 1997-04-10 | | | | | | | | |
| Gross electrical power | : | 1560 MWe | Commercial Date | : | 2000-09-29 | | | | | | | | |
| Reference unit power (net) | : | 1500 MWe | Age at end of year | : | 26 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | : | 15.5 | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Reactor outlet temperature [°C] | : | 329.5 | | | | | | | | |
| Fuel material | : | UO2 | Number of SG | : | 4 | | | | | | | | |
| Refuelling type | : | OFF-line | Containment type | : | Double | | | | | | | | |
| Moderator material | : | H2O | Containment design pressure [MPa] | : | 4.3 | | | | | | | | |
| Average fuel enrichment [% of U235] | : | - | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : | 12 | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Part of the core refuelled [%] | : | 33.3 | Turbine speed [rpm] | : | 1500 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | 39000 | Number of LP cylinders per turbine | : | - | | | | | | | | |
| Active core diameter [m] | : | 3.47 | HP cylinder inlet steam pressure [MPa] | : | 7.1 | | | | | | | | |
| Active core height/length [m] | : | 4.267 | Output voltage [kV] | : | - | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 205 | Primary means of condenser cooling | : | - | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 17.92 | Number of main condensate pumps | : | - | | | | | | | | |
| Number of control rod assemblies | : | 25 | Number of FW pumps for full power operation | : | - | | | | | | | | |
| Number of external reactor coolant loops | : | 4 | Number of on-site safety related diesel generators | : | - | | | | | | | | |
| Coolant type | : | H2O | Non-electrical applications | | | | | | | | | | |
| | | | | | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 7888.17 GW(e).h | Forced Loss Rate (FLR) | : | 11.97 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 62.09 % | Unplanned Capability Loss Factor (UCL) | : | 21.17 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 78.13 % | Planned Unavailability Factor (PUF) | : | 0.7 % | | | | | | | | |
| Load Factor (LF) | : | 60.03 % | Externally cause unavailability (XUF) | : | 16.04 % | | | | | | | | |
| Operating Factor (OF) | : | 63.46 % | Total off-line time | : | 3201 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 0.00 | 14.12 | 0.00 | 481.99 | 1098.59 | 949.31 | 1056.48 | 1061.73 | 267.19 | 799.40 | 1054.43 | 1104.92 | 7888.17 |
| EAF [%] | 0.00 | 1.40 | 0.00 | 44.55 | 99.80 | 90.00 | 99.57 | 99.67 | 26.06 | 78.53 | 99.94 | 99.97 | 62.09 |
| UCF [%] | 0.00 | 1.40 | 83.04 | 63.17 | 99.97 | 90.48 | 99.98 | 99.97 | 99.98 | 93.50 | 99.98 | 99.97 | 78.13 |
| LF [%] | 0.00 | 1.40 | 0.00 | 44.63 | 98.44 | 87.90 | 94.67 | 95.14 | 24.74 | 71.53 | 97.63 | 99.01 | 60.03 |
| OF [%] | 0.00 | 4.17 | 0.00 | 50.42 | 100.00 | 91.25 | 100.00 | 100.00 | 26.81 | 83.49 | 100.00 | 100.00 | 63.46 |
| FLR [%] | 0.00 | 98.01 | 16.96 | 32.95 | 0.00 | 9.48 | 0.00 | 0.02 | 0.00 | 6.44 | 0.00 | 0.00 | 11.97 |
| UCL [%] | 100.00 | 95.88 | 16.96 | 31.05 | 0.00 | 9.47 | 0.00 | 0.02 | 0.00 | 6.43 | 0.00 | 0.00 | 21.17 |
| PUF [%] | 0.00 | 2.72 | 0.00 | 5.78 | 0.03 | 0.05 | 0.02 | 0.01 | 0.02 | 0.07 | 0.02 | 0.03 | 0.70 |
| XUF [%] | 0.00 | 0.00 | 83.04 | 18.63 | 0.17 | 0.47 | 0.41 | 0.30 | 73.92 | 14.97 | 0.04 | 0.00 | 16.04 |

Historical Summary

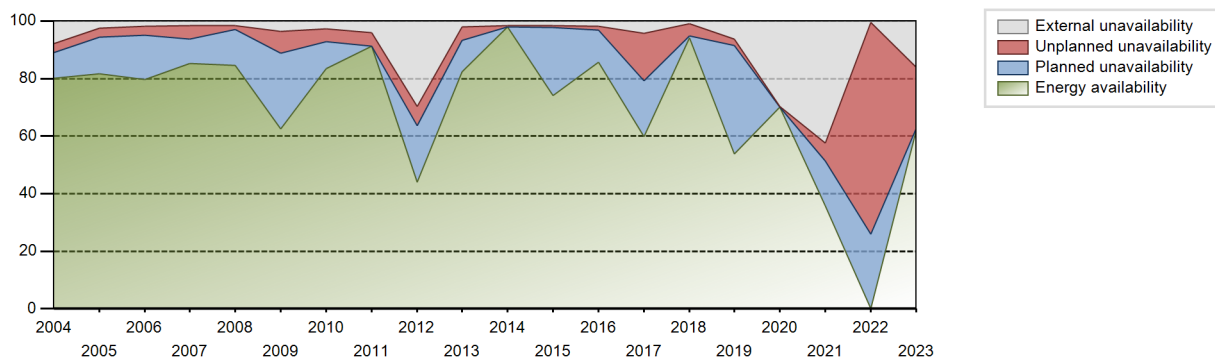
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 226885.67 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.99 % |
| Cumulative Energy Availability Factor (EAF) | : 72.05 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.56 % |
| Cumulative Unit Capability Factor (UCF) | : 79.44 % | Cumulative Planned Unavailability Factor (PUF) | : 13 % |
| Cumulative Load Factor (LF) | : 69.6 % | Cumulative Externally cause unavailability (XUF) | : 7.39 % |
| Cumulative Operating Factor (OF) | : 73.69 % | | |

Electricity Production (net) [GWh]

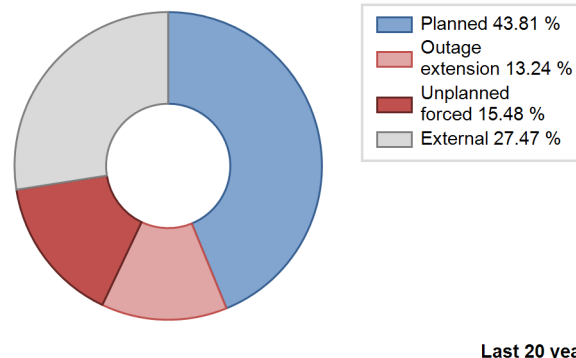
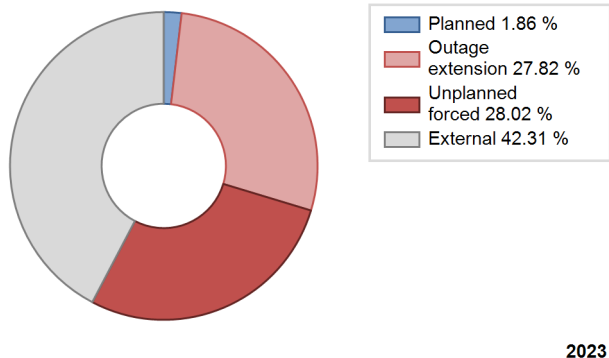


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2000 | 7213.35 | 5347 | 1455 | 90.19 | 90.26 | 92.15 | 94.70 | 9.74 | 9.74 | 0.00 | 0.06 |
| 2001 | 10159.53 | 7221 | 1455 | 80.36 | 83.42 | 79.71 | 82.43 | 0.36 | 0.30 | 16.28 | 3.06 |
| 2002 | 9814.83 | 7240 | 1455 | 81.50 | 83.02 | 77.00 | 82.65 | 0.48 | 0.40 | 16.58 | 1.52 |
| 2003 | 10472.75 | 7457 | 1500 | 83.30 | 87.64 | 79.70 | 85.13 | 2.38 | 2.13 | 10.23 | 4.34 |
| 2004 | 10063.94 | 7061 | 1500 | 80.12 | 88.00 | 76.38 | 80.38 | 3.42 | 3.12 | 8.88 | 7.88 |
| 2005 | 10321.55 | 7343 | 1500 | 81.65 | 84.06 | 78.55 | 83.82 | 1.24 | 3.23 | 12.71 | 2.41 |
| 2006 | 9460.52 | 6845 | 1500 | 79.64 | 81.55 | 72.00 | 78.14 | 1.94 | 2.91 | 15.53 | 1.91 |
| 2007 | 11016.49 | 7725 | 1500 | 85.23 | 86.78 | 83.84 | 88.18 | 3.20 | 4.71 | 8.50 | 1.55 |
| 2008 | 11038.88 | 7639 | 1500 | 84.56 | 86.12 | 83.78 | 86.96 | 1.19 | 1.44 | 12.43 | 1.56 |
| 2009 | 7821.91 | 5593 | 1500 | 62.48 | 66.03 | 59.53 | 63.85 | 0.32 | 7.57 | 26.40 | 3.55 |
| 2010 | 10739.75 | 7529 | 1500 | 83.38 | 86.09 | 81.73 | 85.95 | 2.02 | 4.45 | 9.47 | 2.71 |
| 2011 | 11507.74 | 8076 | 1500 | 91.22 | 95.24 | 87.58 | 92.19 | 4.75 | 4.75 | 0.01 | 4.03 |
| 2012 | 5773.74 | 4092 | 1500 | 44.03 | 73.66 | 43.82 | 46.58 | 0.02 | 6.71 | 19.62 | 29.63 |
| 2013 | 10676.71 | 7351 | 1500 | 82.43 | 84.44 | 81.25 | 83.92 | 0.26 | 4.75 | 10.81 | 2.02 |
| 2014 | 12405.66 | 8686 | 1500 | 98.02 | 99.71 | 94.41 | 99.16 | 0.27 | 0.27 | 0.02 | 1.69 |
| 2015 | 9504.22 | 6673 | 1500 | 74.11 | 75.67 | 72.33 | 76.18 | 0.82 | 0.63 | 23.71 | 1.56 |
| 2016 | 11021.73 | 7791 | 1500 | 85.63 | 87.54 | 83.65 | 88.70 | 1.48 | 1.32 | 11.14 | 1.91 |
| 2017 | 7691.34 | 5351 | 1500 | 59.82 | 64.05 | 58.53 | 61.08 | 2.81 | 16.49 | 19.46 | 4.23 |
| 2018 | 12031.86 | 8388 | 1500 | 94.16 | 95.17 | 91.57 | 95.75 | 4.23 | 4.21 | 0.62 | 1.02 |
| 2019 | 6757.53 | 4846 | 1500 | 53.76 | 60.05 | 51.43 | 55.32 | 0.17 | 2.23 | 37.72 | 6.29 |
| 2020 | 8328.39 | 6107 | 1500 | 70.01 | 99.67 | 63.21 | 69.52 | 0.31 | 0.31 | 0.02 | 29.66 |
| 2021 | 4693.11 | 3523 | 1500 | 35.72 | 78.05 | 35.72 | 40.22 | 7.28 | 6.40 | 15.55 | 42.33 |
| 2022 | 0.00 | 0 | 1500 | 0.00 | 0.55 | 0.00 | 0.00 | 98.90 | 73.42 | 26.03 | 0.55 |
| 2023 | 7888.17 | 5559 | 1500 | 62.09 | 78.13 | 60.03 | 63.46 | 11.97 | 21.17 | 0.70 | 16.04 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2000 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1224 | | | 968 | |
| B. Refuelling without maintenance | | | | 187 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 836 | | |
| E. Testing of plant systems or components | | | | 69 | 0 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 40 |
| L. Human factor related | | 591 | | | 40 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 67 |
| O. Load dispatching, prioritization | | | | | | 6 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 750 | | 10 | 322 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 633 | | | 96 |
| Z. Other | | | | | 43 | |
| Subtotal | | 1815 | 1383 | 1092 | 1061 | 531 |
| Total | | 3198 | | | 2684 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2000 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 12 |
| 12. Reactor I&C Systems | 224 | 54 |
| 13. Reactor Auxiliary Systems | | 26 |
| 14. Safety Systems | | 185 |
| 15. Reactor Cooling Systems | | 6 |
| 16. Steam generation systems | | 14 |
| 21. Fuel Handling and Storage Facilities | | 7 |
| 31. Turbine and auxiliaries | 52 | 276 |
| 32. Feedwater and Main Steam System | 22 | 5 |
| 33. Circulating Water System | | 22 |
| 34. Miscellaneous Systems | 924 | 220 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | 2 | 11 |
| 42. Electrical Power Supply Systems | | 14 |
| Total | 1224 | 854 |

2023 Operating Experience

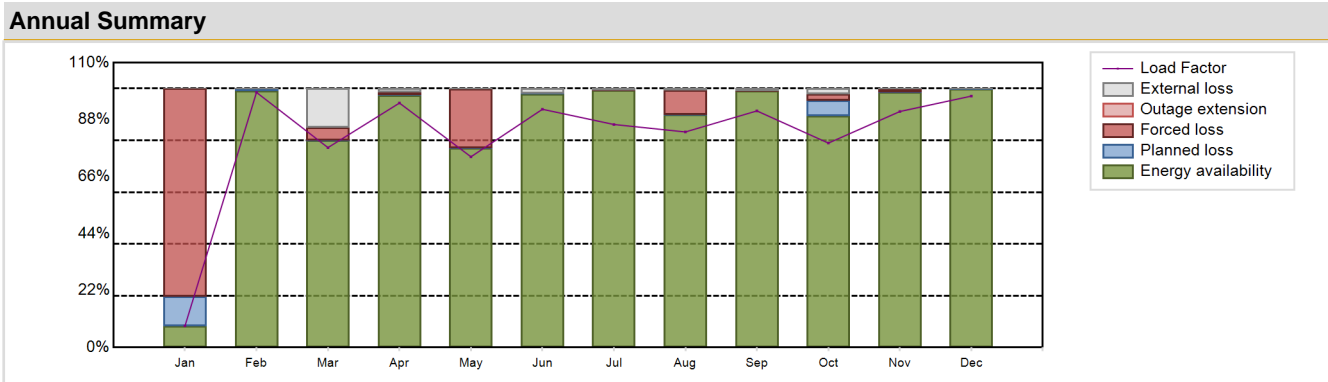
FR-72 CIVAUX-1 FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | Key Dates |
|--|--------------------------------|
| Reactor type and model : PWR / N4 REP 1450 | Construction Date : 1988-10-15 |
| Thermal power : 4270 MWth | Grid Date : 1997-12-24 |
| Gross electrical power : 1561 MWe | Commercial Date : 2002-01-29 |
| Reference unit power (net) : 1495 MWe | Age at end of year : 26 years |

| Design Characteristics | |
|--|--|
| Primary Systems | |
| Reactor vessel centreline orientation : Vertical | Operating coolant pressure [MPa] : 15.5 |
| Fuel material : UO2 | Reactor outlet temperature [°C] : 329.5 |
| Refuelling type : OFF-line | Number of SG : 4 |
| Moderator material : H2O | Containment type : Double |
| Average fuel enrichment [% of U235] : - | Containment design pressure [MPa] : 4.3 |
| Refuelling frequency [month] : 18 | Secondary systems |
| Part of the core refuelled [%] : 33.3 | Number of turbine-generators per unit/reactor : 1 |
| Average discharge burnup [MWd/t] : 35000 | Turbine speed [rpm] : 1500 |
| Active core diameter [m] : 3.47 | Number of LP cylinders per turbine : - |
| Active core height/length [m] : 4.267 | HP cylinder inlet steam pressure [MPa] : 7.1 |
| Number of fissile fuel assemblies/bundles : 205 | Output voltage [kV] : - |
| Fuel linear heat generation rate [kW/m] : 17 | Primary means of condenser cooling : - |
| Number of control rod assemblies : 53 | Number of main condensate pumps : - |
| Number of external reactor coolant loops : 4 | Number of FW pumps for full power operation : - |
| Coolant type : H2O | Number of on-site safety related diesel generators : - |
| | Non-electrical applications : none |

| Annual Production Results (2023) | |
|--|--|
| Net Energy Production : 10575.26 GW(e).h | Forced Loss Rate (FLR) : 10.54 % |
| Energy Availability Factor (EAF) : 86.11 % | Unplanned Capability Loss Factor (UCL) : 10.37 % |
| Unit Capability Factor (UCF) : 88.03 % | Planned Unavailability Factor (PUF) : 1.6 % |
| Load Factor (LF) : 80.75 % | Externally cause unavailability (XUF) : 1.92 % |
| Operating Factor (OF) : 89.93 % | Total off-line time : 882 hours |

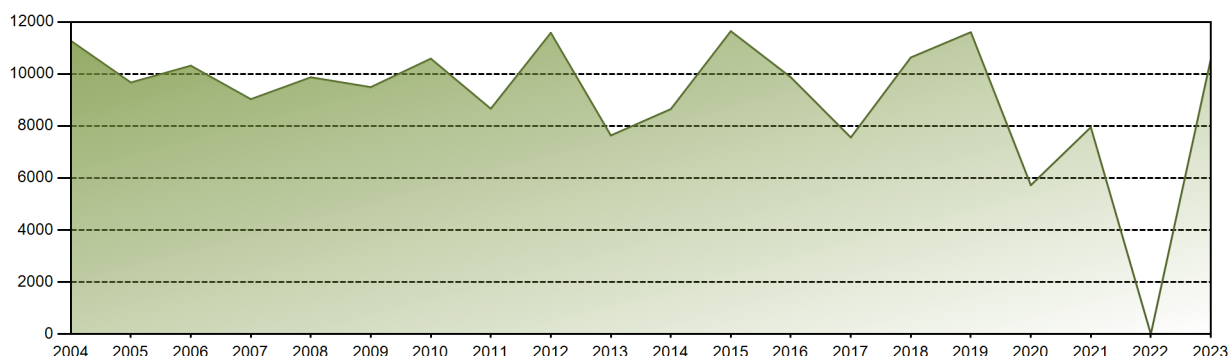


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-------|--------|--------|---------|--------|--------|--------|--------|--------|--------|--------|---------|----------|
| GW(e)-h | 92.97 | 989.96 | 857.66 | 1016.37 | 819.36 | 990.49 | 958.16 | 926.09 | 983.66 | 879.41 | 981.16 | 1079.98 | 10575.26 |
| EAF [%] | 8.36 | 99.04 | 79.98 | 97.48 | 77.08 | 97.92 | 99.29 | 89.94 | 99.02 | 89.46 | 98.63 | 99.95 | 86.11 |
| UCF [%] | 8.36 | 99.05 | 94.88 | 98.91 | 77.22 | 99.89 | 99.95 | 90.65 | 99.84 | 91.54 | 98.68 | 99.95 | 88.03 |
| LF [%] | 8.36 | 98.54 | 77.21 | 94.42 | 73.67 | 92.02 | 86.14 | 83.26 | 91.38 | 78.96 | 91.15 | 97.10 | 80.75 |
| OF [%] | 19.76 | 100.00 | 100.00 | 100.00 | 77.82 | 100.00 | 94.62 | 93.41 | 100.00 | 95.84 | 100.00 | 100.00 | 89.93 |
| FLR [%] | 90.56 | 0.00 | 4.98 | 0.96 | 22.77 | 0.00 | 0.02 | 9.32 | 0.10 | 2.62 | 1.31 | 0.03 | 10.54 |
| UCL [%] | 80.24 | 0.00 | 4.98 | 0.96 | 22.77 | 0.00 | 0.02 | 9.32 | 0.10 | 2.46 | 1.31 | 0.03 | 10.37 |
| PUF [%] | 11.40 | 0.95 | 0.14 | 0.13 | 0.01 | 0.11 | 0.03 | 0.03 | 0.06 | 6.00 | 0.02 | 0.02 | 1.60 |
| XUF [%] | 0.00 | 0.01 | 14.91 | 1.43 | 0.14 | 1.96 | 0.65 | 0.71 | 0.81 | 2.08 | 0.04 | 0.00 | 1.92 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 216848.3 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 10.1 % |
| Cumulative Energy Availability Factor (EAF) | : 72.28 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 10.87 % |
| Cumulative Unit Capability Factor (UCF) | : 74.88 % | Cumulative Planned Unavailability Factor (PUF) | : 14.25 % |
| Cumulative Load Factor (LF) | : 70.43 % | Cumulative Externally cause unavailability (XUF) | : 2.6 % |
| Cumulative Operating Factor (OF) | : 74.54 % | | |

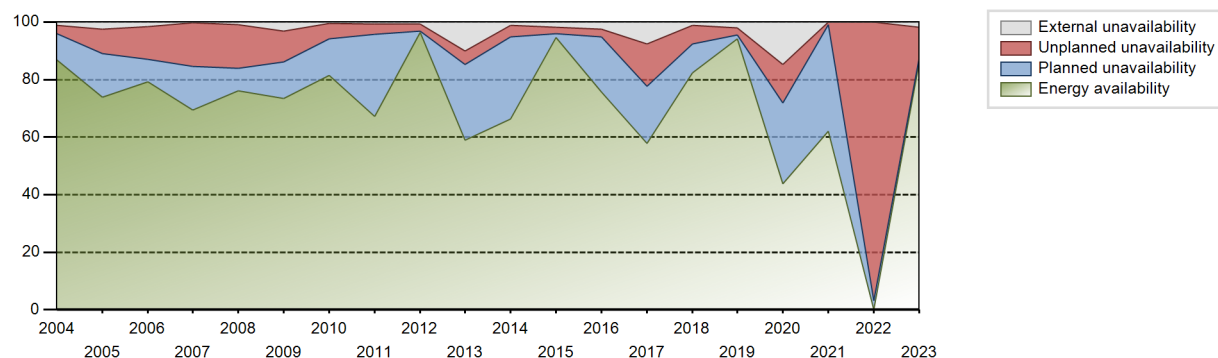
Electricity Production (net) [GWh]



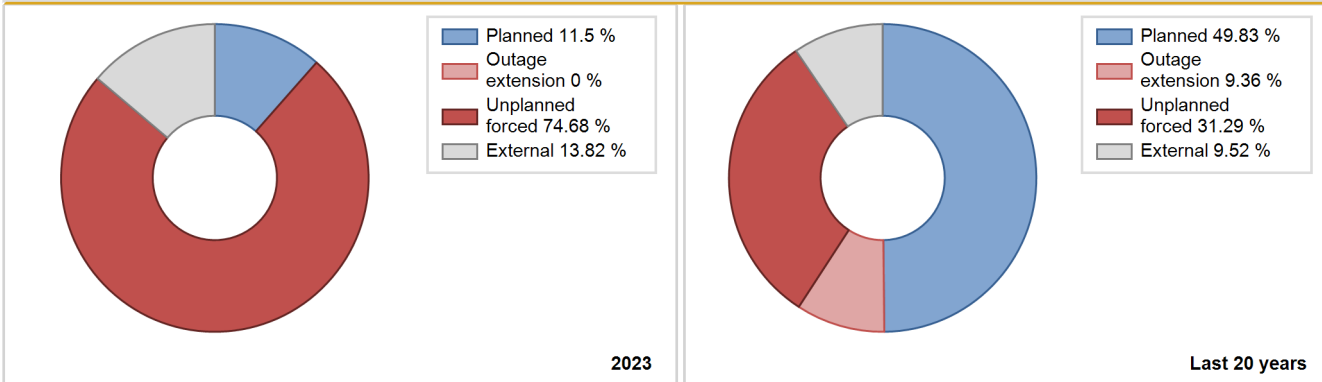
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|------------------------|------------------------------|-------|-------|-------|-------|--------|-------|-------|-------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2002 | 9544.10 | 7331 | 1495 | 82.62 | 83.86 | 74.72 | 84.81 | 2.71 | 2.34 | 13.81 | 1.24 |
| 2003 | 10932.08 | 7438 | 1495 | 83.06 | 84.14 | 83.48 | 84.91 | 2.86 | 2.48 | 13.38 | 1.08 |
| 2004 | 11276.48 | 7816 | 1495 | 86.91 | 87.98 | 85.87 | 88.98 | 3.22 | 2.92 | 9.09 | 1.08 |
| 2005 | 9672.34 | 6855 | 1495 | 73.78 | 76.26 | 73.85 | 78.24 | 4.10 | 8.59 | 15.15 | 2.48 |
| 2006 | 10318.21 | 7189 | 1495 | 79.29 | 80.93 | 78.79 | 82.07 | 8.64 | 11.25 | 7.82 | 1.64 |
| 2007 | 9031.53 | 6242 | 1495 | 69.39 | 69.64 | 68.96 | 71.25 | 15.77 | 15.12 | 15.24 | 0.25 |
| 2008 | 9872.98 | 6967 | 1495 | 76.04 | 77.04 | 75.18 | 79.31 | 13.43 | 14.99 | 7.97 | 1.00 |
| 2009 | 9494.39 | 6852 | 1495 | 73.43 | 76.52 | 72.50 | 78.22 | 9.45 | 10.84 | 12.64 | 3.09 |
| 2010 | 10590.11 | 7582 | 1495 | 81.45 | 81.98 | 80.86 | 86.55 | 5.84 | 5.37 | 12.65 | 0.53 |
| 2011 | 8663.88 | 6006 | 1495 | 67.23 | 67.89 | 66.16 | 68.56 | 0.92 | 3.52 | 28.59 | 0.66 |
| 2012 | 11583.20 | 8487 | 1495 | 96.38 | 97.14 | 88.21 | 96.62 | 2.44 | 2.43 | 0.43 | 0.76 |
| 2013 | 7637.26 | 5425 | 1495 | 58.90 | 68.87 | 58.32 | 61.93 | 2.52 | 4.85 | 26.28 | 9.97 |
| 2014 | 8649.46 | 5902 | 1495 | 66.26 | 67.50 | 66.05 | 67.37 | 0.73 | 3.95 | 28.54 | 1.24 |
| 2015 | 11646.17 | 8359 | 1495 | 94.69 | 96.56 | 88.93 | 95.42 | 2.25 | 2.22 | 1.22 | 1.87 |
| 2016 | 9873.52 | 7010 | 1495 | 75.66 | 78.10 | 75.19 | 79.80 | 3.46 | 2.80 | 19.10 | 2.44 |
| 2017 | 7559.81 | 5263 | 1495 | 57.73 | 65.44 | 57.73 | 60.08 | 3.94 | 14.64 | 19.92 | 7.70 |
| 2018 | 10636.19 | 7321 | 1495 | 82.29 | 83.48 | 81.22 | 83.57 | 4.42 | 6.45 | 10.07 | 1.19 |
| 2019 | 11608.53 | 8247 | 1495 | 94.08 | 96.03 | 88.64 | 94.14 | 2.55 | 2.51 | 1.46 | 1.94 |
| 2020 | 5723.66 | 4025 | 1495 | 43.72 | 58.54 | 43.59 | 45.82 | 1.01 | 13.21 | 28.25 | 14.82 |
| 2021 | 7952.74 | 5519 | 1495 | 62.02 | 62.09 | 60.73 | 63.00 | 1.42 | 0.90 | 37.02 | 0.07 |
| 2022 | 0.00 | 0 | 1495 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 96.71 | 3.29 | 0.00 |
| 2023 | 10575.26 | 7878 | 1495 | 86.11 | 88.03 | 80.75 | 89.93 | 10.54 | 10.37 | 1.60 | 1.92 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2002 to 2023 | | |
|---|------------|------------|-----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 815 | | | 788 | |
| B. Refuelling without maintenance | | | | 424 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 712 | | |
| E. Testing of plant systems or components | 1 | | | 40 | | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 26 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 57 |
| O. Load dispatching, prioritization | | | 66 | | | 9 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 87 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 10 |
| Z. Other | | 0 | | | 45 | |
| Subtotal | 1 | 815 | 66 | 1176 | 862 | 164 |
| Total | | 882 | | | 2202 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2002 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 12 |
| 12. Reactor I&C Systems | | 21 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | 597 | 442 |
| 15. Reactor Cooling Systems | | 15 |
| 16. Steam generation systems | | 32 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | 49 | 15 |
| 32. Feedwater and Main Steam System | | 13 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | 165 | 142 |
| 35. All other I&C Systems | 4 | 11 |
| 41. Main Generator Systems | | 16 |
| 42. Electrical Power Supply Systems | | 93 |
| Total | 815 | 836 |

2023 Operating Experience

FR-73

CIVAUX-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / N4 REP 1450
 Thermal power : 4270 MWth
 Gross electrical power : 1561 MWe
 Reference unit power (net) : 1495 MWe

Key Dates

Construction Date : 1991-04-01
 Grid Date : 1999-12-24
 Commercial Date : 2002-04-23
 Age at end of year : 24 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 35000
 Active core diameter [m] : 3.47
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 205
 Fuel linear heat generation rate [kW/m] : 17
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 329.5
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 4.3

Secondary systems

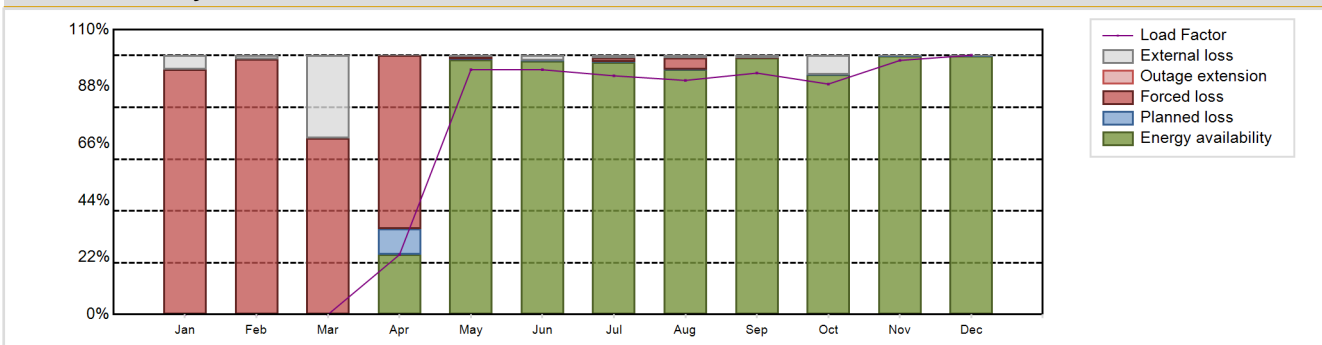
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 7.1
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8513.71 GW(e).h
 Energy Availability Factor (EAF) : 67.32 %
 Unit Capability Factor (UCF) : 71.62 %
 Load Factor (LF) : 65.01 %
 Operating Factor (OF) : 68.73 %
 Forced Loss Rate (FLR) : 27.73 %
 Unplanned Capability Loss Factor (UCL) : 27.49 %
 Planned Unavailability Factor (PUF) : 0.9 %
 Externally cause unavailability (XUF) : 4.3 %
 Total off-line time : 2739 hours

Annual Summary

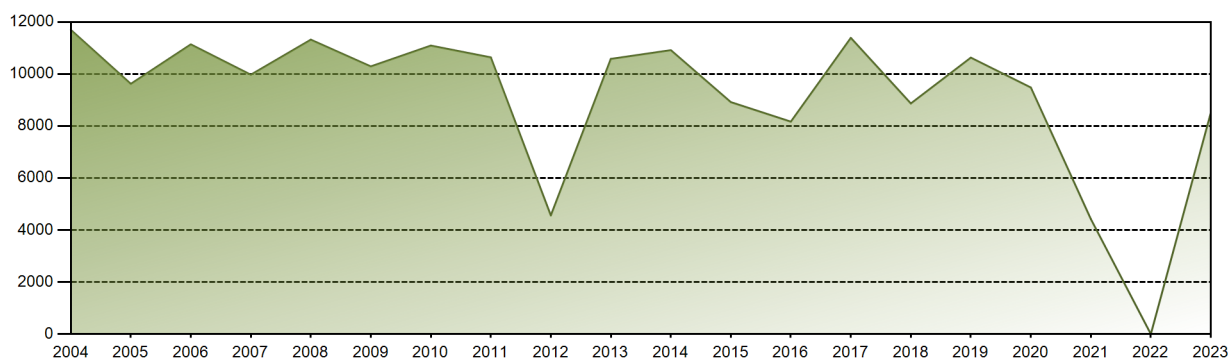


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-------|-------|-------|--------|---------|---------|---------|---------|---------|--------|---------|---------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 248.58 | 1051.85 | 1017.59 | 1025.36 | 1005.55 | 1003.72 | 991.24 | 1056.23 | 1113.59 | 8513.71 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 23.11 | 98.47 | 97.77 | 97.50 | 94.54 | 99.03 | 92.65 | 99.84 | 99.89 | 67.32 |
| UCF [%] | 5.38 | 1.49 | 31.90 | 23.11 | 98.77 | 99.73 | 98.26 | 95.32 | 99.94 | 99.93 | 99.96 | 99.91 | 71.62 |
| LF [%] | 0.00 | 0.00 | 0.00 | 23.09 | 94.57 | 94.54 | 92.19 | 90.40 | 93.25 | 89.00 | 98.13 | 100.12 | 65.01 |
| OF [%] | 0.00 | 0.00 | 0.00 | 33.06 | 99.19 | 100.00 | 97.45 | 95.97 | 100.00 | 94.23 | 100.00 | 100.00 | 68.73 |
| FLR [%] | 94.62 | 98.51 | 68.10 | 74.32 | 1.15 | 0.00 | 1.52 | 4.60 | 0.04 | 0.00 | 0.00 | 0.00 | 27.73 |
| UCL [%] | 94.62 | 98.51 | 68.10 | 66.87 | 1.15 | 0.00 | 1.52 | 4.60 | 0.04 | 0.00 | 0.00 | 0.00 | 27.49 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 10.02 | 0.09 | 0.27 | 0.22 | 0.08 | 0.02 | 0.07 | 0.04 | 0.09 | 0.90 |
| XUF [%] | 5.38 | 1.49 | 31.90 | 0.00 | 0.29 | 1.96 | 0.76 | 0.78 | 0.91 | 7.28 | 0.12 | 0.02 | 4.30 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 214473.46 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.71 % |
| Cumulative Energy Availability Factor (EAF) | : 72.21 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 10.01 % |
| Cumulative Unit Capability Factor (UCF) | : 76.72 % | Cumulative Planned Unavailability Factor (PUF) | : 13.27 % |
| Cumulative Load Factor (LF) | : 69.55 % | Cumulative Externally cause unavailability (XUF) | : 4.51 % |
| Cumulative Operating Factor (OF) | : 74.49 % | | |

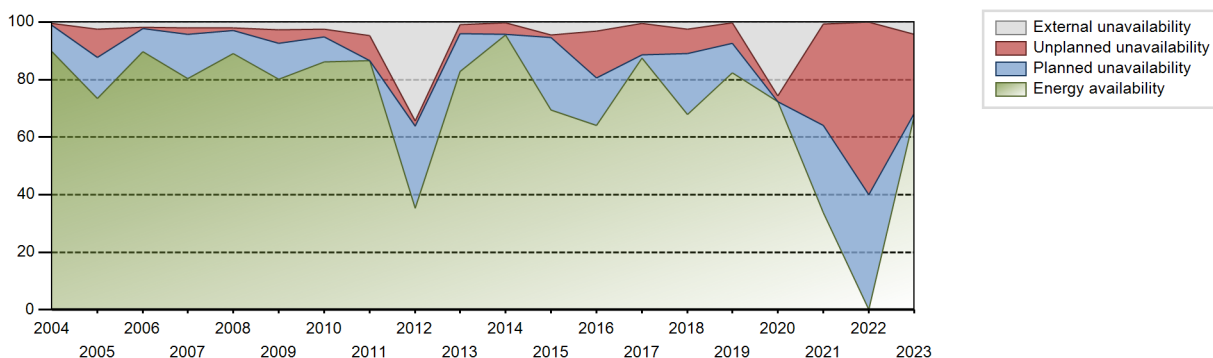
Electricity Production (net) [GWh]



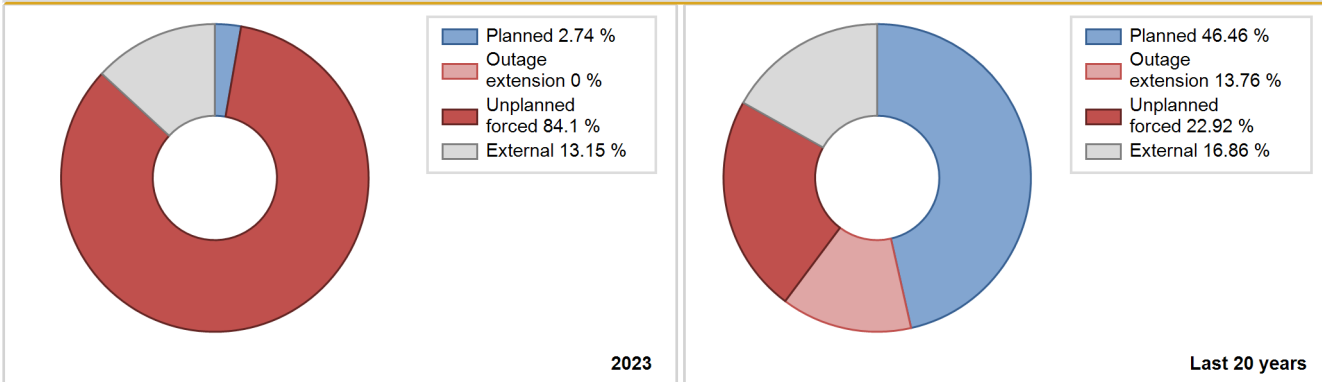
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|--------|-------|-------|-------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2002 | 7491.29 | 6080 | 1495 | 91.94 | 94.81 | 70.33 | 85.80 | 0.68 | 0.65 | 4.55 | 2.86 |
| 2003 | 9084.75 | 6542 | 1495 | 70.38 | 70.48 | 69.37 | 74.68 | 10.67 | 8.42 | 21.10 | 0.10 |
| 2004 | 11698.64 | 8042 | 1495 | 89.64 | 90.04 | 89.08 | 91.55 | 0.90 | 0.82 | 9.14 | 0.40 |
| 2005 | 9621.39 | 6748 | 1495 | 73.47 | 75.92 | 73.47 | 77.03 | 2.45 | 9.90 | 14.18 | 2.44 |
| 2006 | 11140.10 | 7811 | 1495 | 89.78 | 91.57 | 85.06 | 89.17 | 0.33 | 0.55 | 7.89 | 1.78 |
| 2007 | 9973.85 | 7141 | 1495 | 80.24 | 82.26 | 76.15 | 81.51 | 1.58 | 2.36 | 15.38 | 2.01 |
| 2008 | 11321.50 | 8085 | 1495 | 89.02 | 91.06 | 86.21 | 92.04 | 0.61 | 1.00 | 7.94 | 2.04 |
| 2009 | 10293.33 | 7219 | 1495 | 80.14 | 82.76 | 78.60 | 82.41 | 0.14 | 4.84 | 12.40 | 2.62 |
| 2010 | 11094.03 | 7743 | 1495 | 86.06 | 88.55 | 84.71 | 88.39 | 0.92 | 2.71 | 8.74 | 2.48 |
| 2011 | 10640.60 | 7717 | 1495 | 86.58 | 91.40 | 81.25 | 88.09 | 8.58 | 8.58 | 0.03 | 4.81 |
| 2012 | 4561.72 | 3228 | 1495 | 35.27 | 69.60 | 34.74 | 36.75 | 0.92 | 1.93 | 28.48 | 34.32 |
| 2013 | 10581.57 | 7344 | 1495 | 82.73 | 83.76 | 80.80 | 83.84 | 2.15 | 2.95 | 13.29 | 1.04 |
| 2014 | 10918.20 | 8091 | 1495 | 95.40 | 95.63 | 83.37 | 92.36 | 1.85 | 3.95 | 0.42 | 0.23 |
| 2015 | 8920.04 | 6332 | 1495 | 69.44 | 73.89 | 68.11 | 72.28 | 1.14 | 0.85 | 25.26 | 4.45 |
| 2016 | 8169.29 | 5944 | 1495 | 63.97 | 67.12 | 62.21 | 67.67 | 2.01 | 16.19 | 16.68 | 3.15 |
| 2017 | 11390.13 | 7884 | 1495 | 87.55 | 88.06 | 86.97 | 90.00 | 3.66 | 10.93 | 1.01 | 0.51 |
| 2018 | 8867.46 | 6063 | 1495 | 67.90 | 70.32 | 67.71 | 69.21 | 1.69 | 8.46 | 21.23 | 2.41 |
| 2019 | 10630.33 | 7243 | 1495 | 82.37 | 82.53 | 81.17 | 82.68 | 3.91 | 7.30 | 10.17 | 0.17 |
| 2020 | 9482.62 | 8184 | 1495 | 72.26 | 97.99 | 72.21 | 93.17 | 1.96 | 1.96 | 0.05 | 25.73 |
| 2021 | 4424.47 | 3077 | 1495 | 33.74 | 34.36 | 33.78 | 35.13 | 25.44 | 35.28 | 30.37 | 0.61 |
| 2022 | 0.00 | 0 | 1495 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 60.03 | 39.97 | 0.00 |
| 2023 | 8513.71 | 6021 | 1495 | 67.32 | 71.62 | 65.01 | 68.73 | 27.73 | 27.49 | 0.90 | 4.30 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2002 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 2399 | | | 709 | |
| B. Refuelling without maintenance | | | | 249 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 850 | | |
| E. Testing of plant systems or components | | | | 19 | | |
| H. Nuclear regulatory requirements | | | | | 92 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 24 |
| L. Human factor related | | | | | 10 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| O. Load dispatching, prioritization | | | 10 | | | 6 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 287 | | | 168 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 52 |
| Z. Other | | | 42 | | 12 | 2 |
| Subtotal | | 2399 | 339 | 1118 | 823 | 252 |
| Total | | 2738 | | | 2193 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2002 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 16 |
| 12. Reactor I&C Systems | | 14 |
| 13. Reactor Auxiliary Systems | | 16 |
| 14. Safety Systems | 1831 | 390 |
| 15. Reactor Cooling Systems | 9 | 14 |
| 16. Steam generation systems | | 91 |
| 21. Fuel Handling and Storage Facilities | | 16 |
| 31. Turbine and auxiliaries | 437 | 42 |
| 32. Feedwater and Main Steam System | 91 | 12 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 139 |
| 41. Main Generator Systems | 31 | 3 |
| 42. Electrical Power Supply Systems | | 37 |
| Total | 2399 | 792 |

2023 Operating Experience

FR-42

CRUAS-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP2
 Thermal power : 2785 MWth
 Gross electrical power : 956 MWe
 Reference unit power (net) : 915 MWe

Key Dates

Construction Date : 1978-08-01
 Grid Date : 1983-04-29
 Commercial Date : 1984-04-02
 Age at end of year : 40 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 41
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

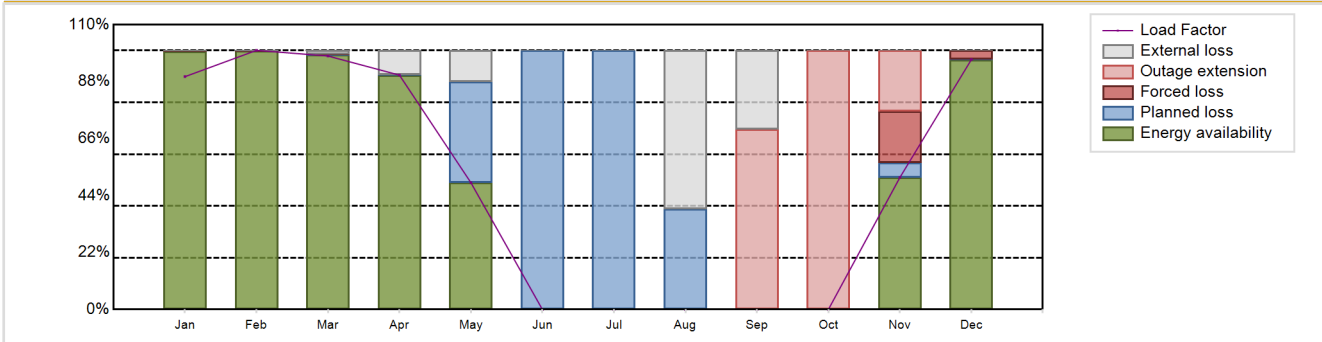
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 3816.03 GW(e).h
 Energy Availability Factor (EAF) : 48.43 %
 Unit Capability Factor (UCF) : 58.05 %
 Load Factor (LF) : 47.61 %
 Operating Factor (OF) : 52.47 %
 Forced Loss Rate (FLR) : 3.24 %
 Unplanned Capability Loss Factor (UCL) : 18.1 %
 Planned Unavailability Factor (PUF) : 23.85 %
 Externally cause unavailability (XUF) : 9.62 %
 Total off-line time : 4164 hours

Annual Summary

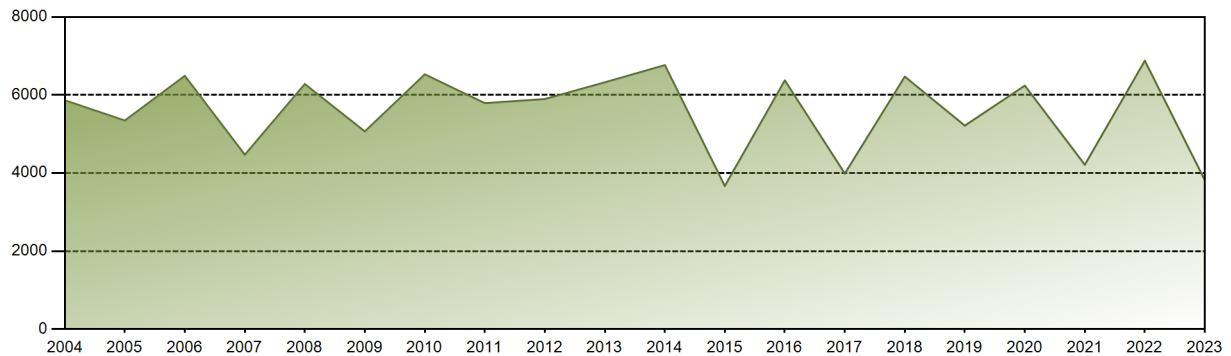


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|-------|-------|--------|--------|--------|---------|
| GW(e)-h | 612.31 | 615.44 | 665.65 | 596.41 | 333.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 335.86 | 657.02 | 3816.03 |
| EAF [%] | 99.67 | 99.84 | 98.33 | 90.53 | 48.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.87 | 96.32 | 48.43 |
| UCF [%] | 99.73 | 99.87 | 99.82 | 99.86 | 60.94 | 0.00 | 0.00 | 61.29 | 30.42 | 0.00 | 50.87 | 96.32 | 58.05 |
| LF [%] | 89.94 | 100.09 | 97.91 | 90.53 | 48.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.98 | 96.51 | 47.61 |
| OF [%] | 95.43 | 100.00 | 100.00 | 100.00 | 61.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 76.39 | 100.00 | 52.47 |
| FLR [%] | 0.19 | 0.05 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 27.96 | 3.45 | 3.24 |
| UCL [%] | 0.19 | 0.05 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 69.58 | 100.00 | 43.31 | 3.44 | 18.10 |
| PUF [%] | 0.08 | 0.08 | 0.10 | 0.14 | 39.06 | 100.00 | 100.00 | 38.71 | 0.00 | 0.00 | 5.81 | 0.24 | 23.85 |
| XUF [%] | 0.06 | 0.04 | 1.49 | 9.33 | 11.97 | 0.00 | 0.00 | 61.29 | 30.42 | 0.00 | 0.00 | 0.00 | 9.62 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 224244.22 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.84 % |
| Cumulative Energy Availability Factor (EAF) | : 75.72 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.75 % |
| Cumulative Unit Capability Factor (UCF) | : 78.37 % | Cumulative Planned Unavailability Factor (PUF) | : 13.88 % |
| Cumulative Load Factor (LF) | : 70.61 % | Cumulative Externally cause unavailability (XUF) | : 2.65 % |
| Cumulative Operating Factor (OF) | : 77.03 % | | |

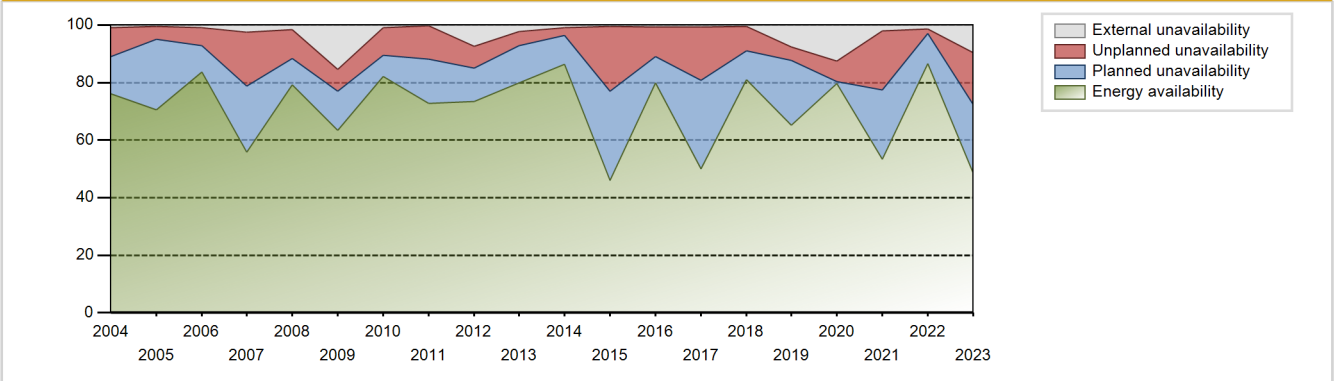
Electricity Production (net) [GWh]



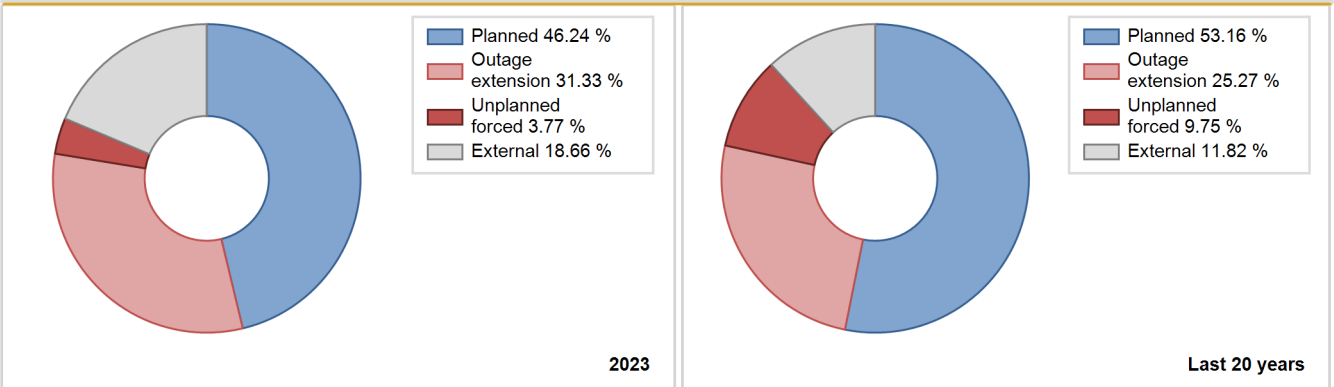
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 5482.00 | 7165 | 880 | 82.63 | 82.63 | 82.63 | 92.86 | 17.37 | 17.37 | 0.00 | 0.00 |
| 1985 | 5185.20 | 6615 | 880 | 71.95 | 77.18 | 67.26 | 75.51 | 3.24 | 2.58 | 20.24 | 5.23 |
| 1986 | 5888.00 | 7377 | 880 | 86.03 | 87.59 | 76.38 | 84.21 | 6.55 | 6.13 | 6.27 | 1.56 |
| 1987 | 5359.50 | 6860 | 880 | 81.83 | 83.73 | 69.52 | 78.31 | 1.62 | 1.38 | 14.89 | 1.90 |
| 1988 | 4025.00 | 5562 | 880 | 96.69 | 98.05 | 52.07 | 63.32 | 1.95 | 1.95 | 0.00 | 1.36 |
| 1989 | 5648.89 | 7239 | 880 | 83.65 | 86.05 | 73.28 | 82.64 | 3.68 | 3.29 | 10.66 | 2.41 |
| 1990 | 4983.52 | 6809 | 880 | 82.63 | 84.77 | 64.65 | 77.73 | 1.48 | 1.27 | 13.95 | 2.14 |
| 1991 | 4477.80 | 5762 | 880 | 65.27 | 68.16 | 58.09 | 65.78 | 9.81 | 7.41 | 24.43 | 2.88 |
| 1992 | 5739.40 | 7183 | 880 | 77.77 | 81.04 | 74.25 | 81.77 | 7.42 | 6.50 | 12.46 | 3.27 |
| 1993 | 6156.63 | 7353 | 880 | 84.56 | 87.16 | 79.86 | 83.94 | 2.42 | 2.16 | 10.68 | 2.59 |
| 1994 | 6181.24 | 7498 | 915 | 84.25 | 84.46 | 77.12 | 85.59 | 5.48 | 4.90 | 10.64 | 0.21 |
| 1995 | 4630.41 | 5624 | 915 | 62.47 | 63.33 | 57.77 | 64.20 | 12.73 | 9.24 | 27.43 | 0.86 |
| 1996 | 6258.55 | 7478 | 915 | 82.96 | 83.87 | 77.87 | 85.13 | 5.97 | 5.32 | 10.81 | 0.91 |
| 1997 | 5271.22 | 6784 | 915 | 74.09 | 77.89 | 65.76 | 77.44 | 9.97 | 8.62 | 13.49 | 3.80 |
| 1998 | 6387.28 | 7864 | 915 | 89.54 | 90.75 | 79.69 | 89.77 | 3.61 | 3.40 | 5.85 | 1.21 |
| 1999 | 5890.67 | 7367 | 915 | 83.80 | 85.49 | 73.49 | 84.10 | 3.81 | 3.39 | 11.12 | 1.69 |
| 2000 | 6320.52 | 7742 | 915 | 85.96 | 87.61 | 78.64 | 88.14 | 0.74 | 0.65 | 11.73 | 1.65 |
| 2001 | 5918.31 | 7264 | 915 | 81.07 | 81.69 | 73.84 | 82.92 | 6.09 | 5.30 | 13.02 | 0.61 |
| 2002 | 6069.76 | 7349 | 915 | 80.46 | 80.61 | 75.73 | 83.89 | 11.38 | 10.35 | 9.04 | 0.16 |
| 2003 | 6120.53 | 7403 | 915 | 81.14 | 82.53 | 76.36 | 84.51 | 5.31 | 4.62 | 12.84 | 1.39 |
| 2004 | 5866.08 | 6907 | 915 | 76.11 | 76.96 | 72.99 | 78.63 | 11.69 | 10.19 | 12.85 | 0.84 |
| 2005 | 5345.43 | 6311 | 915 | 70.60 | 71.08 | 66.69 | 72.04 | 5.29 | 4.57 | 24.35 | 0.48 |
| 2006 | 6491.00 | 7716 | 915 | 83.73 | 84.76 | 80.98 | 88.08 | 3.88 | 6.16 | 9.08 | 1.02 |
| 2007 | 4468.50 | 5506 | 915 | 55.86 | 58.41 | 55.75 | 62.85 | 4.55 | 18.60 | 22.99 | 2.55 |
| 2008 | 6281.45 | 7285 | 915 | 79.29 | 80.79 | 78.15 | 82.93 | 5.37 | 10.11 | 9.10 | 1.51 |
| 2009 | 5066.64 | 6016 | 915 | 63.43 | 78.80 | 63.21 | 68.68 | 2.27 | 7.62 | 13.58 | 15.37 |
| 2010 | 6529.54 | 7413 | 915 | 82.19 | 83.20 | 81.46 | 84.62 | 3.46 | 9.49 | 7.31 | 1.01 |
| 2011 | 5791.82 | 6573 | 915 | 72.78 | 73.05 | 72.26 | 75.03 | 2.56 | 11.63 | 15.32 | 0.27 |
| 2012 | 5896.70 | 6640 | 915 | 73.48 | 80.89 | 73.37 | 75.59 | 2.26 | 7.59 | 11.51 | 7.41 |
| 2013 | 6325.06 | 7087 | 915 | 79.90 | 82.28 | 78.91 | 80.90 | 1.09 | 4.75 | 12.98 | 2.38 |
| 2014 | 6767.39 | 7720 | 915 | 86.34 | 87.34 | 84.43 | 88.13 | 1.31 | 2.70 | 9.97 | 1.00 |
| 2015 | 3668.25 | 4245 | 915 | 45.93 | 46.48 | 45.77 | 48.46 | 6.71 | 22.54 | 30.98 | 0.55 |
| 2016 | 6374.97 | 7417 | 915 | 80.00 | 80.61 | 79.32 | 84.44 | 6.32 | 10.34 | 9.05 | 0.61 |
| 2017 | 3987.13 | 4655 | 915 | 49.92 | 50.59 | 49.74 | 53.14 | 2.97 | 18.52 | 30.89 | 0.67 |
| 2018 | 6471.31 | 7364 | 915 | 80.93 | 81.32 | 80.74 | 84.06 | 5.60 | 8.65 | 10.03 | 0.40 |
| 2019 | 5215.27 | 5891 | 915 | 65.17 | 72.69 | 65.07 | 67.25 | 2.12 | 4.69 | 22.62 | 7.52 |
| 2020 | 6241.26 | 7161 | 915 | 79.62 | 92.18 | 77.65 | 81.52 | 0.38 | 7.01 | 0.81 | 12.56 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|-------|-------|------|
| 2021 | 4211.93 | 4932 | 915 | 53.43 | 55.51 | 52.55 | 56.30 | 1.78 | 20.52 | 23.96 | 2.08 |
| 2022 | 6879.40 | 7711 | 915 | 86.68 | 88.09 | 85.83 | 88.03 | 1.68 | 1.51 | 10.40 | 1.42 |
| 2023 | 3816.03 | 4596 | 915 | 48.43 | 58.05 | 47.61 | 52.47 | 3.24 | 18.10 | 23.85 | 9.62 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1415 | | | 547 | |
| B. Refuelling without maintenance | | | | 150 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2039 | | | 962 | 13 | |
| D. Inspection, maintenance or repair without refuelling | | | | 16 | | |
| E. Testing of plant systems or components | | | | 13 | | |
| H. Nuclear regulatory requirements | | | | | 4 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 8 |
| L. Human factor related | | | | | 55 | |
| M. Governmental requirements or court decisions | | | | | | 0 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 11 |
| O. Load dispatching, prioritization | | | 34 | | | 3 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 675 | | 13 | 77 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 26 |
| Z. Other | | | | 2 | 35 | |
| Subtotal | 2039 | 1415 | 709 | 1143 | 667 | 126 |
| Total | | 4163 | | | 1936 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 13 |
| 12. Reactor I&C Systems | | 15 |
| 13. Reactor Auxiliary Systems | | 36 |
| 14. Safety Systems | | 37 |
| 15. Reactor Cooling Systems | | 14 |
| 16. Steam generation systems | | 7 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 32 |
| 32. Feedwater and Main Steam System | | 8 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | 1415 | 189 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 158 |
| 42. Electrical Power Supply Systems | | 22 |
| Total | 1415 | 538 |

2023 Operating Experience

FR-43

CRUAS-2

FRANCE

| | |
|-----------------------|-------------------------------|
| Status at end of year | : Operational |
| Operator | : EDF (ÉLECTRICITÉ DE FRANCE) |
| Owner | : EDF (ÉLECTRICITÉ DE FRANCE) |
| Reactor Supplier | : FRAM (FRAMATOME) |
| Turbine Supplier | : ALSTOM (ALSTOM) |

Reactor Unit Details

| | |
|----------------------------|-------------|
| Reactor type and model | : PWR / CP2 |
| Thermal power | : 2785 MWth |
| Gross electrical power | : 956 MWe |
| Reference unit power (net) | : 915 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 1978-11-15 |
| Grid Date | : 1984-09-06 |
| Commercial Date | : 1985-04-01 |
| Age at end of year | : 39 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : 12 |
| Part of the core refuelled [%] | : 33 |
| Average discharge burnup [MWd/t] | : 33735 |
| Active core diameter [m] | : 3.04 |
| Active core height/length [m] | : 3.66 |
| Number of fissile fuel assemblies/bundles | : 157 |
| Fuel linear heat generation rate [kW/m] | : 17.8 |
| Number of control rod assemblies | : 41 |
| Number of external reactor coolant loops | : 3 |
| Coolant type | : H2O |

| | |
|-----------------------------------|----------|
| Operating coolant pressure [MPa] | : 15.8 |
| Reactor outlet temperature [°C] | : 321 |
| Number of SG | : 3 |
| Containment type | : Single |
| Containment design pressure [MPa] | : 5 |

Secondary systems

| | |
|--|------------------|
| Number of turbine-generators per unit/reactor | : 1 |
| Turbine speed [rpm] | : 1500 |
| Number of LP cylinders per turbine | : - |
| HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : Cooling towers |
| Number of main condensate pumps | : - |
| Number of FW pumps for full power operation | : - |
| Number of on-site safety related diesel generators | : - |

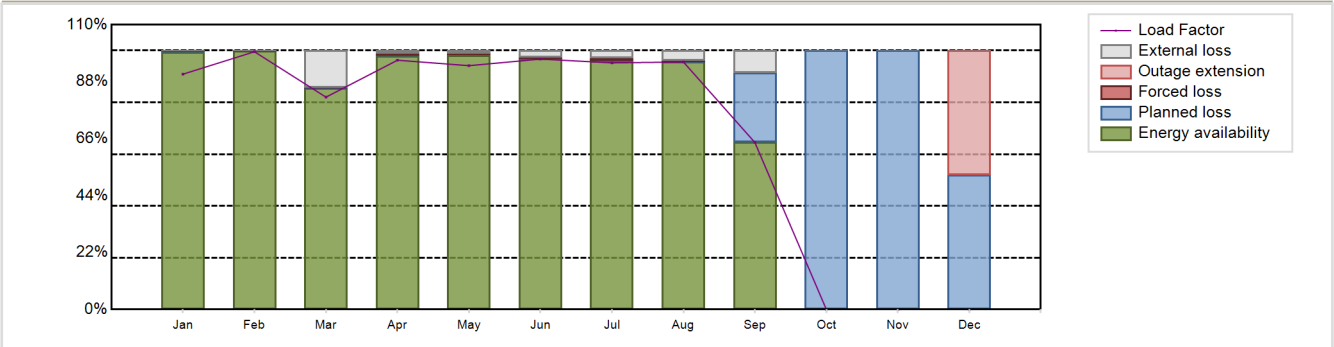
Non-electrical applications

| | |
|-----------------------------|--------|
| Non-electrical applications | : none |
|-----------------------------|--------|

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 5425.63 GW(e).h | Forced Loss Rate (FLR) | : 0.37 % |
| Energy Availability Factor (EAF) | : 69.23 % | Unplanned Capability Loss Factor (UCL) | : 4.36 % |
| Unit Capability Factor (UCF) | : 72.19 % | Planned Unavailability Factor (PUF) | : 23.46 % |
| Load Factor (LF) | : 67.69 % | Externally cause unavailability (XUF) | : 2.95 % |
| Operating Factor (OF) | : 72.33 % | Total off-line time | : 2424 hours |

Annual Summary

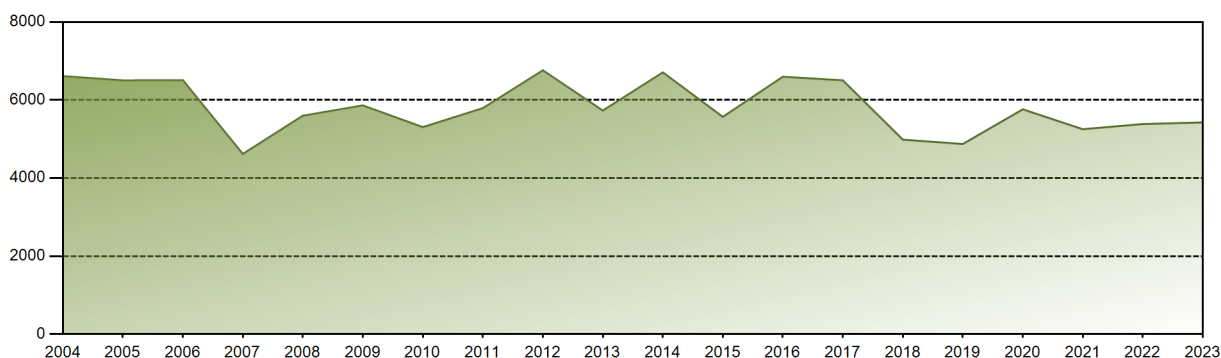


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|---------|
| GW(e)-h | 618.85 | 612.15 | 557.64 | 634.30 | 641.11 | 637.15 | 648.56 | 650.84 | 425.03 | 0.00 | 0.00 | 0.00 | 5425.63 |
| EAF [%] | 99.38 | 99.74 | 85.38 | 97.81 | 98.16 | 96.82 | 95.83 | 95.65 | 64.51 | 0.00 | 0.00 | 0.00 | 69.23 |
| UCF [%] | 99.53 | 99.78 | 99.70 | 99.02 | 99.40 | 99.56 | 98.80 | 99.64 | 73.08 | 0.00 | 0.00 | 0.00 | 72.19 |
| LF [%] | 90.91 | 99.56 | 82.02 | 96.28 | 94.18 | 96.71 | 95.27 | 95.60 | 64.52 | 0.00 | 0.00 | 0.00 | 67.69 |
| OF [%] | 96.77 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 73.47 | 0.00 | 0.00 | 0.00 | 72.33 |
| FLR [%] | 0.19 | 0.12 | 0.17 | 0.65 | 0.50 | 0.31 | 0.98 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 |
| UCL [%] | 0.19 | 0.12 | 0.17 | 0.65 | 0.50 | 0.31 | 0.98 | 0.28 | 0.00 | 0.00 | 0.00 | 48.12 | 4.36 |
| PUF [%] | 0.28 | 0.10 | 0.13 | 0.34 | 0.10 | 0.13 | 0.21 | 0.09 | 26.92 | 100.00 | 100.00 | 51.88 | 23.46 |
| XUF [%] | 0.15 | 0.03 | 14.32 | 1.20 | 1.25 | 2.74 | 2.98 | 3.98 | 8.56 | 0.00 | 0.00 | 0.00 | 2.95 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 226522.12 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.07 % |
| Cumulative Energy Availability Factor (EAF) | : 76.65 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.47 % |
| Cumulative Unit Capability Factor (UCF) | : 80.05 % | Cumulative Planned Unavailability Factor (PUF) | : 13.48 % |
| Cumulative Load Factor (LF) | : 72.49 % | Cumulative Externally cause unavailability (XUF) | : 3.4 % |
| Cumulative Operating Factor (OF) | : 79.41 % | | |

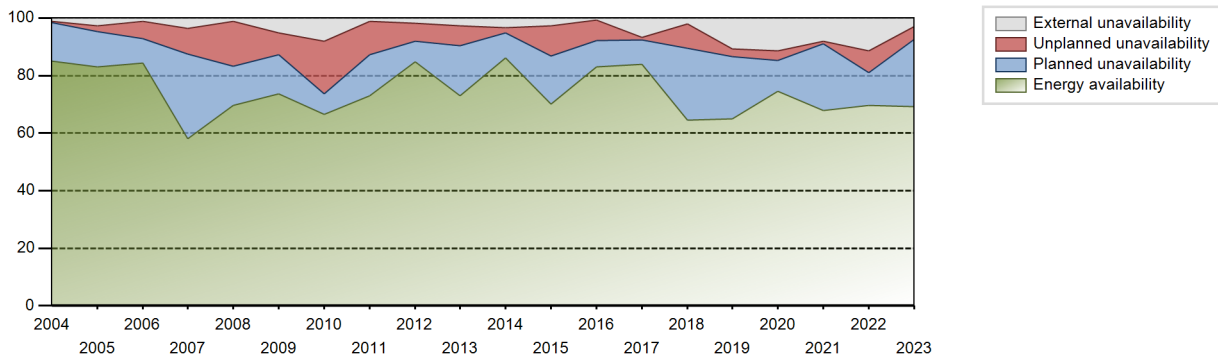
Electricity Production (net) [GWh]



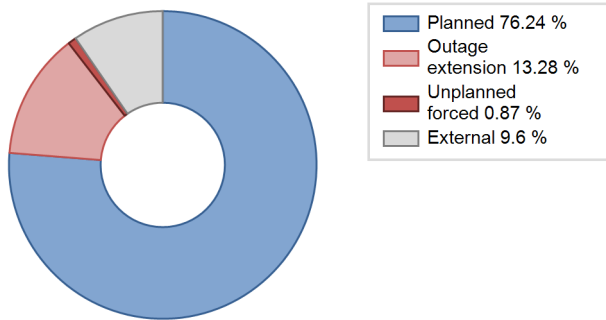
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 6103.20 | 8330 | 880 | 96.00 | 98.29 | 83.40 | 97.33 | 1.71 | 1.71 | 0.00 | 2.29 |
| 1986 | 4955.00 | 6258 | 880 | 70.06 | 70.42 | 64.28 | 71.44 | 22.40 | 20.33 | 9.25 | 0.36 |
| 1987 | 5559.90 | 6761 | 900 | 79.13 | 79.79 | 70.52 | 77.18 | 1.84 | 1.50 | 18.72 | 0.65 |
| 1988 | 5698.00 | 7176 | 915 | 80.60 | 84.97 | 70.89 | 81.69 | 4.03 | 3.57 | 11.46 | 4.37 |
| 1989 | 6298.51 | 7697 | 915 | 83.27 | 86.17 | 78.58 | 87.87 | 3.45 | 3.08 | 10.74 | 2.91 |
| 1990 | 6001.78 | 7114 | 915 | 77.72 | 79.83 | 74.88 | 81.21 | 9.42 | 8.30 | 11.87 | 2.11 |
| 1991 | 4099.88 | 4838 | 915 | 53.75 | 55.32 | 51.15 | 55.23 | 27.56 | 21.05 | 23.63 | 1.58 |
| 1992 | 5946.87 | 6910 | 915 | 76.96 | 76.99 | 73.99 | 78.67 | 11.95 | 10.44 | 12.57 | 0.03 |
| 1993 | 5441.04 | 6463 | 915 | 73.54 | 78.13 | 67.88 | 73.78 | 12.01 | 10.66 | 11.20 | 4.59 |
| 1994 | 5566.06 | 6765 | 915 | 94.12 | 96.79 | 69.44 | 77.23 | 3.16 | 3.16 | 0.05 | 2.66 |
| 1995 | 5366.77 | 6581 | 915 | 72.41 | 76.26 | 66.96 | 75.13 | 11.85 | 10.25 | 13.48 | 3.85 |
| 1996 | 6521.86 | 7870 | 915 | 87.09 | 88.83 | 81.14 | 89.59 | 1.32 | 1.19 | 9.98 | 1.75 |
| 1997 | 5176.08 | 6596 | 915 | 76.47 | 80.91 | 64.58 | 75.30 | 0.87 | 0.71 | 18.38 | 4.44 |
| 1998 | 6003.57 | 7396 | 915 | 79.02 | 82.81 | 74.90 | 84.43 | 3.10 | 2.65 | 14.54 | 3.79 |
| 1999 | 6393.81 | 7787 | 915 | 85.31 | 88.14 | 79.77 | 88.89 | 0.23 | 0.20 | 11.65 | 2.84 |
| 2000 | 6420.91 | 7755 | 915 | 85.55 | 86.99 | 79.89 | 88.29 | 0.81 | 0.71 | 12.31 | 1.43 |
| 2001 | 5914.40 | 7053 | 915 | 76.50 | 79.70 | 73.79 | 80.51 | 8.14 | 7.06 | 13.23 | 3.20 |
| 2002 | 6547.44 | 7776 | 915 | 85.99 | 86.53 | 81.69 | 88.77 | 3.83 | 3.45 | 10.03 | 0.54 |
| 2003 | 5727.93 | 6927 | 915 | 75.57 | 75.77 | 71.46 | 79.08 | 12.21 | 10.54 | 13.69 | 0.20 |
| 2004 | 6612.96 | 7661 | 915 | 84.92 | 85.96 | 82.28 | 87.22 | 0.57 | 0.49 | 13.55 | 1.04 |
| 2005 | 6504.12 | 7684 | 915 | 83.04 | 85.81 | 81.14 | 87.71 | 1.42 | 1.88 | 12.31 | 2.77 |
| 2006 | 6509.49 | 7736 | 915 | 84.34 | 85.58 | 81.21 | 88.31 | 3.94 | 5.89 | 8.52 | 1.24 |
| 2007 | 4617.90 | 5602 | 915 | 58.03 | 61.62 | 57.61 | 63.95 | 1.94 | 8.91 | 29.47 | 3.59 |
| 2008 | 5597.43 | 6633 | 915 | 69.75 | 70.93 | 69.64 | 75.51 | 6.25 | 15.48 | 13.59 | 1.18 |
| 2009 | 5862.16 | 6886 | 915 | 73.60 | 78.67 | 73.14 | 78.61 | 2.91 | 7.61 | 13.71 | 5.07 |
| 2010 | 5305.44 | 6036 | 915 | 66.55 | 74.51 | 66.19 | 68.90 | 11.78 | 18.28 | 7.21 | 7.96 |
| 2011 | 5791.15 | 6577 | 915 | 73.02 | 74.13 | 72.25 | 75.08 | 6.56 | 11.55 | 14.31 | 1.12 |
| 2012 | 6761.59 | 7665 | 915 | 84.70 | 86.48 | 84.13 | 87.26 | 0.15 | 6.31 | 7.21 | 1.78 |
| 2013 | 5729.40 | 6729 | 915 | 73.03 | 75.71 | 71.48 | 76.82 | 1.26 | 7.02 | 17.27 | 2.67 |
| 2014 | 6708.45 | 7931 | 915 | 86.15 | 89.62 | 83.69 | 90.54 | 1.26 | 1.69 | 8.69 | 3.47 |
| 2015 | 5568.66 | 6630 | 915 | 70.20 | 72.96 | 69.47 | 75.68 | 3.80 | 10.54 | 16.50 | 2.76 |
| 2016 | 6596.10 | 7743 | 915 | 83.08 | 83.78 | 82.07 | 88.15 | 4.55 | 7.17 | 9.05 | 0.71 |
| 2017 | 6505.00 | 7739 | 915 | 84.01 | 90.78 | 81.16 | 88.34 | 0.97 | 0.89 | 8.34 | 6.77 |
| 2018 | 4984.84 | 5958 | 915 | 64.41 | 66.36 | 62.19 | 68.01 | 2.10 | 8.57 | 25.07 | 1.94 |
| 2019 | 4872.15 | 6038 | 915 | 65.06 | 75.74 | 60.78 | 68.93 | 1.70 | 2.75 | 21.51 | 10.68 |
| 2020 | 5761.69 | 6924 | 915 | 74.50 | 85.90 | 71.69 | 78.83 | 0.96 | 3.35 | 10.75 | 11.40 |
| 2021 | 5251.28 | 6401 | 915 | 67.89 | 76.01 | 65.51 | 73.07 | 0.61 | 0.79 | 23.20 | 8.12 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|-------|
| 2022 | 5384.34 | 6707 | 915 | 69.59 | 81.04 | 67.17 | 76.56 | 3.48 | 7.50 | 11.46 | 11.45 |
| 2023 | 5425.63 | 6336 | 915 | 69.23 | 72.19 | 67.69 | 72.33 | 0.37 | 4.36 | 23.46 | 2.95 |

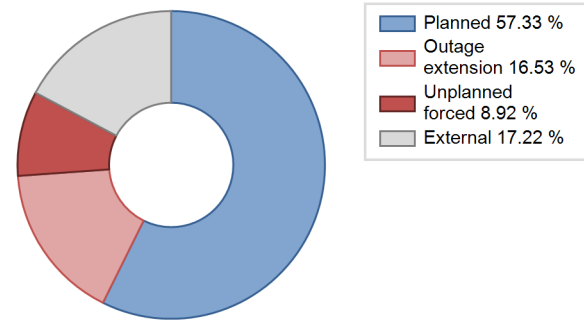
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 358 | | | 356 | |
| B. Refuelling without maintenance | | | | 132 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2041 | | | 955 | 6 | |
| E. Testing of plant systems or components | | | | 6 | 0 | |
| H. Nuclear regulatory requirements | | | | | 5 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 42 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 31 |
| O. Load dispatching, prioritization | | | 24 | | | 3 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 8 | 44 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 3 | 37 |
| Z. Other | | | | | 39 | 0 |
| Subtotal | 2041 | 358 | 24 | 1093 | 459 | 115 |
| Total | | 2423 | | | 1667 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 25 |
| 12. Reactor I&C Systems | | 14 |
| 13. Reactor Auxiliary Systems | | 9 |
| 14. Safety Systems | | 9 |
| 15. Reactor Cooling Systems | | 8 |
| 16. Steam generation systems | | 20 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 81 |
| 32. Feedwater and Main Steam System | | 15 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | 358 | 67 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 96 |
| 42. Electrical Power Supply Systems | | 7 |
| Total | 358 | 356 |

2023 Operating Experience

FR-44

CRUAS-3

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP2
 Thermal power : 2785 MWth
 Gross electrical power : 956 MWe
 Reference unit power (net) : 915 MWe

Key Dates

Construction Date : 1979-04-15
 Grid Date : 1984-05-14
 Commercial Date : 1984-09-10
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 41
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

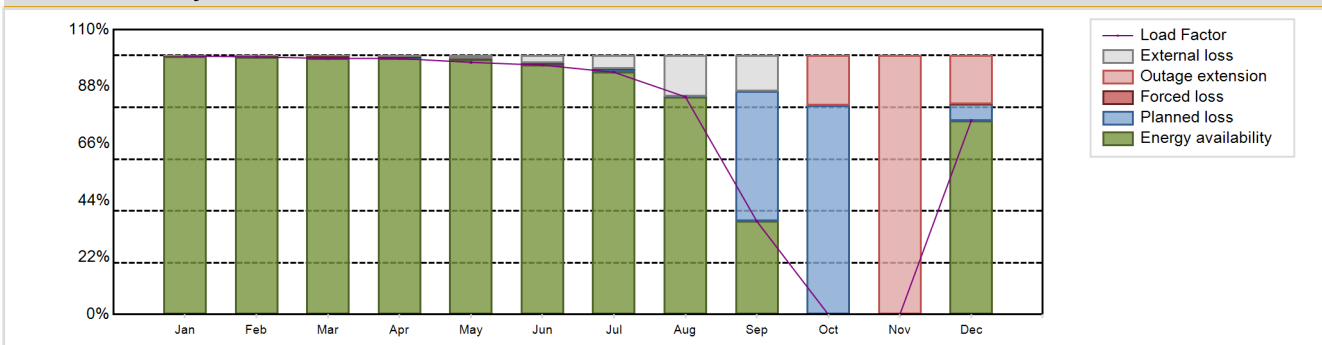
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5869.28 GW(e).h
 Energy Availability Factor (EAF) : 73.27 %
 Unit Capability Factor (UCF) : 76.56 %
 Load Factor (LF) : 73.23 %
 Operating Factor (OF) : 77.58 %

Forced Loss Rate (FLR) : 0.34 %
 Unplanned Capability Loss Factor (UCL) : 11.7 %
 Planned Unavailability Factor (PUF) : 11.74 %
 Externally cause unavailability (XUF) : 3.29 %
 Total off-line time : 1964 hours

Annual Summary

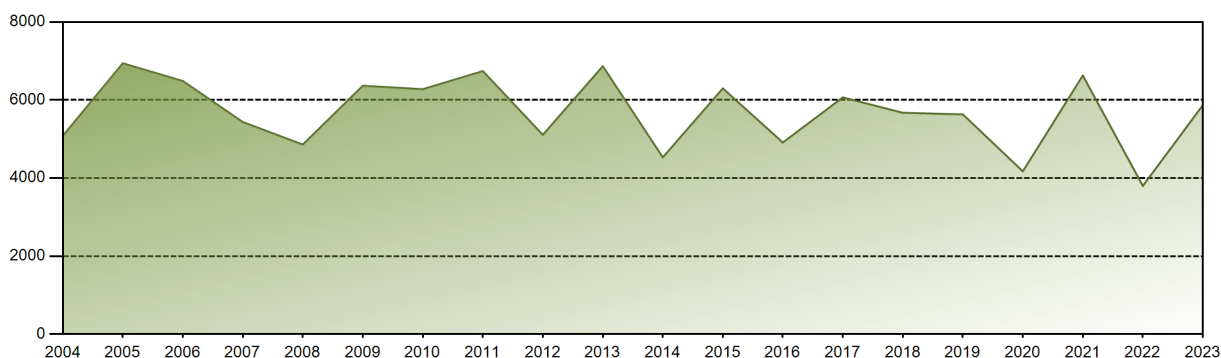


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 679.88 | 611.77 | 672.22 | 651.41 | 662.83 | 634.54 | 636.95 | 572.32 | 237.06 | 0.00 | 0.00 | 510.30 | 5869.28 |
| EAF [%] | 99.59 | 99.40 | 98.91 | 98.92 | 98.26 | 96.38 | 93.63 | 84.05 | 35.98 | 0.00 | 0.00 | 74.80 | 73.27 |
| UCF [%] | 99.62 | 99.41 | 99.06 | 99.31 | 99.46 | 99.23 | 98.80 | 99.79 | 49.78 | 0.00 | 0.00 | 74.80 | 76.56 |
| LF [%] | 99.87 | 99.49 | 98.88 | 98.88 | 97.37 | 96.32 | 93.56 | 84.07 | 35.98 | 0.00 | 0.00 | 74.96 | 73.23 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 50.00 | 0.00 | 0.00 | 81.32 | 77.58 |
| FLR [%] | 0.28 | 0.44 | 0.81 | 0.53 | 0.24 | 0.59 | 0.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.34 |
| UCL [%] | 0.28 | 0.44 | 0.81 | 0.53 | 0.24 | 0.59 | 0.29 | 0.00 | 0.00 | 19.19 | 100.00 | 18.66 | 11.70 |
| PUF [%] | 0.11 | 0.15 | 0.14 | 0.16 | 0.30 | 0.18 | 0.91 | 0.21 | 50.22 | 80.81 | 0.00 | 6.54 | 11.74 |
| XUF [%] | 0.03 | 0.01 | 0.14 | 0.39 | 1.20 | 2.85 | 5.17 | 15.74 | 13.80 | 0.00 | 0.00 | 0.00 | 3.29 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 224788.7 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.37 % |
| Cumulative Energy Availability Factor (EAF) | : 76.46 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.99 % |
| Cumulative Unit Capability Factor (UCF) | : 80.07 % | Cumulative Planned Unavailability Factor (PUF) | : 12.94 % |
| Cumulative Load Factor (LF) | : 71.36 % | Cumulative Externally cause unavailability (XUF) | : 3.6 % |
| Cumulative Operating Factor (OF) | : 78.04 % | | |

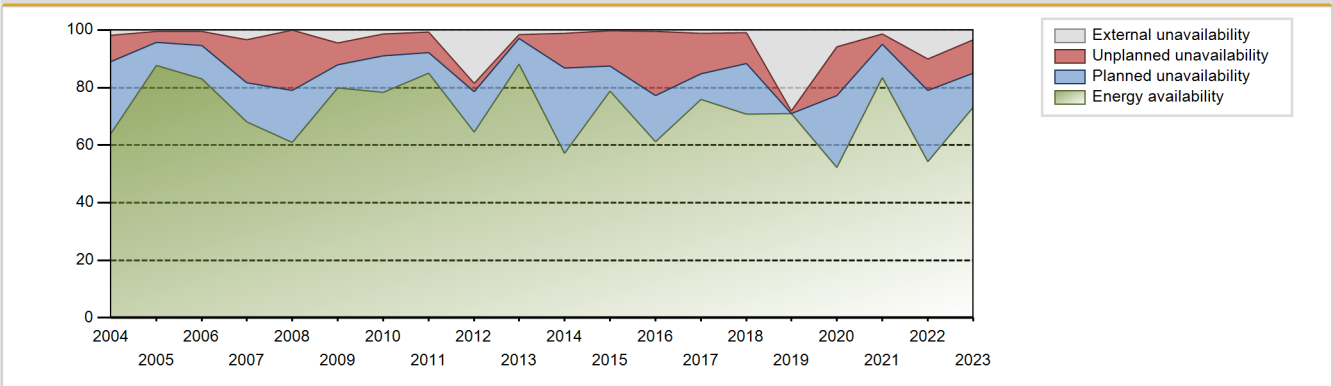
Electricity Production (net) [GWh]



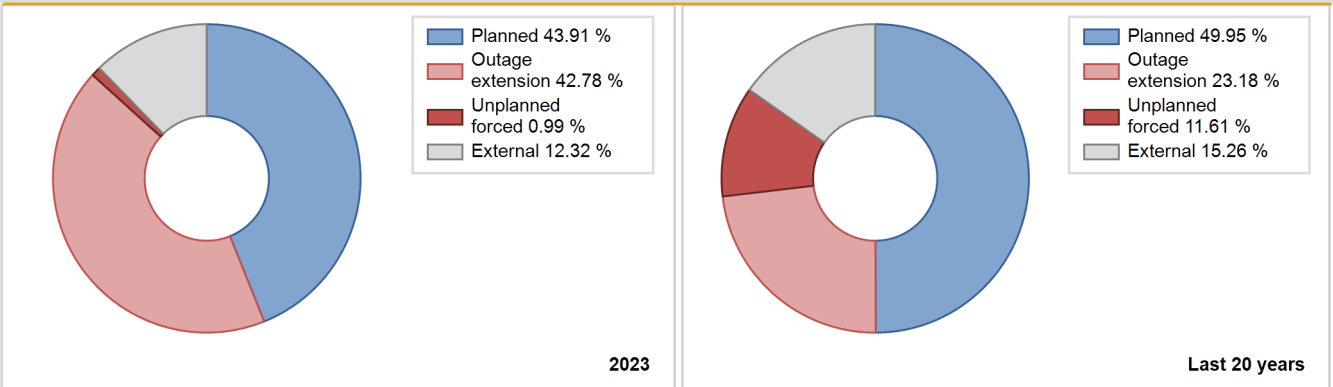
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 3272.00 | 4380 | 880 | 91.93 | 91.93 | 89.66 | 92.73 | 8.07 | 8.07 | 0.00 | 0.00 |
| 1985 | 5247.40 | 6557 | 880 | 72.54 | 74.60 | 68.07 | 74.85 | 8.27 | 6.72 | 18.68 | 2.06 |
| 1986 | 5967.08 | 7456 | 880 | 89.23 | 89.52 | 77.41 | 85.11 | 1.96 | 1.79 | 8.70 | 0.28 |
| 1987 | 4721.40 | 6013 | 880 | 75.08 | 75.71 | 61.25 | 68.64 | 11.51 | 9.84 | 14.45 | 0.63 |
| 1988 | 4773.00 | 6679 | 880 | 98.63 | 99.87 | 61.75 | 76.04 | 0.13 | 0.13 | 0.00 | 1.24 |
| 1989 | 5577.93 | 6571 | 880 | 72.81 | 74.19 | 72.36 | 75.01 | 8.98 | 7.32 | 18.49 | 1.38 |
| 1990 | 6129.16 | 7499 | 915 | 85.18 | 87.48 | 76.47 | 85.61 | 1.04 | 0.92 | 11.60 | 2.30 |
| 1991 | 6003.22 | 7374 | 915 | 84.75 | 85.16 | 74.90 | 84.18 | 2.27 | 1.97 | 12.87 | 0.41 |
| 1992 | 5174.61 | 6323 | 915 | 70.99 | 73.16 | 64.38 | 71.98 | 9.76 | 7.91 | 18.93 | 2.17 |
| 1993 | 5715.35 | 7232 | 915 | 73.91 | 85.66 | 71.30 | 82.56 | 2.81 | 2.47 | 11.87 | 11.75 |
| 1994 | 5013.99 | 6428 | 915 | 78.11 | 78.86 | 62.55 | 73.38 | 0.72 | 0.57 | 20.57 | 0.75 |
| 1995 | 6032.66 | 7525 | 915 | 84.28 | 89.56 | 75.26 | 85.90 | 0.94 | 0.85 | 9.59 | 5.29 |
| 1996 | 5882.20 | 7724 | 915 | 91.89 | 99.67 | 73.19 | 87.93 | 0.22 | 0.22 | 0.11 | 7.78 |
| 1997 | 5347.79 | 6961 | 915 | 80.20 | 86.11 | 66.72 | 79.46 | 0.27 | 0.24 | 13.66 | 5.91 |
| 1998 | 6281.40 | 7758 | 915 | 78.69 | 81.74 | 78.37 | 88.56 | 7.63 | 6.75 | 11.51 | 3.05 |
| 1999 | 6316.70 | 7654 | 915 | 87.83 | 89.77 | 78.81 | 87.37 | 2.25 | 2.07 | 8.17 | 1.93 |
| 2000 | 5493.99 | 6914 | 915 | 78.98 | 81.39 | 68.36 | 78.71 | 6.81 | 5.94 | 12.67 | 2.40 |
| 2001 | 5867.85 | 7254 | 915 | 79.61 | 82.12 | 73.21 | 82.81 | 8.89 | 8.02 | 9.86 | 2.51 |
| 2002 | 6052.00 | 7307 | 915 | 80.94 | 82.10 | 75.50 | 83.41 | 6.56 | 5.77 | 12.14 | 1.16 |
| 2003 | 5779.36 | 7146 | 915 | 76.75 | 79.21 | 72.10 | 81.58 | 7.77 | 6.67 | 14.13 | 2.45 |
| 2004 | 5081.25 | 6074 | 915 | 64.07 | 65.92 | 63.22 | 69.15 | 12.26 | 9.21 | 24.87 | 1.85 |
| 2005 | 6941.58 | 7863 | 915 | 87.79 | 88.28 | 86.59 | 89.75 | 2.66 | 3.72 | 8.00 | 0.49 |
| 2006 | 6487.52 | 7520 | 915 | 83.06 | 83.49 | 80.94 | 85.84 | 2.45 | 4.95 | 11.56 | 0.43 |
| 2007 | 5435.78 | 6456 | 915 | 68.07 | 71.39 | 67.82 | 73.70 | 5.03 | 14.99 | 13.62 | 3.32 |
| 2008 | 4858.57 | 5750 | 915 | 60.85 | 61.00 | 60.45 | 65.46 | 6.02 | 20.85 | 18.16 | 0.14 |
| 2009 | 6365.97 | 7392 | 915 | 79.89 | 84.35 | 79.42 | 84.38 | 5.10 | 7.58 | 8.07 | 4.45 |
| 2010 | 6277.78 | 7004 | 915 | 78.27 | 79.59 | 78.32 | 79.95 | 3.10 | 7.69 | 12.72 | 1.32 |
| 2011 | 6741.60 | 7580 | 915 | 85.02 | 85.72 | 84.11 | 86.53 | 5.39 | 7.15 | 7.14 | 0.70 |
| 2012 | 5106.74 | 5899 | 915 | 64.48 | 83.03 | 63.54 | 67.16 | 2.31 | 2.90 | 14.07 | 18.55 |
| 2013 | 6866.75 | 7750 | 915 | 88.16 | 89.86 | 85.67 | 88.47 | 0.32 | 1.26 | 8.88 | 1.70 |
| 2014 | 4529.71 | 5148 | 915 | 57.11 | 58.35 | 56.51 | 58.77 | 1.09 | 12.03 | 29.62 | 1.24 |
| 2015 | 6297.99 | 7085 | 915 | 78.71 | 79.01 | 78.57 | 80.88 | 11.58 | 12.23 | 8.76 | 0.30 |
| 2016 | 4910.49 | 6144 | 915 | 61.26 | 61.76 | 61.10 | 69.95 | 6.85 | 22.17 | 16.07 | 0.50 |
| 2017 | 6067.31 | 6910 | 915 | 75.99 | 77.24 | 75.70 | 78.88 | 3.27 | 14.04 | 8.71 | 1.25 |
| 2018 | 5672.76 | 6425 | 915 | 70.87 | 71.89 | 70.77 | 73.34 | 5.03 | 10.67 | 17.44 | 1.02 |
| 2019 | 5632.07 | 6451 | 915 | 70.96 | 99.01 | 70.27 | 73.64 | 0.87 | 0.87 | 0.12 | 28.05 |
| 2020 | 4171.74 | 4917 | 915 | 52.15 | 57.98 | 51.90 | 55.98 | 0.83 | 17.00 | 25.02 | 5.84 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|-------|-------|-------|
| 2021 | 6628.24 | 7614 | 915 | 83.54 | 84.88 | 82.69 | 86.92 | 4.10 | 3.63 | 11.48 | 1.35 |
| 2022 | 3797.13 | 4493 | 915 | 54.22 | 64.23 | 53.92 | 59.44 | 3.73 | 10.99 | 24.79 | 10.01 |
| 2023 | 5869.28 | 6796 | 915 | 73.27 | 76.56 | 73.23 | 77.58 | 0.34 | 11.70 | 11.74 | 3.29 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1001 | | | 376 | |
| B. Refuelling without maintenance | 962 | | | 147 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 911 | 21 | |
| D. Inspection, maintenance or repair without refuelling | | | | | 4 | |
| E. Testing of plant systems or components | | | | 6 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 66 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 29 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 61 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 39 |
| Z. Other | | | | | 49 | 13 |
| Subtotal | 962 | 1001 | | 1064 | 516 | 146 |
| Total | | 1963 | | | 1726 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 5 |
| 12. Reactor I&C Systems | | 22 |
| 13. Reactor Auxiliary Systems | | 14 |
| 14. Safety Systems | | 16 |
| 15. Reactor Cooling Systems | | 55 |
| 16. Steam generation systems | | 20 |
| 21. Fuel Handling and Storage Facilities | | 2 |
| 31. Turbine and auxiliaries | | 50 |
| 32. Feedwater and Main Steam System | | 11 |
| 34. Miscellaneous Systems | 1001 | 151 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 15 |
| 42. Electrical Power Supply Systems | | 32 |
| Total | 1001 | 395 |

2023 Operating Experience

FR-45

CRUAS-4

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP2
 Thermal power : 2785 MWth
 Gross electrical power : 956 MWe
 Reference unit power (net) : 915 MWe

Key Dates

Construction Date : 1979-10-01
 Grid Date : 1984-10-27
 Commercial Date : 1985-02-11
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 41
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

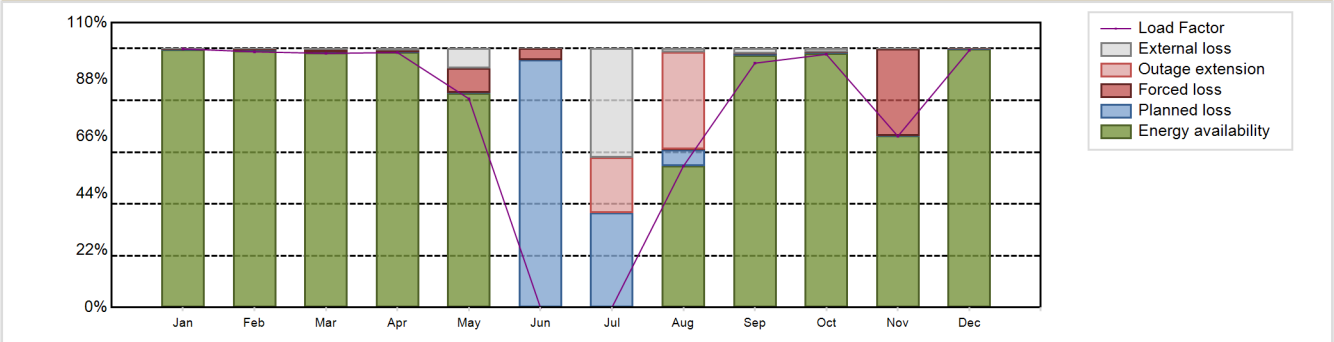
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 5923.87 GW(e).h
 Energy Availability Factor (EAF) : 74.47 %
 Unit Capability Factor (UCF) : 79.18 %
 Load Factor (LF) : 73.91 %
 Operating Factor (OF) : 76.43 %
 Forced Loss Rate (FLR) : 5.06 %
 Unplanned Capability Loss Factor (UCL) : 9.23 %
 Planned Unavailability Factor (PUF) : 11.59 %
 Externally cause unavailability (XUF) : 4.71 %
 Total off-line time : 2065 hours

Annual Summary

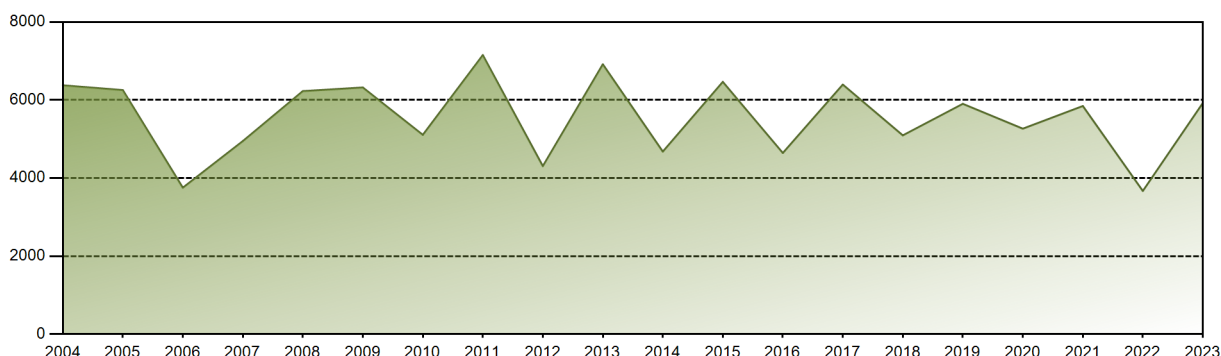


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 680.02 | 607.16 | 667.29 | 648.76 | 548.82 | 0.00 | 0.00 | 371.69 | 621.64 | 666.47 | 435.76 | 676.25 | 5923.87 |
| EAF [%] | 99.67 | 99.20 | 98.44 | 98.51 | 82.83 | 0.00 | 0.00 | 54.62 | 97.36 | 98.14 | 66.25 | 99.86 | 74.47 |
| UCF [%] | 99.71 | 99.26 | 98.82 | 99.06 | 90.52 | 0.00 | 42.14 | 55.89 | 99.32 | 99.58 | 66.28 | 99.86 | 79.18 |
| LF [%] | 99.89 | 98.74 | 98.15 | 98.48 | 80.62 | 0.00 | 0.00 | 54.60 | 94.36 | 97.77 | 66.15 | 99.34 | 73.91 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 88.58 | 0.00 | 0.00 | 62.37 | 100.00 | 99.87 | 67.36 | 100.00 | 76.43 |
| FLR [%] | 0.25 | 0.58 | 1.12 | 0.87 | 9.40 | 100.00 | 0.00 | 0.12 | 0.28 | 0.30 | 33.66 | 0.08 | 5.06 |
| UCL [%] | 0.25 | 0.58 | 1.12 | 0.87 | 9.39 | 4.44 | 21.30 | 37.72 | 0.28 | 0.30 | 33.63 | 0.08 | 9.23 |
| PUF [%] | 0.05 | 0.16 | 0.06 | 0.08 | 0.10 | 95.56 | 36.56 | 6.38 | 0.40 | 0.12 | 0.09 | 0.06 | 11.59 |
| XUF [%] | 0.03 | 0.06 | 0.38 | 0.55 | 7.69 | 0.00 | 42.14 | 1.27 | 1.96 | 1.43 | 0.03 | 0.00 | 4.71 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 220719.75 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.35 % |
| Cumulative Energy Availability Factor (EAF) | : 74.91 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.07 % |
| Cumulative Unit Capability Factor (UCF) | : 78.01 % | Cumulative Planned Unavailability Factor (PUF) | : 13.91 % |
| Cumulative Load Factor (LF) | : 70.84 % | Cumulative Externally cause unavailability (XUF) | : 3.1 % |
| Cumulative Operating Factor (OF) | : 76.2 % | | |

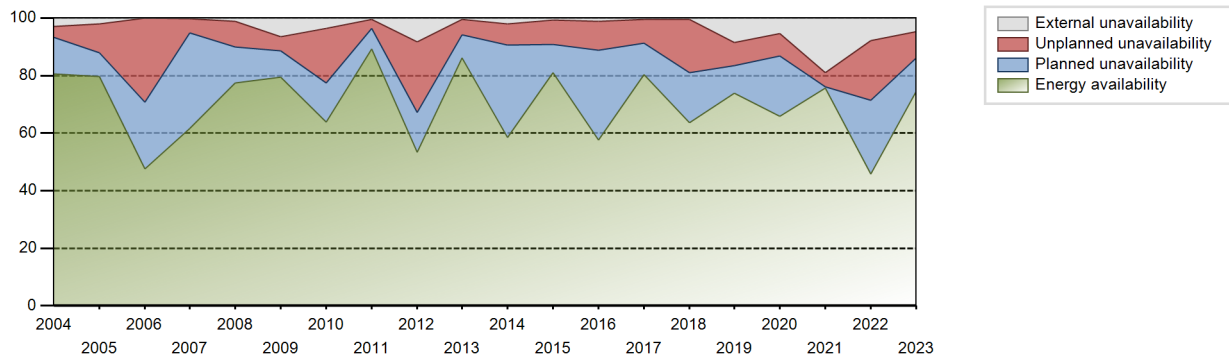
Electricity Production (net) [GWh]



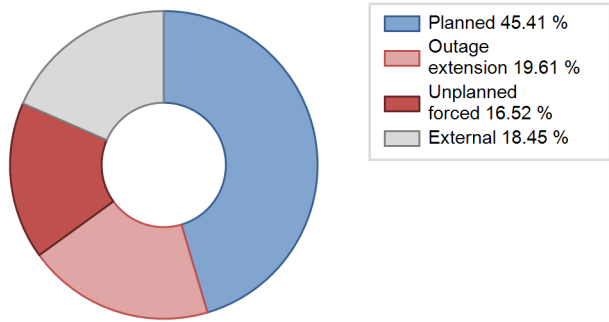
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 5773.60 | 7434 | 880 | 85.67 | 87.12 | 73.53 | 84.32 | 12.88 | 12.88 | 0.00 | 1.45 |
| 1986 | 5452.60 | 6816 | 880 | 76.67 | 80.33 | 70.73 | 77.81 | 0.60 | 0.48 | 19.18 | 3.66 |
| 1987 | 5313.40 | 6888 | 880 | 84.24 | 85.14 | 68.93 | 78.63 | 4.76 | 4.25 | 10.60 | 0.90 |
| 1988 | 3247.00 | 4271 | 880 | 74.17 | 75.95 | 42.01 | 48.62 | 15.53 | 13.96 | 10.09 | 1.79 |
| 1989 | 4852.19 | 6025 | 880 | 71.30 | 71.43 | 62.94 | 68.78 | 17.85 | 15.52 | 13.05 | 0.14 |
| 1990 | 6215.34 | 7607 | 880 | 86.02 | 86.39 | 80.63 | 86.84 | 8.69 | 8.23 | 5.38 | 0.38 |
| 1991 | 6005.38 | 7259 | 880 | 81.10 | 83.93 | 77.90 | 82.87 | 8.63 | 7.93 | 8.13 | 2.83 |
| 1992 | 4953.60 | 5862 | 880 | 64.95 | 66.00 | 64.08 | 66.73 | 13.05 | 9.90 | 24.10 | 1.04 |
| 1993 | 5279.97 | 6653 | 880 | 77.14 | 84.92 | 68.49 | 75.95 | 2.69 | 2.35 | 12.73 | 7.78 |
| 1994 | 5552.11 | 6856 | 915 | 83.79 | 86.83 | 69.27 | 78.26 | 2.94 | 2.63 | 10.54 | 3.04 |
| 1995 | 6280.30 | 7375 | 915 | 82.14 | 85.97 | 78.35 | 84.19 | 4.78 | 4.31 | 9.71 | 3.83 |
| 1996 | 5886.51 | 7180 | 915 | 79.43 | 80.67 | 73.24 | 81.74 | 0.71 | 0.58 | 18.75 | 1.24 |
| 1997 | 5976.62 | 7334 | 915 | 80.23 | 84.06 | 74.56 | 83.72 | 1.47 | 1.25 | 14.69 | 3.83 |
| 1998 | 6629.20 | 7885 | 915 | 85.52 | 88.69 | 82.71 | 90.01 | 0.97 | 0.87 | 10.43 | 3.18 |
| 1999 | 5829.81 | 7159 | 915 | 81.90 | 85.43 | 72.73 | 81.72 | 1.81 | 1.57 | 13.00 | 3.53 |
| 2000 | 6630.69 | 7915 | 915 | 88.43 | 89.66 | 82.50 | 90.11 | 0.72 | 0.65 | 9.69 | 1.22 |
| 2001 | 5915.77 | 7172 | 915 | 80.63 | 83.26 | 73.81 | 81.87 | 2.82 | 2.42 | 14.32 | 2.63 |
| 2002 | 6399.58 | 7474 | 915 | 82.89 | 83.41 | 79.84 | 85.32 | 3.93 | 3.41 | 13.18 | 0.53 |
| 2003 | 6296.69 | 7371 | 915 | 81.63 | 82.86 | 78.56 | 84.14 | 5.97 | 5.26 | 11.88 | 1.23 |
| 2004 | 6377.38 | 7443 | 915 | 80.62 | 83.44 | 79.35 | 84.73 | 4.36 | 3.80 | 12.75 | 2.82 |
| 2005 | 6255.06 | 7360 | 915 | 79.62 | 81.58 | 78.04 | 84.02 | 10.98 | 10.06 | 8.35 | 1.96 |
| 2006 | 3752.65 | 4259 | 915 | 47.64 | 47.64 | 46.82 | 48.62 | 21.85 | 29.21 | 23.15 | 0.00 |
| 2007 | 4947.25 | 5839 | 915 | 61.73 | 61.97 | 61.72 | 66.66 | 5.80 | 5.03 | 33.00 | 0.24 |
| 2008 | 6228.77 | 7011 | 915 | 77.36 | 78.52 | 77.50 | 79.82 | 0.47 | 8.84 | 12.64 | 1.16 |
| 2009 | 6321.83 | 7347 | 915 | 79.49 | 86.09 | 78.87 | 83.87 | 1.17 | 4.77 | 9.14 | 6.60 |
| 2010 | 5107.05 | 5779 | 915 | 63.76 | 67.48 | 63.72 | 65.97 | 3.99 | 18.93 | 13.60 | 3.72 |
| 2011 | 7152.54 | 7938 | 915 | 89.16 | 89.73 | 89.23 | 90.62 | 0.83 | 3.06 | 7.21 | 0.57 |
| 2012 | 4305.94 | 4853 | 915 | 53.33 | 61.67 | 53.57 | 55.25 | 0.78 | 24.41 | 13.91 | 8.34 |
| 2013 | 6916.18 | 7727 | 915 | 86.05 | 86.62 | 86.29 | 88.21 | 0.72 | 5.31 | 8.07 | 0.57 |
| 2014 | 4677.86 | 5611 | 915 | 58.41 | 60.46 | 58.36 | 64.05 | 2.88 | 7.31 | 32.23 | 2.05 |
| 2015 | 6465.66 | 7267 | 915 | 81.10 | 81.88 | 80.67 | 82.96 | 8.14 | 8.35 | 9.77 | 0.78 |
| 2016 | 4642.10 | 5435 | 915 | 57.68 | 58.89 | 57.76 | 61.87 | 8.02 | 10.04 | 31.07 | 1.20 |
| 2017 | 6395.66 | 7187 | 915 | 80.24 | 80.72 | 79.79 | 82.04 | 1.59 | 8.30 | 10.97 | 0.49 |
| 2018 | 5094.14 | 5821 | 915 | 63.65 | 64.08 | 63.55 | 66.45 | 2.29 | 18.62 | 17.30 | 0.43 |
| 2019 | 5902.70 | 7017 | 915 | 73.89 | 82.37 | 73.64 | 80.10 | 8.64 | 8.14 | 9.48 | 8.48 |
| 2020 | 5265.57 | 6262 | 915 | 65.86 | 71.21 | 65.51 | 71.29 | 1.03 | 7.79 | 20.99 | 5.35 |
| 2021 | 5846.62 | 6851 | 915 | 75.77 | 94.85 | 72.94 | 78.21 | 4.91 | 4.90 | 0.26 | 19.08 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|-------|-------|------|
| 2022 | 3668.57 | 4363 | 915 | 45.76 | 53.60 | 45.77 | 49.81 | 6.71 | 20.82 | 25.58 | 7.84 |
| 2023 | 5923.87 | 6695 | 915 | 74.47 | 79.18 | 73.91 | 76.43 | 5.06 | 9.23 | 11.59 | 4.71 |

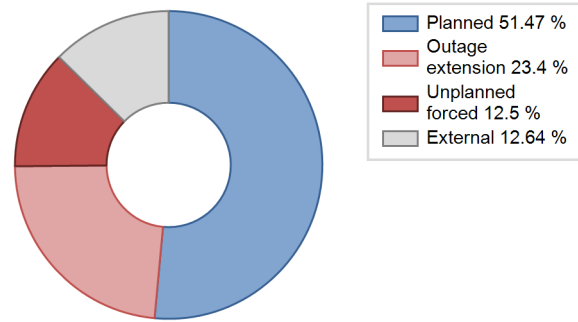
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 775 | | | 522 | |
| B. Refuelling without maintenance | 960 | | | 176 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 852 | 35 | |
| D. Inspection, maintenance or repair without refuelling | | | | 6 | | |
| E. Testing of plant systems or components | | | | 9 | 2 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 68 | | |
| H. Nuclear regulatory requirements | | | | | 2 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 17 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 25 |
| O. Load dispatching, prioritization | | | 16 | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 314 | | | 83 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 44 |
| Z. Other | | | | | 22 | |
| Subtotal | 960 | 775 | 330 | 1111 | 600 | 153 |
| Total | | 2065 | | | 1864 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 13 |
| 13. Reactor Auxiliary Systems | | 23 |
| 14. Safety Systems | 235 | 24 |
| 15. Reactor Cooling Systems | | 31 |
| 16. Steam generation systems | | 85 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 4 |
| 31. Turbine and auxiliaries | 101 | 85 |
| 32. Feedwater and Main Steam System | | 13 |
| 34. Miscellaneous Systems | 439 | 189 |
| 41. Main Generator Systems | | 25 |
| 42. Electrical Power Supply Systems | | 27 |
| Total | 775 | 522 |

2023 Operating Experience

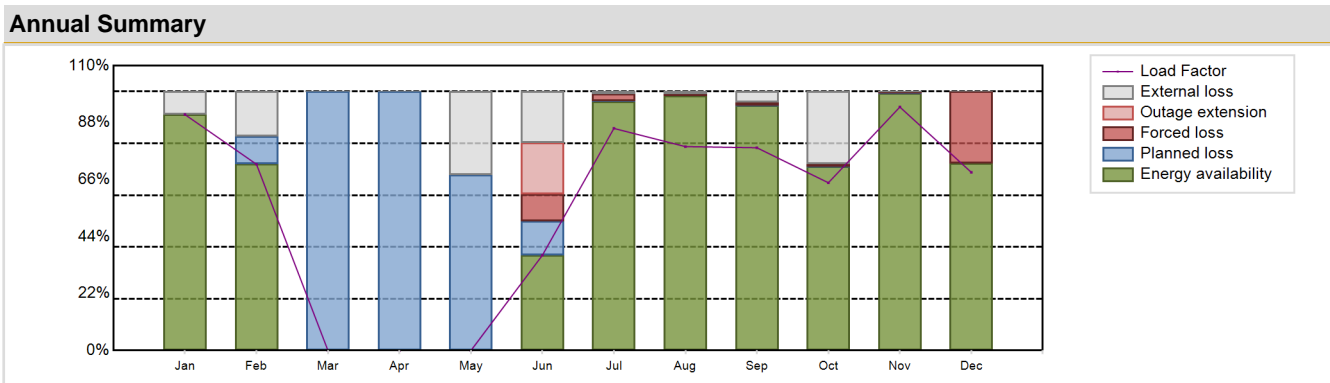
FR-22 **DAMPIERRE-1** **FRANCE**

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP1 | Construction Date | : 1975-02-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1980-03-23 |
| Gross electrical power | : 937 MWe | Commercial Date | : 1980-09-10 |
| Reference unit power (net) | : 890 MWe | Age at end of year | : 43 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 321 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33735 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Cooling towers |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 41 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4348.67 GW(e).h | Forced Loss Rate (FLR) | : 5.02 % |
| Energy Availability Factor (EAF) | : 60.94 % | Unplanned Capability Loss Factor (UCL) | : 5.36 % |
| Unit Capability Factor (UCF) | : 70.25 % | Planned Unavailability Factor (PUF) | : 24.4 % |
| Load Factor (LF) | : 55.78 % | Externally cause unavailability (XUF) | : 9.31 % |
| Operating Factor (OF) | : 65.06 % | Total off-line time | : 3061 hours |

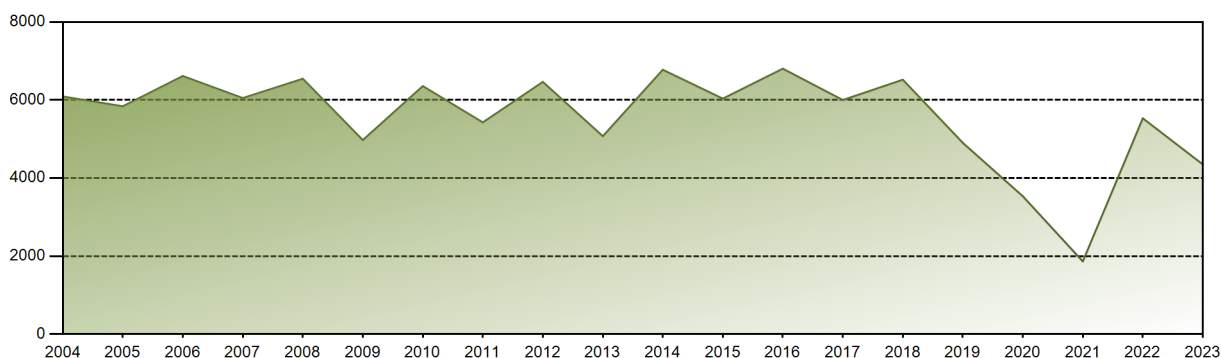


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 603.35 | 430.22 | 0.00 | 0.00 | 0.00 | 235.90 | 568.02 | 521.49 | 501.84 | 429.64 | 602.60 | 455.60 | 4348.67 |
| EAF [%] | 91.11 | 72.04 | 0.00 | 0.00 | 0.00 | 36.88 | 96.06 | 98.42 | 94.69 | 71.09 | 99.26 | 72.29 | 60.94 |
| UCF [%] | 100.00 | 89.21 | 0.00 | 0.00 | 32.24 | 56.51 | 96.93 | 99.41 | 98.85 | 99.01 | 99.34 | 72.29 | 70.25 |
| LF [%] | 91.12 | 71.93 | 0.00 | 0.00 | 0.00 | 36.81 | 85.78 | 78.76 | 78.31 | 64.80 | 94.04 | 68.81 | 55.78 |
| OF [%] | 100.00 | 89.29 | 0.00 | 0.00 | 0.00 | 50.42 | 100.00 | 100.00 | 96.94 | 72.89 | 100.00 | 72.98 | 65.06 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.49 | 2.78 | 0.59 | 1.11 | 0.94 | 0.63 | 27.71 | 5.02 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 30.37 | 2.77 | 0.59 | 1.11 | 0.94 | 0.63 | 27.71 | 5.36 |
| PUF [%] | 0.00 | 10.79 | 100.00 | 100.00 | 67.76 | 13.12 | 0.30 | 0.00 | 0.04 | 0.05 | 0.02 | 0.00 | 24.40 |
| XUF [%] | 8.89 | 17.17 | 0.00 | 0.00 | 32.24 | 19.63 | 0.87 | 0.99 | 4.16 | 27.93 | 0.08 | 0.00 | 9.31 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 239676.74 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.94 % |
| Cumulative Energy Availability Factor (EAF) | : 74.42 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.35 % |
| Cumulative Unit Capability Factor (UCF) | : 77.66 % | Cumulative Planned Unavailability Factor (PUF) | : 14.99 % |
| Cumulative Load Factor (LF) | : 70.55 % | Cumulative Externally cause unavailability (XUF) | : 3.24 % |
| Cumulative Operating Factor (OF) | : 76.48 % | | |

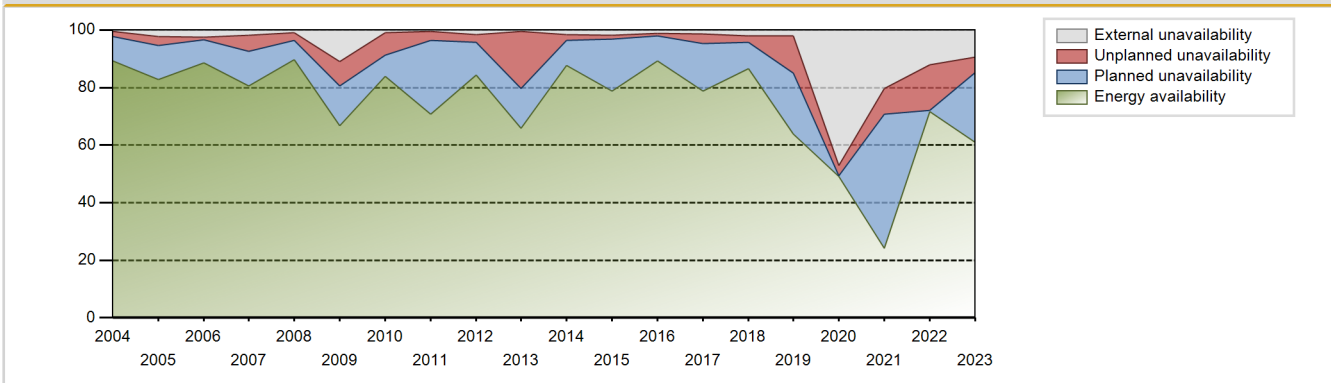
Electricity Production (net) [GWh]



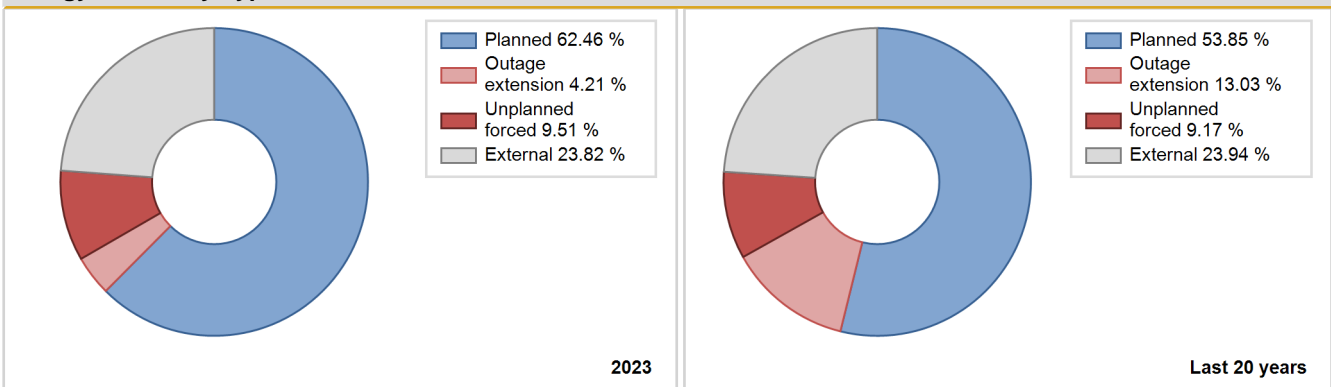
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | 2764.00 | 3950 | 898 | 61.91 | 61.91 | 69.14 | 73.12 | 5.60 | 3.67 | 34.41 | 0.00 |
| 1981 | 4322.10 | 5270 | 900 | 55.90 | 55.90 | 54.82 | 60.16 | 14.79 | 9.70 | 34.39 | 0.00 |
| 1982 | 5043.90 | 5994 | 890 | 65.56 | 65.56 | 64.70 | 68.42 | 20.59 | 17.00 | 17.43 | 0.00 |
| 1983 | 6263.00 | 7847 | 890 | 85.88 | 85.88 | 80.33 | 89.58 | 14.12 | 14.12 | 0.00 | 0.00 |
| 1984 | 5391.00 | 6777 | 890 | 73.61 | 73.61 | 68.96 | 77.15 | 9.12 | 7.38 | 19.01 | 0.00 |
| 1985 | 5738.50 | 7223 | 890 | 80.64 | 80.91 | 73.60 | 82.45 | 7.64 | 6.69 | 12.40 | 0.27 |
| 1986 | 5157.40 | 6673 | 890 | 75.73 | 75.91 | 66.15 | 76.18 | 5.33 | 4.27 | 19.82 | 0.18 |
| 1987 | 4780.20 | 6245 | 890 | 65.93 | 67.88 | 61.31 | 71.29 | 12.79 | 9.96 | 22.16 | 1.95 |
| 1988 | 3920.00 | 5239 | 890 | 59.60 | 61.15 | 50.14 | 59.64 | 25.06 | 20.45 | 18.39 | 1.55 |
| 1989 | 6467.63 | 8207 | 890 | 97.86 | 98.65 | 82.96 | 93.69 | 1.22 | 1.22 | 0.13 | 0.79 |
| 1990 | 2187.08 | 3110 | 890 | 33.96 | 36.33 | 28.05 | 35.50 | 6.49 | 2.52 | 61.15 | 2.37 |
| 1991 | 6390.92 | 7305 | 890 | 81.80 | 82.25 | 81.97 | 83.39 | 5.49 | 4.78 | 12.97 | 0.45 |
| 1992 | 6305.06 | 7293 | 890 | 80.73 | 81.73 | 80.65 | 83.03 | 1.93 | 1.61 | 16.66 | 1.00 |
| 1993 | 6702.80 | 7676 | 890 | 86.38 | 86.64 | 85.97 | 87.63 | 2.63 | 2.34 | 11.02 | 0.26 |
| 1994 | 5299.19 | 6185 | 890 | 68.88 | 69.68 | 67.97 | 70.61 | 20.96 | 18.48 | 11.85 | 0.80 |
| 1995 | 6193.95 | 7413 | 890 | 82.91 | 84.36 | 79.45 | 84.62 | 4.82 | 4.27 | 11.37 | 1.44 |
| 1996 | 5895.50 | 7378 | 890 | 82.24 | 83.11 | 75.41 | 83.99 | 5.96 | 5.27 | 11.62 | 0.88 |
| 1997 | 5172.13 | 6465 | 890 | 71.92 | 72.27 | 66.34 | 73.80 | 14.89 | 12.65 | 15.08 | 0.35 |
| 1998 | 6042.70 | 7294 | 890 | 80.53 | 81.91 | 77.51 | 83.26 | 5.07 | 4.38 | 13.71 | 1.39 |
| 1999 | 5492.41 | 6815 | 890 | 75.31 | 76.85 | 70.45 | 77.80 | 15.21 | 13.79 | 9.36 | 1.54 |
| 2000 | 6153.75 | 7676 | 890 | 85.40 | 87.01 | 78.72 | 87.39 | 1.08 | 0.95 | 12.04 | 1.61 |
| 2001 | 4125.07 | 5152 | 890 | 56.67 | 56.75 | 52.91 | 58.81 | 35.87 | 31.74 | 11.50 | 0.09 |
| 2002 | 6249.59 | 7586 | 890 | 86.84 | 87.56 | 80.16 | 86.60 | 0.58 | 1.91 | 10.54 | 0.72 |
| 2003 | 5733.30 | 6964 | 890 | 76.79 | 78.32 | 73.54 | 79.50 | 10.57 | 9.26 | 12.42 | 1.53 |
| 2004 | 6091.18 | 7840 | 890 | 89.26 | 89.71 | 77.91 | 89.25 | 1.97 | 1.81 | 8.48 | 0.45 |
| 2005 | 5838.83 | 7554 | 890 | 82.84 | 85.19 | 74.89 | 86.23 | 1.46 | 3.00 | 11.81 | 2.35 |
| 2006 | 6615.07 | 8077 | 890 | 88.56 | 91.15 | 84.85 | 92.20 | 0.96 | 0.89 | 7.96 | 2.59 |
| 2007 | 6050.04 | 7329 | 890 | 80.66 | 82.56 | 77.60 | 83.66 | 0.92 | 5.59 | 11.84 | 1.90 |
| 2008 | 6545.33 | 8051 | 890 | 89.68 | 90.71 | 83.72 | 91.66 | 1.59 | 2.47 | 6.82 | 1.03 |
| 2009 | 4973.23 | 6048 | 890 | 66.69 | 77.56 | 63.79 | 69.04 | 7.83 | 8.58 | 13.86 | 10.87 |
| 2010 | 6357.03 | 7511 | 890 | 83.94 | 84.85 | 81.54 | 85.74 | 2.34 | 7.82 | 7.33 | 0.91 |
| 2011 | 5426.06 | 6373 | 890 | 70.74 | 71.18 | 69.60 | 72.75 | 1.60 | 3.20 | 25.62 | 0.43 |
| 2012 | 6464.50 | 7623 | 890 | 84.47 | 86.10 | 82.69 | 86.78 | 0.74 | 2.69 | 11.21 | 1.63 |
| 2013 | 5072.13 | 5882 | 890 | 65.93 | 66.35 | 65.06 | 67.15 | 3.87 | 19.87 | 13.78 | 0.42 |
| 2014 | 6775.73 | 7927 | 890 | 87.71 | 89.35 | 86.91 | 90.49 | 0.64 | 1.87 | 8.78 | 1.64 |
| 2015 | 6035.49 | 7168 | 890 | 78.68 | 80.56 | 77.41 | 81.83 | 1.62 | 1.33 | 18.11 | 1.89 |
| 2016 | 6803.89 | 8073 | 890 | 89.34 | 90.51 | 87.03 | 91.91 | 0.77 | 0.92 | 8.56 | 1.18 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2017 | 6000.03 | 7027 | 890 | 78.72 | 79.99 | 76.96 | 80.22 | 0.30 | 3.42 | 16.59 | 1.27 |
| 2018 | 6520.92 | 7824 | 890 | 86.61 | 88.58 | 83.64 | 89.32 | 1.40 | 2.23 | 9.19 | 1.97 |
| 2019 | 4901.76 | 5699 | 890 | 63.90 | 65.93 | 62.87 | 65.06 | 10.34 | 12.95 | 21.11 | 2.03 |
| 2020 | 3532.86 | 4156 | 890 | 49.03 | 96.01 | 45.19 | 47.31 | 3.66 | 3.65 | 0.34 | 46.98 |
| 2021 | 1862.24 | 2238 | 890 | 24.11 | 44.47 | 23.89 | 25.55 | 3.90 | 8.93 | 46.60 | 20.36 |
| 2022 | 5530.96 | 6476 | 890 | 71.56 | 83.54 | 70.94 | 73.93 | 7.04 | 15.97 | 0.50 | 11.98 |
| 2023 | 4348.67 | 5699 | 890 | 60.94 | 70.25 | 55.78 | 65.06 | 5.02 | 5.36 | 24.40 | 9.31 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|---|-------------|-------------|------------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 417 | | | 357 | |
| B. Refuelling without maintenance | | | | 125 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2039 | | | 1073 | 24 | |
| D. Inspection, maintenance or repair without refuelling | | | | 43 | 1 | |
| E. Testing of plant systems or components | | | | 2 | 1 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 26 | |
| M. Governmental requirements or court decisions | | | | | | 6 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 381 | | | 58 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 224 | | 5 | 162 |
| Z. Other | | | | | 123 | |
| Subtotal | 2039 | 417 | 605 | 1243 | 537 | 232 |
| Total | | 3061 | | | 2012 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1980 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 10 |
| 12. Reactor I&C Systems | 72 | 29 |
| 13. Reactor Auxiliary Systems | | 13 |
| 14. Safety Systems | 201 | 26 |
| 15. Reactor Cooling Systems | | 30 |
| 16. Steam generation systems | | 35 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 18 |
| 32. Feedwater and Main Steam System | | 21 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | 144 | 113 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 41 |
| 42. Electrical Power Supply Systems | | 17 |
| Total | 417 | 356 |

2023 Operating Experience

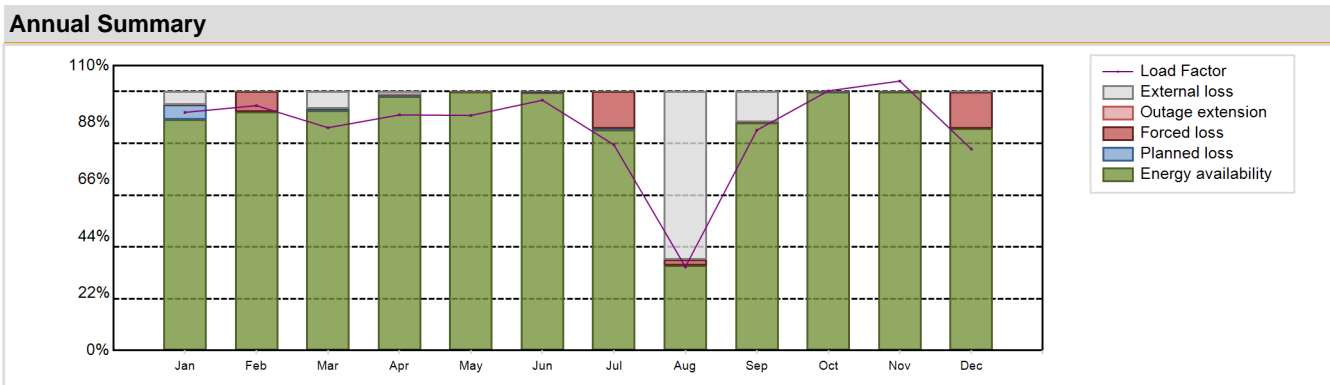
FR-29 **DAMPIERRE-2** **FRANCE**

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP1 | Construction Date | : 1975-04-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1980-12-10 |
| Gross electrical power | : 937 MWe | Commercial Date | : 1981-02-16 |
| Reference unit power (net) | : 890 MWe | Age at end of year | : 43 years |

| Design Characteristics | | | |
|---|------------|--|----------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 321 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33735 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : - |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 41 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 6679.55 GW(e).h | Forced Loss Rate (FLR) | : 3.32 % |
| Energy Availability Factor (EAF) | : 88.49 % | Unplanned Capability Loss Factor (UCL) | : 3.3 % |
| Unit Capability Factor (UCF) | : 96.09 % | Planned Unavailability Factor (PUF) | : 0.62 % |
| Load Factor (LF) | : 85.67 % | Externally cause unavailability (XUF) | : 7.6 % |
| Operating Factor (OF) | : 89.53 % | Total off-line time | : 917 hours |

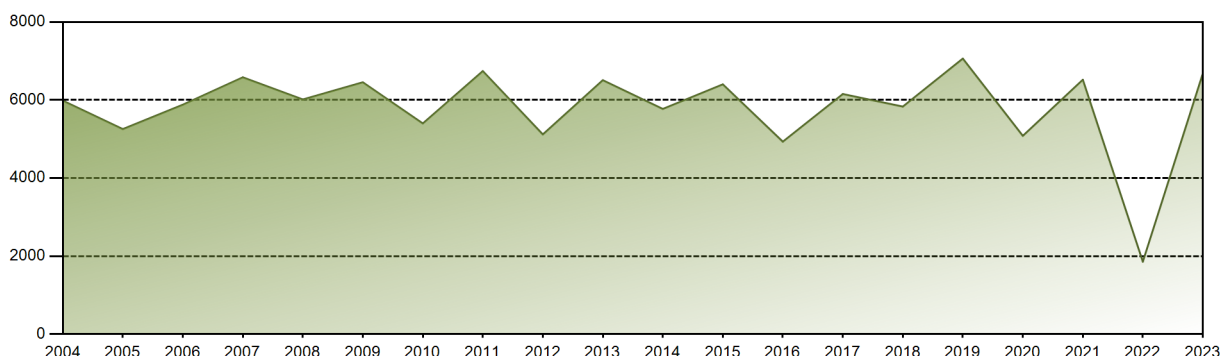


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 609.03 | 565.67 | 569.02 | 583.12 | 601.18 | 619.44 | 526.12 | 213.82 | 545.33 | 664.99 | 666.82 | 515.01 | 6679.55 |
| EAF [%] | 89.16 | 92.13 | 92.59 | 98.03 | 99.75 | 99.67 | 85.34 | 32.95 | 88.06 | 99.95 | 99.94 | 85.70 | 88.49 |
| UCF [%] | 94.34 | 92.13 | 99.20 | 99.30 | 99.75 | 99.67 | 85.34 | 97.84 | 99.85 | 99.95 | 99.94 | 85.83 | 96.09 |
| LF [%] | 91.98 | 94.58 | 86.05 | 91.00 | 90.79 | 96.67 | 79.46 | 32.29 | 85.10 | 100.29 | 104.06 | 77.78 | 85.67 |
| OF [%] | 95.30 | 93.15 | 100.00 | 100.00 | 100.00 | 100.00 | 86.83 | 35.62 | 88.89 | 99.87 | 100.00 | 76.08 | 89.53 |
| FLR [%] | 0.04 | 7.87 | 0.02 | 0.30 | 0.25 | 0.30 | 14.33 | 2.16 | 0.12 | 0.02 | 0.06 | 14.17 | 3.32 |
| UCL [%] | 0.04 | 7.87 | 0.02 | 0.30 | 0.25 | 0.30 | 14.28 | 2.16 | 0.12 | 0.02 | 0.06 | 14.17 | 3.30 |
| PUF [%] | 5.62 | 0.00 | 0.78 | 0.40 | 0.00 | 0.03 | 0.38 | 0.00 | 0.03 | 0.03 | 0.00 | 0.00 | 0.62 |
| XUF [%] | 5.18 | 0.00 | 6.61 | 1.27 | 0.00 | 0.00 | 0.00 | 64.90 | 11.79 | 0.00 | 0.00 | 0.13 | 7.60 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 237851.38 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.67 % |
| Cumulative Energy Availability Factor (EAF) | : 76.12 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.31 % |
| Cumulative Unit Capability Factor (UCF) | : 77.89 % | Cumulative Planned Unavailability Factor (PUF) | : 14.8 % |
| Cumulative Load Factor (LF) | : 70.79 % | Cumulative Externally cause unavailability (XUF) | : 1.77 % |
| Cumulative Operating Factor (OF) | : 76.37 % | | |

Electricity Production (net) [GWh]

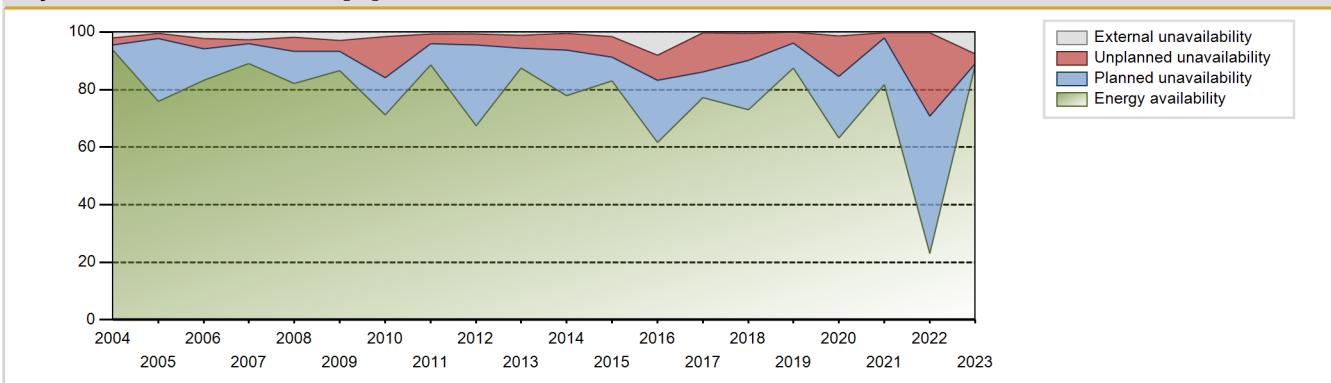


Performance for Years of Commercial Operation

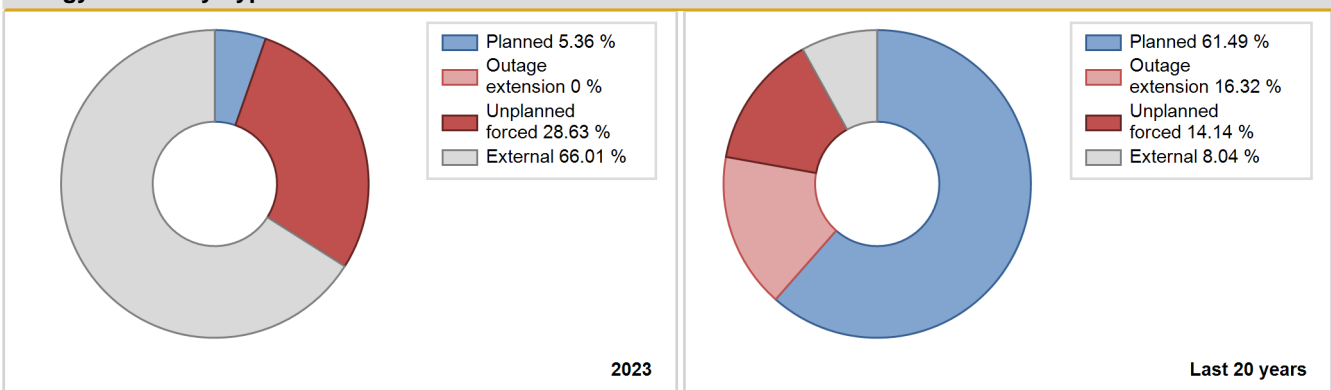
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 5818.40 | 7306 | 900 | 75.54 | 75.54 | 73.88 | 81.74 | 3.68 | 2.89 | 21.58 | 0.00 |
| 1982 | 4110.80 | 4848 | 890 | 53.04 | 53.04 | 52.73 | 55.34 | 19.31 | 12.69 | 34.27 | 0.00 |
| 1983 | 5191.00 | 6139 | 890 | 67.67 | 67.67 | 66.58 | 70.08 | 13.96 | 10.98 | 21.36 | 0.00 |
| 1984 | 5781.00 | 6884 | 890 | 76.07 | 76.07 | 73.95 | 78.37 | 8.21 | 6.80 | 17.12 | 0.00 |
| 1985 | 6056.90 | 7400 | 890 | 84.34 | 84.47 | 77.69 | 84.47 | 8.91 | 8.26 | 7.27 | 0.13 |
| 1986 | 5658.50 | 6983 | 890 | 81.99 | 82.18 | 72.58 | 79.71 | 2.22 | 1.87 | 15.95 | 0.19 |
| 1987 | 4855.97 | 5715 | 890 | 76.42 | 78.85 | 62.28 | 65.24 | 9.38 | 8.16 | 12.99 | 2.43 |
| 1988 | 4583.00 | 6153 | 890 | 92.39 | 95.06 | 58.62 | 70.05 | 4.94 | 4.94 | 0.00 | 2.67 |
| 1989 | 5485.29 | 6927 | 890 | 76.96 | 79.73 | 70.36 | 79.08 | 2.27 | 1.85 | 18.42 | 2.77 |
| 1990 | 4869.51 | 6292 | 890 | 67.77 | 69.95 | 62.46 | 71.83 | 10.53 | 8.23 | 21.82 | 2.18 |
| 1991 | 4201.95 | 5407 | 890 | 63.27 | 67.59 | 53.90 | 61.72 | 8.16 | 6.00 | 26.41 | 4.32 |
| 1992 | 5049.75 | 6429 | 890 | 74.74 | 75.87 | 64.59 | 73.19 | 11.67 | 10.02 | 14.11 | 1.13 |
| 1993 | 5976.57 | 7625 | 890 | 79.62 | 87.41 | 76.66 | 87.04 | 1.28 | 1.13 | 11.46 | 7.80 |
| 1994 | 4444.99 | 5328 | 890 | 84.77 | 84.84 | 57.01 | 60.82 | 3.76 | 3.31 | 11.85 | 0.07 |
| 1995 | 5562.04 | 6952 | 890 | 94.97 | 95.55 | 71.34 | 79.36 | 4.38 | 4.38 | 0.07 | 0.58 |
| 1996 | 5761.00 | 7437 | 890 | 81.47 | 84.23 | 73.69 | 84.67 | 3.01 | 2.61 | 13.16 | 2.75 |
| 1997 | 4966.59 | 6204 | 890 | 67.53 | 69.32 | 63.70 | 70.82 | 21.57 | 19.06 | 11.62 | 1.79 |
| 1998 | 5855.92 | 7192 | 890 | 78.32 | 80.33 | 75.11 | 82.10 | 5.67 | 4.82 | 14.85 | 2.01 |
| 1999 | 5312.90 | 6688 | 890 | 69.21 | 72.58 | 68.15 | 76.35 | 16.72 | 14.57 | 12.85 | 3.37 |
| 2000 | 5866.14 | 7121 | 890 | 76.03 | 77.55 | 75.04 | 81.07 | 10.45 | 9.05 | 13.40 | 1.52 |
| 2001 | 5355.88 | 6593 | 890 | 72.43 | 75.09 | 68.70 | 75.26 | 10.96 | 9.25 | 15.66 | 2.67 |
| 2002 | 4307.55 | 5196 | 890 | 55.95 | 56.33 | 55.25 | 59.32 | 22.06 | 15.94 | 27.72 | 0.38 |
| 2003 | 6268.32 | 7631 | 890 | 81.32 | 81.37 | 80.40 | 87.11 | 8.14 | 7.21 | 11.42 | 0.04 |
| 2004 | 5983.93 | 7286 | 890 | 93.70 | 95.73 | 76.54 | 82.95 | 2.41 | 2.36 | 1.91 | 2.03 |
| 2005 | 5255.28 | 6719 | 890 | 75.79 | 76.34 | 67.41 | 76.70 | 1.27 | 1.64 | 22.02 | 0.55 |
| 2006 | 5880.50 | 7371 | 890 | 83.23 | 85.47 | 75.43 | 84.14 | 1.12 | 3.63 | 10.90 | 2.24 |
| 2007 | 6582.66 | 8201 | 890 | 88.94 | 91.70 | 84.43 | 93.62 | 1.32 | 1.23 | 7.07 | 2.76 |
| 2008 | 6014.89 | 7462 | 890 | 82.11 | 83.97 | 76.94 | 84.95 | 2.95 | 4.77 | 11.26 | 1.86 |
| 2009 | 6455.29 | 7902 | 890 | 86.56 | 89.50 | 82.80 | 90.21 | 2.14 | 3.72 | 6.78 | 2.94 |
| 2010 | 5399.78 | 6491 | 890 | 71.18 | 72.78 | 69.26 | 74.10 | 3.65 | 14.22 | 13.00 | 1.60 |
| 2011 | 6741.93 | 7890 | 890 | 88.69 | 89.33 | 86.47 | 90.07 | 1.08 | 3.34 | 7.32 | 0.64 |
| 2012 | 5117.98 | 6091 | 890 | 67.39 | 68.14 | 65.47 | 69.34 | 0.96 | 3.72 | 28.15 | 0.74 |
| 2013 | 6508.82 | 7666 | 890 | 87.41 | 88.66 | 83.48 | 87.51 | 1.66 | 4.38 | 6.96 | 1.25 |
| 2014 | 5771.73 | 6913 | 890 | 77.81 | 78.39 | 74.03 | 78.92 | 0.99 | 5.71 | 15.89 | 0.58 |
| 2015 | 6402.25 | 7490 | 890 | 82.98 | 84.49 | 82.12 | 85.50 | 7.87 | 7.21 | 8.30 | 1.51 |
| 2016 | 4932.37 | 5619 | 890 | 61.60 | 69.59 | 63.09 | 63.97 | 0.64 | 8.86 | 21.55 | 7.99 |
| 2017 | 6153.50 | 6869 | 890 | 77.15 | 77.36 | 78.93 | 78.41 | 13.03 | 13.67 | 8.97 | 0.21 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2018 | 5831.89 | 6585 | 890 | 72.94 | 73.46 | 74.80 | 75.17 | 5.93 | 9.23 | 17.30 | 0.53 |
| 2019 | 7062.17 | 7793 | 890 | 87.56 | 87.57 | 90.58 | 88.96 | 4.20 | 3.84 | 8.58 | 0.01 |
| 2020 | 5081.11 | 6011 | 890 | 63.08 | 64.56 | 64.99 | 68.43 | 9.29 | 13.96 | 21.48 | 1.48 |
| 2021 | 6520.64 | 7346 | 890 | 81.73 | 81.93 | 83.64 | 83.86 | 1.98 | 1.94 | 16.14 | 0.20 |
| 2022 | 1855.50 | 2069 | 890 | 23.07 | 23.21 | 23.80 | 23.62 | 27.60 | 28.99 | 47.79 | 0.14 |
| 2023 | 6679.55 | 7843 | 890 | 88.49 | 96.09 | 85.67 | 89.53 | 3.32 | 3.30 | 0.62 | 7.60 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 250 | | | 408 | |
| B. Refuelling without maintenance | | | | 141 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1032 | 11 | |
| D. Inspection, maintenance or repair without refuelling | | | | 53 | | |
| E. Testing of plant systems or components | | | | 5 | 0 | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 2 |
| L. Human factor related | | | | | 13 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| O. Load dispatching, prioritization | | | 72 | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 1 | 19 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 589 | | 8 | 14 |
| Z. Other | | | | | 94 | 15 |
| Subtotal | | 250 | 661 | 1231 | 538 | 54 |
| Total | | 911 | | | 1823 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 4 |
| 12. Reactor I&C Systems | | 11 |
| 13. Reactor Auxiliary Systems | | 11 |
| 14. Safety Systems | 106 | 26 |
| 15. Reactor Cooling Systems | 46 | 35 |
| 16. Steam generation systems | | 34 |
| 21. Fuel Handling and Storage Facilities | | 6 |
| 31. Turbine and auxiliaries | 98 | 68 |
| 32. Feedwater and Main Steam System | | 17 |
| 34. Miscellaneous Systems | | 130 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 35 |
| 42. Electrical Power Supply Systems | | 44 |
| Total | 250 | 421 |

2023 Operating Experience

FR-30 **DAMPIERRE-3** **FRANCE**

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP1 | Construction Date | : 1975-09-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1981-01-30 |
| Gross electrical power | : 937 MWe | Commercial Date | : 1981-05-27 |
| Reference unit power (net) | : 890 MWe | Age at end of year | : 42 years |

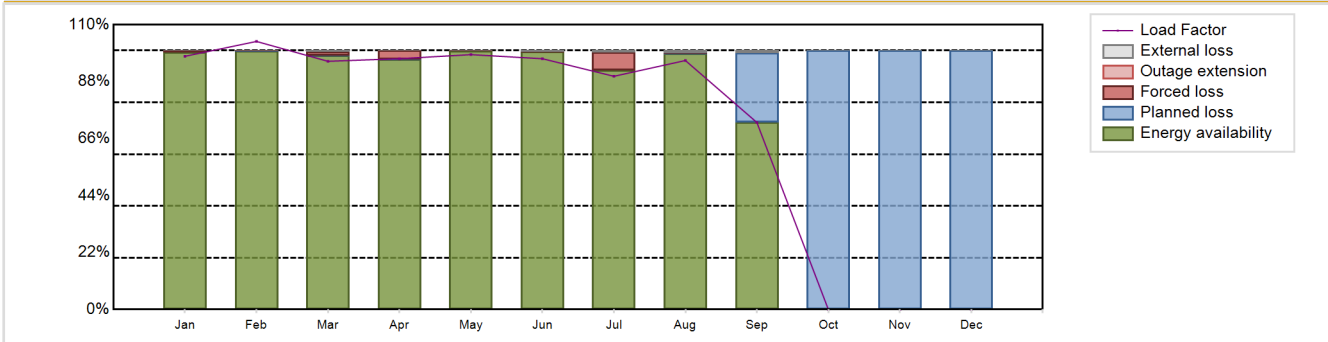
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.8 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 321 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 5 |
| Refuelling frequency [month] | : 12 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 33735 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : 41 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 5490.16 GW(e).h | Forced Loss Rate (FLR) | : 1.45 % |
| Energy Availability Factor (EAF) | : 71.24 % | Unplanned Capability Loss Factor (UCL) | : 1.05 % |
| Unit Capability Factor (UCF) | : 71.52 % | Planned Unavailability Factor (PUF) | : 27.43 % |
| Load Factor (LF) | : 70.42 % | Externally cause unavailability (XUF) | : 0.28 % |
| Operating Factor (OF) | : 71.85 % | Total off-line time | : 2466 hours |

Annual Summary

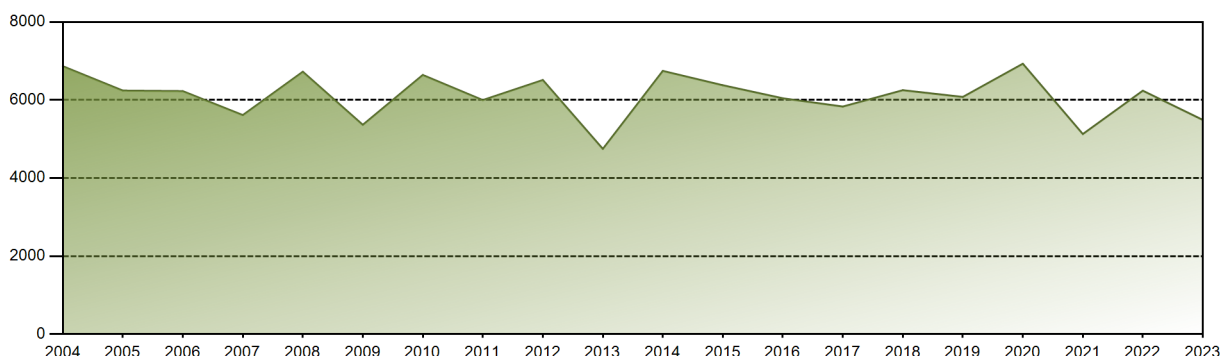


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 647.57 | 619.22 | 633.92 | 620.79 | 651.80 | 620.72 | 596.44 | 636.80 | 462.90 | 0.00 | 0.00 | 0.00 | 5490.16 |
| EAF [%] | 99.48 | 99.97 | 98.04 | 96.74 | 99.97 | 99.51 | 92.40 | 98.89 | 72.25 | 0.00 | 0.00 | 0.00 | 71.24 |
| UCF [%] | 99.48 | 99.97 | 98.41 | 96.74 | 99.97 | 99.96 | 93.04 | 99.82 | 73.25 | 0.00 | 0.00 | 0.00 | 71.52 |
| LF [%] | 97.80 | 103.53 | 95.86 | 96.88 | 98.44 | 96.87 | 90.08 | 96.17 | 72.24 | 0.00 | 0.00 | 0.00 | 70.42 |
| OF [%] | 97.85 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.41 | 100.00 | 73.33 | 0.00 | 0.00 | 0.00 | 71.85 |
| FLR [%] | 0.52 | 0.03 | 1.53 | 3.25 | 0.03 | 0.01 | 6.96 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 1.45 |
| UCL [%] | 0.52 | 0.03 | 1.53 | 3.25 | 0.03 | 0.01 | 6.96 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 1.05 |
| PUF [%] | 0.00 | 0.01 | 0.06 | 0.00 | 0.00 | 0.03 | 0.00 | 0.05 | 26.75 | 100.00 | 100.00 | 100.00 | 27.43 |
| XUF [%] | 0.00 | 0.00 | 0.37 | 0.00 | 0.00 | 0.45 | 0.64 | 0.93 | 1.00 | 0.00 | 0.00 | 0.00 | 0.28 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 248813.39 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.65 % |
| Cumulative Energy Availability Factor (EAF) | : 77.58 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.97 % |
| Cumulative Unit Capability Factor (UCF) | : 79.28 % | Cumulative Planned Unavailability Factor (PUF) | : 14.75 % |
| Cumulative Load Factor (LF) | : 74.43 % | Cumulative Externally cause unavailability (XUF) | : 1.7 % |
| Cumulative Operating Factor (OF) | : 79 % | | |

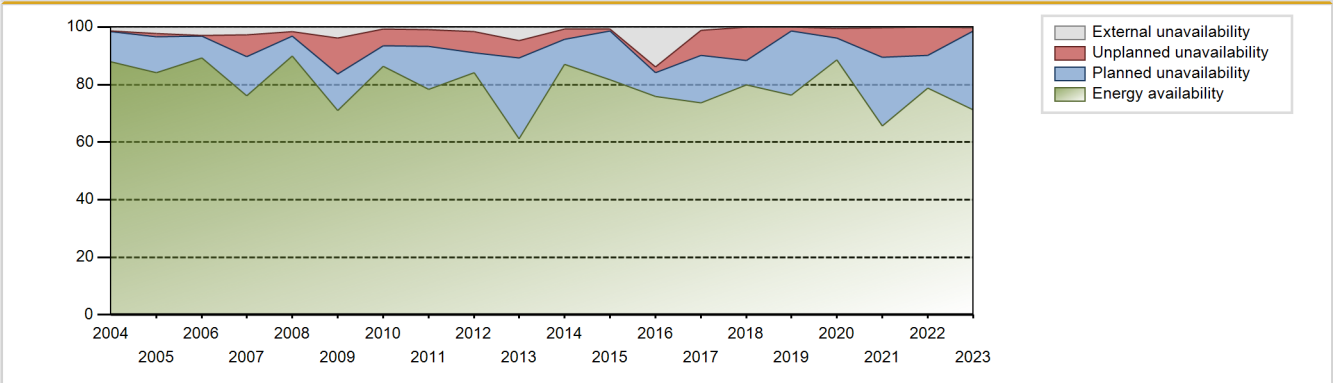
Electricity Production (net) [GWh]



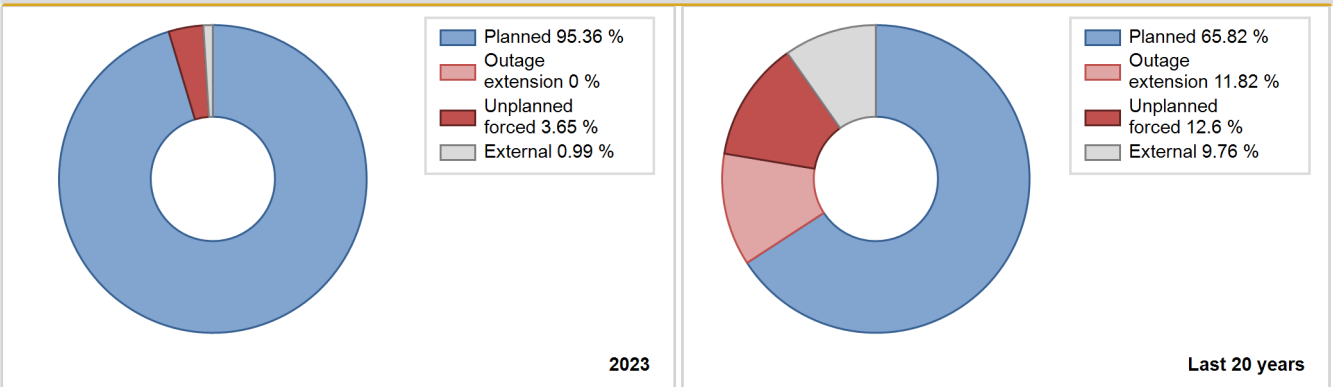
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 5123.40 | 6452 | 900 | 83.51 | 83.51 | 81.70 | 86.95 | 3.93 | 3.41 | 13.08 | 0.00 |
| 1982 | 3767.60 | 4632 | 890 | 48.72 | 48.72 | 48.32 | 52.88 | 22.04 | 13.77 | 37.51 | 0.00 |
| 1983 | 5517.00 | 6638 | 890 | 72.69 | 72.69 | 70.76 | 75.78 | 12.35 | 10.24 | 17.07 | 0.00 |
| 1984 | 6206.00 | 7121 | 890 | 79.68 | 79.68 | 79.38 | 81.07 | 7.35 | 6.32 | 14.00 | 0.00 |
| 1985 | 6364.40 | 7523 | 890 | 84.89 | 85.11 | 81.63 | 85.88 | 2.99 | 2.62 | 12.26 | 0.22 |
| 1986 | 6717.20 | 8330 | 890 | 99.52 | 99.87 | 86.16 | 95.09 | 0.13 | 0.13 | 0.00 | 0.35 |
| 1987 | 5019.50 | 6269 | 890 | 79.33 | 82.43 | 64.38 | 71.56 | 7.76 | 6.94 | 10.63 | 3.10 |
| 1988 | 4964.00 | 6435 | 890 | 68.53 | 72.91 | 63.50 | 73.26 | 8.48 | 6.75 | 20.34 | 4.37 |
| 1989 | 5912.85 | 7242 | 890 | 78.38 | 82.16 | 75.84 | 82.67 | 5.95 | 5.20 | 12.65 | 3.78 |
| 1990 | 5996.46 | 7348 | 890 | 79.77 | 82.50 | 76.91 | 83.88 | 1.91 | 1.61 | 15.89 | 2.73 |
| 1991 | 5124.05 | 6244 | 890 | 69.56 | 70.04 | 65.72 | 71.28 | 18.40 | 15.79 | 14.17 | 0.47 |
| 1992 | 4875.11 | 5814 | 890 | 65.50 | 65.51 | 62.36 | 66.19 | 5.88 | 4.10 | 30.40 | 0.00 |
| 1993 | 6148.83 | 7333 | 890 | 82.76 | 82.76 | 78.87 | 83.71 | 4.85 | 4.22 | 13.02 | 0.00 |
| 1994 | 5537.56 | 7013 | 890 | 82.73 | 86.17 | 71.03 | 80.06 | 0.38 | 0.33 | 13.50 | 3.43 |
| 1995 | 4773.50 | 6343 | 890 | 80.20 | 83.44 | 61.23 | 72.41 | 0.78 | 0.65 | 15.91 | 3.24 |
| 1996 | 5575.09 | 6940 | 890 | 77.08 | 77.63 | 71.31 | 79.01 | 7.66 | 6.44 | 15.93 | 0.55 |
| 1997 | 5720.89 | 7211 | 890 | 78.29 | 81.02 | 73.38 | 82.32 | 8.56 | 7.59 | 11.39 | 2.73 |
| 1998 | 5905.83 | 7210 | 890 | 81.44 | 82.67 | 75.75 | 82.31 | 6.68 | 5.91 | 11.41 | 1.24 |
| 1999 | 5779.45 | 7186 | 890 | 78.23 | 80.89 | 74.13 | 82.03 | 6.34 | 5.47 | 13.64 | 2.66 |
| 2000 | 4308.35 | 5378 | 890 | 57.58 | 59.78 | 55.11 | 61.22 | 31.56 | 27.56 | 12.66 | 2.20 |
| 2001 | 5993.02 | 7060 | 890 | 77.38 | 77.75 | 76.87 | 80.59 | 5.76 | 7.77 | 14.48 | 0.38 |
| 2002 | 5929.80 | 6877 | 890 | 76.85 | 77.42 | 76.06 | 78.50 | 9.75 | 8.36 | 14.22 | 0.57 |
| 2003 | 5346.90 | 6152 | 890 | 68.91 | 68.98 | 68.58 | 70.23 | 4.75 | 3.44 | 27.59 | 0.07 |
| 2004 | 6867.17 | 7920 | 890 | 87.98 | 89.25 | 87.84 | 90.16 | 0.43 | 0.39 | 10.36 | 1.27 |
| 2005 | 6242.37 | 7627 | 890 | 84.13 | 86.49 | 80.06 | 87.06 | 1.25 | 1.10 | 12.41 | 2.36 |
| 2006 | 6228.48 | 7991 | 890 | 89.29 | 92.26 | 79.89 | 91.22 | 0.30 | 0.28 | 7.46 | 2.98 |
| 2007 | 5614.09 | 6928 | 890 | 76.03 | 78.72 | 72.01 | 79.09 | 7.35 | 7.58 | 13.69 | 2.69 |
| 2008 | 6725.61 | 8100 | 890 | 89.97 | 91.52 | 86.03 | 92.21 | 0.31 | 1.52 | 6.97 | 1.55 |
| 2009 | 5364.97 | 6486 | 890 | 71.00 | 74.75 | 68.81 | 74.04 | 3.64 | 12.66 | 12.59 | 3.75 |
| 2010 | 6642.91 | 7660 | 890 | 86.31 | 87.03 | 85.20 | 87.44 | 3.52 | 5.89 | 7.08 | 0.72 |
| 2011 | 5999.40 | 7020 | 890 | 78.44 | 79.35 | 76.95 | 80.14 | 0.30 | 5.88 | 14.77 | 0.91 |
| 2012 | 6513.75 | 7595 | 890 | 84.17 | 85.86 | 83.32 | 86.46 | 0.30 | 7.24 | 6.90 | 1.68 |
| 2013 | 4747.59 | 5438 | 890 | 61.14 | 65.81 | 60.89 | 62.08 | 0.78 | 6.13 | 28.06 | 4.67 |
| 2014 | 6746.72 | 7824 | 890 | 87.13 | 87.95 | 86.54 | 89.32 | 0.89 | 3.42 | 8.64 | 0.82 |
| 2015 | 6378.71 | 7269 | 890 | 81.62 | 82.37 | 81.82 | 82.98 | 0.68 | 0.57 | 17.06 | 0.75 |
| 2016 | 6045.05 | 6807 | 890 | 75.83 | 89.75 | 77.32 | 77.49 | 0.36 | 1.94 | 8.32 | 13.91 |
| 2017 | 5832.29 | 6540 | 890 | 73.65 | 74.76 | 74.81 | 74.66 | 6.55 | 8.80 | 16.44 | 1.11 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2018 | 6252.31 | 7054 | 890 | 79.82 | 79.84 | 80.19 | 80.53 | 7.26 | 11.58 | 8.58 | 0.02 |
| 2019 | 6079.01 | 6794 | 890 | 76.33 | 76.40 | 77.97 | 77.56 | 1.66 | 1.29 | 22.31 | 0.08 |
| 2020 | 6930.71 | 7929 | 890 | 88.50 | 88.90 | 88.65 | 90.27 | 3.82 | 3.53 | 7.57 | 0.40 |
| 2021 | 5127.77 | 5899 | 890 | 65.67 | 65.84 | 65.77 | 67.34 | 12.25 | 10.35 | 23.81 | 0.16 |
| 2022 | 6238.98 | 6953 | 890 | 78.77 | 78.92 | 80.02 | 79.37 | 9.73 | 9.67 | 11.42 | 0.15 |
| 2023 | 5490.16 | 6294 | 890 | 71.24 | 71.52 | 70.42 | 71.85 | 1.45 | 1.05 | 27.43 | 0.28 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|-------------|-------------|-----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 49 | | | 332 | |
| B. Refuelling without maintenance | | | | 105 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2400 | | | 1128 | 7 | |
| D. Inspection, maintenance or repair without refuelling | | | | 20 | 1 | |
| E. Testing of plant systems or components | | | | 4 | 1 | |
| I. Grid capacity limitation | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 2 |
| L. Human factor related | | | | | 23 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| O. Load dispatching, prioritization | | | 16 | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 3 | 43 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 5 | 1 |
| Z. Other | | | | | 68 | |
| Subtotal | 2400 | 49 | 16 | 1257 | 440 | 48 |
| Total | | 2465 | | | 1745 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 1 |
| 12. Reactor I&C Systems | | 5 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | | 43 |
| 15. Reactor Cooling Systems | | 58 |
| 16. Steam generation systems | | 61 |
| 31. Turbine and auxiliaries | 49 | 35 |
| 32. Feedwater and Main Steam System | | 10 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 75 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 22 |
| 42. Electrical Power Supply Systems | 0 | 38 |
| Total | 49 | 359 |

2023 Operating Experience

FR-31

DAMPIERRE-4

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2785 MWth
 Gross electrical power : 937 MWe
 Reference unit power (net) : 890 MWe

Key Dates

Construction Date : 1975-12-01
 Grid Date : 1981-08-18
 Commercial Date : 1981-11-20
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 41
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.61
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

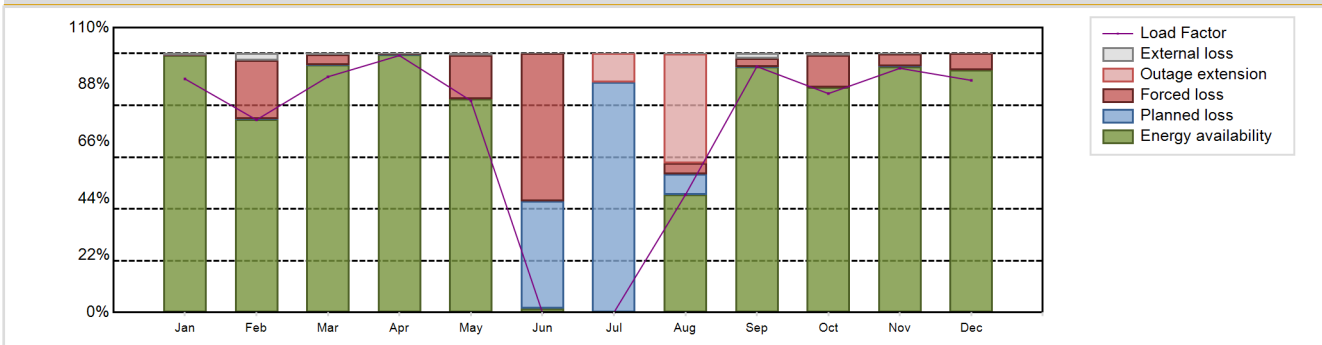
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 5490.5 GW(e).h
 Energy Availability Factor (EAF) : 72.42 %
 Unit Capability Factor (UCF) : 72.97 %
 Load Factor (LF) : 70.42 %
 Operating Factor (OF) : 75.73 %
 Forced Loss Rate (FLR) : 12.94 %
 Unplanned Capability Loss Factor (UCL) : 15.36 %
 Planned Unavailability Factor (PUF) : 11.68 %
 Externally cause unavailability (XUF) : 0.54 %
 Total off-line time : 2126 hours

Annual Summary

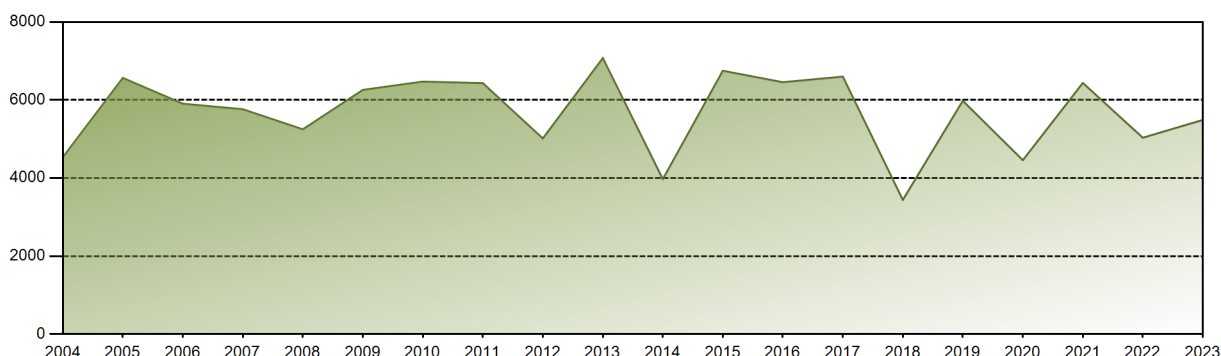


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|-------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 597.42 | 445.04 | 602.09 | 635.99 | 541.63 | 0.01 | 0.00 | 300.88 | 608.72 | 560.66 | 604.42 | 593.65 | 5490.50 |
| EAF [%] | 99.29 | 74.60 | 95.55 | 99.57 | 82.61 | 1.69 | 0.00 | 45.44 | 95.01 | 86.90 | 94.99 | 93.71 | 72.42 |
| UCF [%] | 99.80 | 77.21 | 95.92 | 99.72 | 83.13 | 1.69 | 0.00 | 45.56 | 96.80 | 87.47 | 95.05 | 93.71 | 72.97 |
| LF [%] | 90.22 | 74.41 | 91.05 | 99.25 | 81.80 | 0.00 | 0.00 | 45.44 | 94.99 | 84.56 | 94.32 | 89.65 | 70.42 |
| OF [%] | 100.00 | 82.14 | 100.00 | 100.00 | 84.95 | 0.00 | 0.00 | 57.93 | 100.00 | 88.59 | 95.56 | 100.00 | 75.73 |
| FLR [%] | 0.18 | 22.68 | 4.07 | 0.17 | 16.87 | 97.11 | 0.00 | 8.45 | 3.19 | 12.53 | 4.89 | 6.29 | 12.94 |
| UCL [%] | 0.18 | 22.65 | 4.07 | 0.17 | 16.87 | 56.92 | 11.02 | 46.32 | 3.19 | 12.53 | 4.88 | 6.29 | 15.36 |
| PUF [%] | 0.02 | 0.14 | 0.01 | 0.11 | 0.00 | 41.39 | 88.98 | 8.12 | 0.01 | 0.00 | 0.07 | 0.00 | 11.68 |
| XUF [%] | 0.52 | 2.61 | 0.37 | 0.16 | 0.53 | 0.00 | 0.00 | 0.11 | 1.80 | 0.57 | 0.06 | 0.00 | 0.54 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 236149.93 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.52 % |
| Cumulative Energy Availability Factor (EAF) | : 75.38 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.54 % |
| Cumulative Unit Capability Factor (UCF) | : 77.68 % | Cumulative Planned Unavailability Factor (PUF) | : 13.78 % |
| Cumulative Load Factor (LF) | : 71.57 % | Cumulative Externally cause unavailability (XUF) | : 2.3 % |
| Cumulative Operating Factor (OF) | : 77.52 % | | |

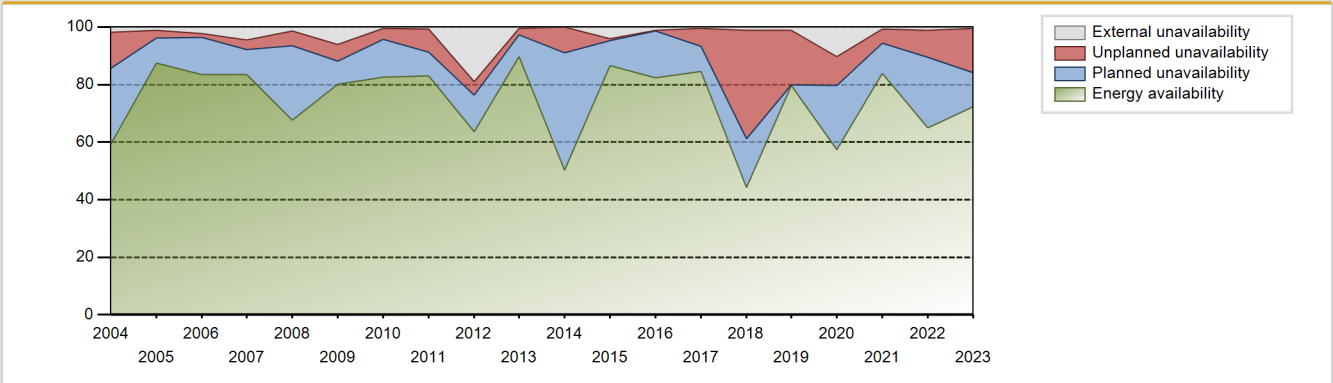
Electricity Production (net) [GWh]



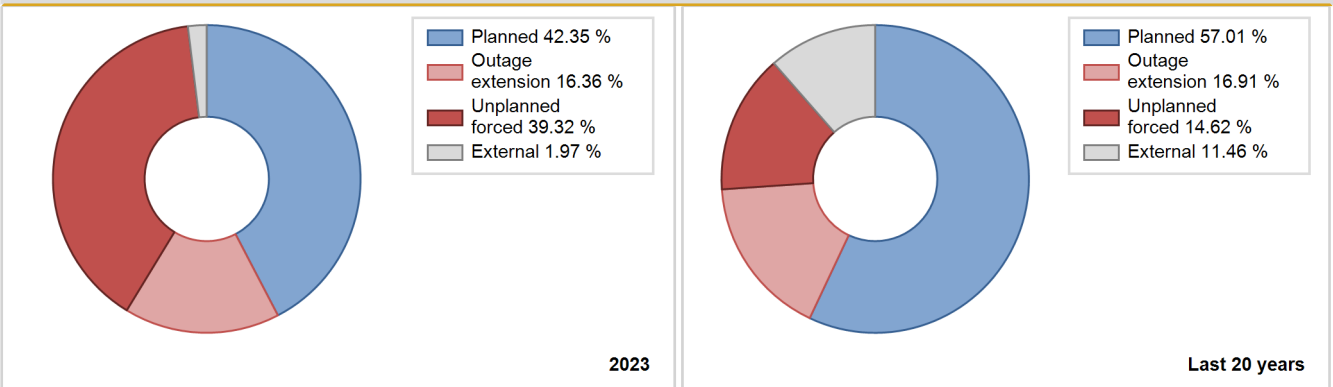
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 1569.50 | 2392 | 894 | 77.30 | 77.30 | 77.30 | 79.30 | 0.00 | 0.00 | 22.70 | 0.00 |
| 1982 | 5745.60 | 7413 | 890 | 81.81 | 81.81 | 73.70 | 84.62 | 18.19 | 18.19 | 0.00 | 0.00 |
| 1983 | 4156.00 | 5207 | 890 | 57.60 | 57.60 | 53.31 | 59.44 | 13.86 | 9.27 | 33.13 | 0.00 |
| 1984 | 6276.00 | 7765 | 890 | 85.10 | 85.10 | 80.28 | 88.40 | 4.15 | 3.69 | 11.21 | 0.00 |
| 1985 | 5859.90 | 7387 | 890 | 78.92 | 83.46 | 75.16 | 84.33 | 5.42 | 4.78 | 11.76 | 4.54 |
| 1986 | 6664.90 | 7862 | 890 | 88.47 | 88.80 | 85.49 | 89.75 | 1.03 | 0.93 | 10.28 | 0.33 |
| 1987 | 5447.80 | 6795 | 890 | 78.10 | 78.40 | 69.88 | 77.57 | 6.17 | 5.15 | 16.44 | 0.31 |
| 1988 | 5086.00 | 6645 | 890 | 79.93 | 82.92 | 65.06 | 75.65 | 4.87 | 4.25 | 12.83 | 2.99 |
| 1989 | 5392.37 | 6621 | 890 | 72.88 | 73.73 | 69.16 | 75.58 | 6.75 | 5.33 | 20.94 | 0.85 |
| 1990 | 5153.00 | 6792 | 890 | 87.31 | 91.20 | 66.09 | 77.53 | 2.32 | 2.17 | 6.63 | 3.89 |
| 1991 | 6062.80 | 7612 | 890 | 86.70 | 88.34 | 77.76 | 86.89 | 3.50 | 3.21 | 8.45 | 1.64 |
| 1992 | 5331.48 | 6832 | 890 | 74.50 | 76.68 | 68.20 | 77.78 | 10.71 | 9.19 | 14.13 | 2.18 |
| 1993 | 4827.70 | 6103 | 890 | 63.35 | 69.25 | 61.92 | 69.67 | 8.17 | 6.16 | 24.59 | 5.90 |
| 1994 | 5263.99 | 7103 | 890 | 79.52 | 80.74 | 67.52 | 81.08 | 9.93 | 8.90 | 10.36 | 1.22 |
| 1995 | 5488.04 | 6997 | 890 | 75.36 | 78.84 | 70.39 | 79.87 | 10.89 | 9.63 | 11.52 | 3.48 |
| 1996 | 6118.49 | 7596 | 890 | 82.93 | 83.67 | 78.26 | 86.48 | 4.95 | 4.35 | 11.98 | 0.74 |
| 1997 | 5918.58 | 7178 | 890 | 80.46 | 80.86 | 75.91 | 81.94 | 5.26 | 4.48 | 14.66 | 0.39 |
| 1998 | 4506.48 | 5435 | 890 | 58.98 | 60.59 | 57.80 | 62.04 | 26.81 | 22.20 | 17.22 | 1.60 |
| 1999 | 4642.53 | 5770 | 890 | 64.13 | 64.76 | 59.55 | 65.87 | 28.25 | 25.50 | 9.74 | 0.63 |
| 2000 | 5598.66 | 6752 | 890 | 75.15 | 76.02 | 71.61 | 76.87 | 11.87 | 10.24 | 13.74 | 0.87 |
| 2001 | 5361.82 | 6422 | 890 | 70.08 | 70.91 | 68.77 | 73.31 | 28.41 | 28.14 | 0.95 | 0.83 |
| 2002 | 6134.48 | 7576 | 890 | 83.77 | 85.28 | 78.68 | 86.48 | 2.77 | 2.43 | 12.30 | 1.50 |
| 2003 | 5547.40 | 6759 | 890 | 73.37 | 77.39 | 71.15 | 77.16 | 3.55 | 9.60 | 13.02 | 4.02 |
| 2004 | 4531.79 | 5551 | 890 | 59.44 | 61.31 | 57.97 | 63.19 | 16.90 | 12.47 | 26.23 | 1.87 |
| 2005 | 6566.95 | 7956 | 890 | 87.56 | 88.67 | 84.22 | 90.81 | 1.62 | 2.61 | 8.71 | 1.11 |
| 2006 | 5905.36 | 7428 | 890 | 83.57 | 85.77 | 75.74 | 84.79 | 1.50 | 1.45 | 12.79 | 2.20 |
| 2007 | 5763.52 | 7384 | 890 | 83.51 | 88.11 | 73.93 | 84.29 | 3.21 | 3.30 | 8.59 | 4.60 |
| 2008 | 5249.14 | 6317 | 890 | 67.53 | 68.82 | 67.14 | 71.91 | 4.44 | 5.11 | 26.07 | 1.29 |
| 2009 | 6259.13 | 7151 | 890 | 80.17 | 86.31 | 80.28 | 81.63 | 2.04 | 5.80 | 7.90 | 6.13 |
| 2010 | 6472.40 | 7344 | 890 | 82.59 | 83.17 | 83.02 | 83.84 | 0.18 | 3.71 | 13.12 | 0.59 |
| 2011 | 6433.47 | 7506 | 890 | 83.13 | 83.74 | 82.52 | 85.68 | 5.60 | 8.16 | 8.10 | 0.61 |
| 2012 | 5014.64 | 5644 | 890 | 63.57 | 82.56 | 64.14 | 64.25 | 0.30 | 4.66 | 12.78 | 18.98 |
| 2013 | 7074.86 | 7942 | 890 | 89.80 | 90.31 | 90.75 | 90.66 | 0.65 | 2.17 | 7.51 | 0.52 |
| 2014 | 3970.80 | 4507 | 890 | 50.26 | 50.26 | 50.93 | 51.45 | 0.36 | 8.86 | 40.87 | 0.00 |
| 2015 | 6750.08 | 8025 | 890 | 86.66 | 90.66 | 86.58 | 91.61 | 0.38 | 0.81 | 8.53 | 4.00 |
| 2016 | 6456.43 | 7442 | 890 | 82.44 | 83.60 | 82.59 | 84.72 | 0.19 | 0.16 | 16.24 | 1.16 |
| 2017 | 6599.79 | 7688 | 890 | 84.58 | 85.18 | 84.65 | 87.76 | 3.79 | 6.03 | 8.80 | 0.60 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2018 | 3438.52 | 4116 | 890 | 44.32 | 45.36 | 44.10 | 46.99 | 4.16 | 37.73 | 16.91 | 1.03 |
| 2019 | 5979.78 | 7196 | 890 | 79.76 | 80.98 | 76.70 | 82.15 | 19.00 | 19.00 | 0.03 | 1.21 |
| 2020 | 4457.67 | 5335 | 890 | 57.36 | 67.76 | 57.02 | 60.74 | 4.49 | 9.84 | 22.40 | 10.40 |
| 2021 | 6437.40 | 7571 | 890 | 83.92 | 84.56 | 82.57 | 86.43 | 5.59 | 5.01 | 10.43 | 0.64 |
| 2022 | 5033.31 | 6027 | 890 | 65.03 | 66.22 | 64.56 | 68.80 | 2.58 | 9.39 | 24.39 | 1.19 |
| 2023 | 5490.50 | 6634 | 890 | 72.42 | 72.97 | 70.42 | 75.73 | 12.94 | 15.36 | 11.68 | 0.54 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|-------------|-----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1154 | | | 524 | |
| B. Refuelling without maintenance | 960 | | | 138 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1007 | 20 | |
| D. Inspection, maintenance or repair without refuelling | | | | 4 | 1 | |
| E. Testing of plant systems or components | | | | 4 | 1 | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 12 |
| L. Human factor related | | | | | 17 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 24 |
| O. Load dispatching, prioritization | | | 12 | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 3 | 61 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 6 | 1 |
| Z. Other | | | | | 63 | 6 |
| Subtotal | 960 | 1154 | 12 | 1153 | 636 | 106 |
| Total | | 2126 | | | 1895 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 36 |
| 12. Reactor I&C Systems | 112 | 6 |
| 13. Reactor Auxiliary Systems | | 37 |
| 14. Safety Systems | | 9 |
| 15. Reactor Cooling Systems | | 13 |
| 16. Steam generation systems | | 130 |
| 21. Fuel Handling and Storage Facilities | | 10 |
| 31. Turbine and auxiliaries | | 39 |
| 32. Feedwater and Main Steam System | 120 | 27 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | 395 | 124 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | 117 | 71 |
| 42. Electrical Power Supply Systems | 410 | 18 |
| Total | 1154 | 522 |

2023 Operating Experience

FR-46 **FLAMANVILLE-1** **FRANCE**

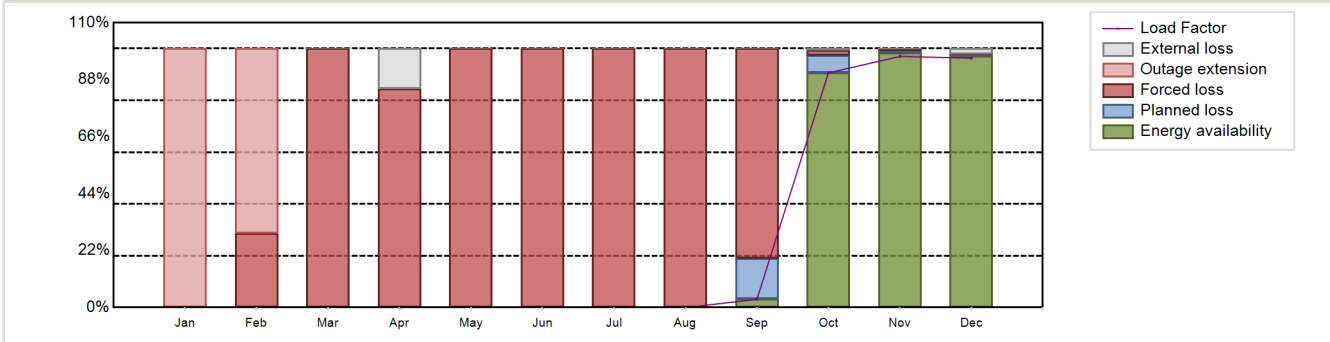
Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PWR / P4 REP 1300 | Construction Date | : 1979-12-01 |
| Thermal power | : 3817 MWth | Grid Date | : 1985-12-04 |
| Gross electrical power | : 1382 MWe | Commercial Date | : 1986-12-01 |
| Reference unit power (net) | : 1330 MWe | Age at end of year | : 38 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 328.7 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 4.1 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.37 | HP cylinder inlet steam pressure [MPa] | : 6.95 |
| Active core height/length [m] | : 4.267 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 193 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.2 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 53 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 2809.51 GW(e).h | Forced Loss Rate (FLR) | : 69.28 % |
| Energy Availability Factor (EAF) | : 24.31 % | Unplanned Capability Loss Factor (UCL) | : 72.21 % |
| Unit Capability Factor (UCF) | : 25.83 % | Planned Unavailability Factor (PUF) | : 1.96 % |
| Load Factor (LF) | : 24.11 % | Externally cause unavailability (XUF) | : 1.52 % |
| Operating Factor (OF) | : 26.6 % | Total off-line time | : 6430 hours |

Annual Summary

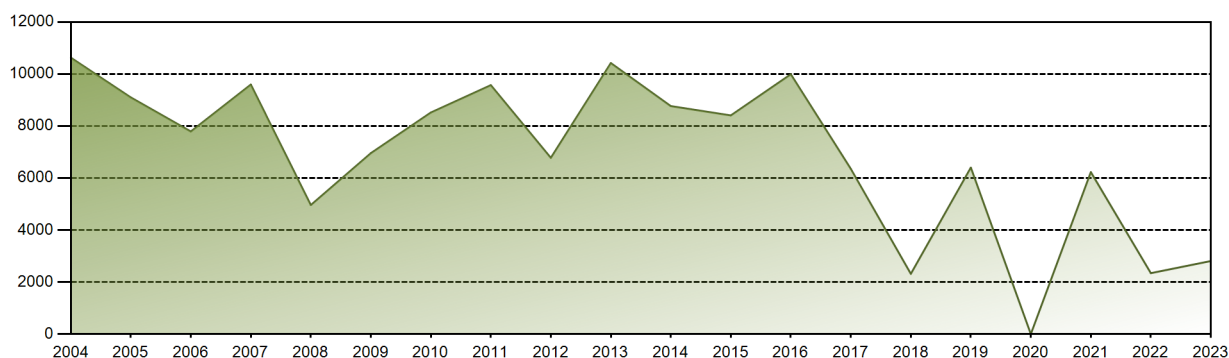


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|-------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 30.08 | 897.83 | 928.51 | 953.09 | 2809.51 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.22 | 90.65 | 98.38 | 97.13 | 24.31 |
| UCF [%] | 0.00 | 0.00 | 0.00 | 15.42 | 0.00 | 0.00 | 0.00 | 0.00 | 3.22 | 91.24 | 98.54 | 99.30 | 25.83 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.14 | 90.61 | 96.96 | 96.32 | 24.11 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.89 | 99.87 | 100.00 | 98.12 | 26.60 |
| FLR [%] | 0.00 | 100.00 | 100.00 | 84.58 | 100.00 | 100.00 | 100.00 | 100.00 | 96.18 | 2.30 | 0.63 | 0.22 | 69.28 |
| UCL [%] | 100.00 | 100.00 | 100.00 | 84.58 | 100.00 | 100.00 | 100.00 | 100.00 | 81.09 | 2.15 | 0.63 | 0.22 | 72.21 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.69 | 6.61 | 0.83 | 0.48 | 1.96 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 15.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.59 | 0.17 | 2.18 | 1.52 |

Historical Summary

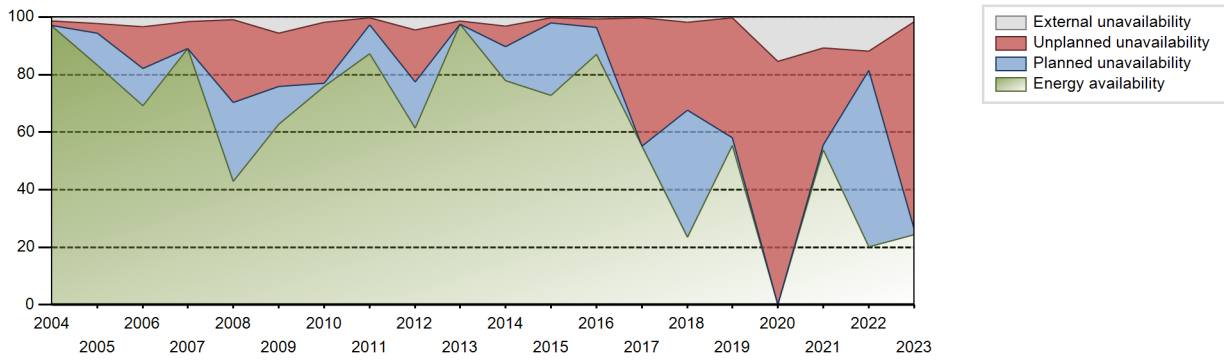
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 275472.49 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 16.47 % |
| Cumulative Energy Availability Factor (EAF) | : 66.85 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 16.9 % |
| Cumulative Unit Capability Factor (UCF) | : 69.93 % | Cumulative Planned Unavailability Factor (PUF) | : 13.16 % |
| Cumulative Load Factor (LF) | : 63.04 % | Cumulative Externally cause unavailability (XUF) | : 3.09 % |
| Cumulative Operating Factor (OF) | : 69.22 % | | |

Electricity Production (net) [GWh]

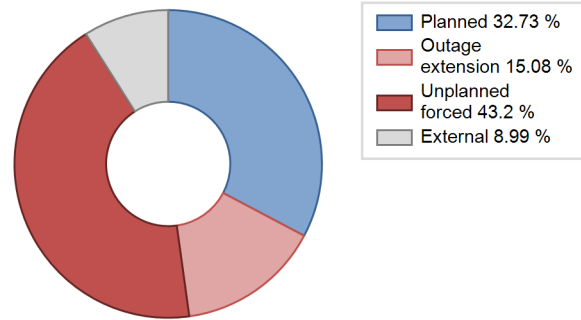
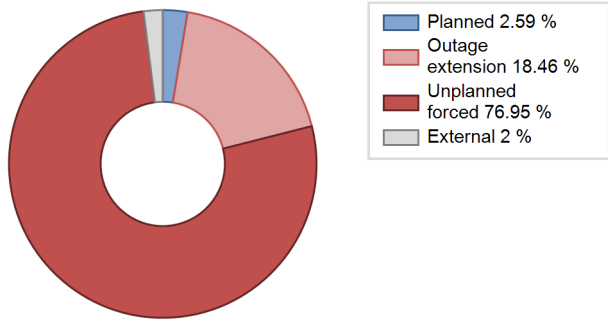


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 5273.00 | 4840 | 1290 | 97.32 | 97.34 | 100.64 | 97.58 | 2.66 | 2.66 | 0.00 | 0.02 |
| 1987 | 7150.80 | 5656 | 1290 | 62.17 | 63.23 | 63.28 | 64.57 | 15.78 | 11.84 | 24.93 | 1.06 |
| 1988 | 7175.00 | 5757 | 1330 | 66.02 | 67.42 | 61.42 | 65.54 | 19.17 | 15.99 | 16.59 | 1.40 |
| 1989 | 8775.16 | 7146 | 1330 | 80.59 | 81.02 | 75.32 | 81.58 | 18.90 | 18.88 | 0.10 | 0.43 |
| 1990 | 7089.98 | 6360 | 1330 | 65.70 | 67.04 | 60.85 | 72.60 | 18.85 | 15.57 | 17.39 | 1.35 |
| 1991 | 5882.88 | 5481 | 1330 | 59.40 | 68.35 | 50.49 | 62.57 | 15.52 | 12.56 | 19.09 | 8.96 |
| 1992 | 7606.83 | 5901 | 1330 | 66.20 | 66.20 | 65.11 | 67.18 | 20.37 | 16.93 | 16.87 | 0.00 |
| 1993 | 9301.82 | 7936 | 1330 | 87.17 | 96.79 | 79.84 | 90.59 | 3.15 | 3.15 | 0.06 | 9.63 |
| 1994 | 7145.81 | 6515 | 1330 | 75.32 | 80.13 | 61.33 | 74.37 | 5.29 | 4.48 | 15.39 | 4.81 |
| 1995 | 7665.06 | 6654 | 1330 | 73.20 | 77.40 | 65.79 | 75.96 | 10.29 | 8.87 | 13.72 | 4.20 |
| 1996 | 8598.28 | 7050 | 1330 | 77.80 | 84.58 | 73.60 | 80.26 | 4.04 | 3.56 | 11.86 | 6.79 |
| 1997 | 6853.94 | 5529 | 1330 | 62.33 | 63.92 | 58.83 | 63.12 | 16.88 | 12.98 | 23.09 | 1.60 |
| 1998 | 9469.38 | 7855 | 1330 | 86.66 | 86.67 | 81.28 | 89.67 | 11.93 | 11.74 | 1.59 | 0.01 |
| 1999 | 6979.37 | 5906 | 1330 | 64.45 | 66.13 | 59.90 | 67.42 | 12.88 | 9.78 | 24.10 | 1.68 |
| 2000 | 8035.27 | 6607 | 1330 | 74.51 | 75.55 | 68.78 | 75.22 | 10.11 | 8.50 | 15.95 | 1.04 |
| 2001 | 10038.55 | 8126 | 1330 | 92.54 | 92.57 | 86.16 | 92.76 | 6.82 | 6.77 | 0.66 | 0.03 |
| 2002 | 8141.77 | 6736 | 1330 | 73.11 | 75.51 | 69.88 | 76.89 | 11.60 | 9.91 | 14.57 | 2.40 |
| 2003 | 7510.77 | 6090 | 1330 | 67.81 | 68.17 | 64.47 | 69.52 | 12.17 | 9.45 | 22.38 | 0.36 |
| 2004 | 10630.05 | 8668 | 1330 | 96.85 | 98.20 | 90.99 | 98.68 | 1.67 | 1.66 | 0.13 | 1.35 |
| 2005 | 9099.89 | 7627 | 1330 | 83.28 | 85.64 | 78.10 | 87.06 | 3.77 | 3.36 | 11.00 | 2.36 |
| 2006 | 7790.93 | 6675 | 1330 | 69.12 | 72.51 | 66.87 | 76.20 | 9.65 | 14.55 | 12.93 | 3.39 |
| 2007 | 9595.59 | 8041 | 1330 | 88.98 | 90.50 | 82.36 | 91.79 | 9.49 | 9.49 | 0.02 | 1.52 |
| 2008 | 4962.39 | 4018 | 1330 | 42.91 | 43.78 | 42.48 | 45.74 | 26.40 | 28.80 | 27.41 | 0.87 |
| 2009 | 6956.71 | 5593 | 1330 | 62.70 | 68.20 | 59.71 | 63.85 | 5.98 | 18.71 | 13.09 | 5.50 |
| 2010 | 8519.72 | 6955 | 1330 | 75.78 | 77.58 | 73.13 | 79.39 | 14.73 | 21.22 | 1.21 | 1.80 |
| 2011 | 9572.66 | 7768 | 1330 | 87.24 | 87.45 | 82.16 | 88.68 | 0.75 | 2.59 | 9.97 | 0.21 |
| 2012 | 6778.12 | 5618 | 1330 | 61.38 | 65.94 | 58.02 | 63.96 | 5.74 | 18.02 | 16.04 | 4.57 |
| 2013 | 10422.78 | 8682 | 1330 | 97.47 | 98.81 | 89.46 | 99.11 | 1.17 | 1.17 | 0.02 | 1.34 |
| 2014 | 8767.06 | 7002 | 1330 | 77.96 | 81.21 | 75.25 | 79.93 | 6.24 | 7.04 | 11.75 | 3.26 |
| 2015 | 8408.87 | 6584 | 1330 | 72.76 | 72.92 | 72.17 | 75.16 | 2.46 | 1.84 | 25.24 | 0.16 |
| 2016 | 9991.47 | 8013 | 1330 | 87.04 | 87.68 | 85.52 | 91.22 | 3.22 | 2.92 | 9.41 | 0.64 |
| 2017 | 6352.00 | 5245 | 1330 | 55.17 | 55.42 | 54.52 | 59.87 | 44.56 | 44.55 | 0.04 | 0.25 |
| 2018 | 2316.68 | 1832 | 1330 | 23.48 | 25.31 | 19.88 | 20.91 | 10.02 | 30.57 | 44.12 | 1.83 |
| 2019 | 6402.31 | 5227 | 1330 | 55.39 | 55.57 | 54.95 | 59.67 | 38.19 | 41.69 | 2.74 | 0.18 |
| 2020 | 0.00 | 0 | 1330 | 0.00 | 15.43 | 0.00 | 0.00 | 84.57 | 84.57 | 0.00 | 15.43 |
| 2021 | 6229.83 | 5161 | 1330 | 53.77 | 64.47 | 53.47 | 58.92 | 34.32 | 33.69 | 1.83 | 10.70 |
| 2022 | 2342.90 | 1940 | 1330 | 20.17 | 32.02 | 20.11 | 22.15 | 0.49 | 6.71 | 61.27 | 11.85 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 6304 | | | 1409 | |
| B. Refuelling without maintenance | | | | 238 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 848 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 21 | | |
| E. Testing of plant systems or components | | | | 9 | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 9 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 12 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 55 |
| O. Load dispatching, prioritization | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 111 | | 1 | 36 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 47 |
| Z. Other | | | 14 | | 16 | 1 |
| Subtotal | | 6304 | 125 | 1116 | 1439 | 149 |
| Total | | 6429 | | | 2704 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 83 |
| 12. Reactor I&C Systems | | 33 |
| 13. Reactor Auxiliary Systems | | 37 |
| 14. Safety Systems | 5080 | 400 |
| 15. Reactor Cooling Systems | | 16 |
| 16. Steam generation systems | | 45 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | | 127 |
| 32. Feedwater and Main Steam System | | 57 |
| 33. Circulating Water System | | 14 |
| 34. Miscellaneous Systems | 1224 | 201 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 97 |
| 42. Electrical Power Supply Systems | | 260 |
| Total | 6304 | 1380 |

2023 Operating Experience

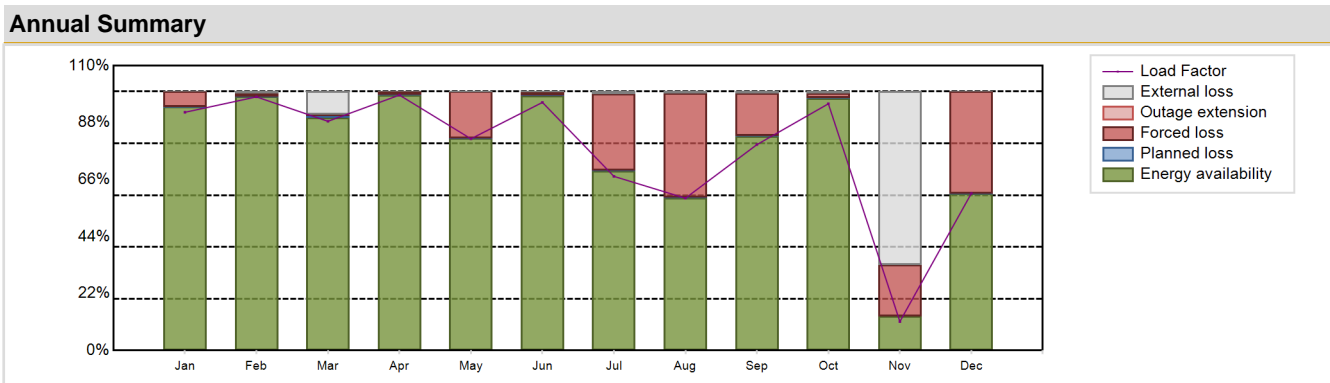
FR-47 **FLAMANVILLE-2** **FRANCE**

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PWR / P4 REP 1300 | Construction Date | : 1980-05-01 |
| Thermal power | : 3817 MWth | Grid Date | : 1986-07-18 |
| Gross electrical power | : 1382 MWe | Commercial Date | : 1987-03-09 |
| Reference unit power (net) | : 1330 MWe | Age at end of year | : 37 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 328.7 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 4.1 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.37 | HP cylinder inlet steam pressure [MPa] | : 6.95 |
| Active core height/length [m] | : 4.267 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 193 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.2 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 53 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 8993.91 GW(e).h | Forced Loss Rate (FLR) | : 14.75 % |
| Energy Availability Factor (EAF) | : 78.52 % | Unplanned Capability Loss Factor (UCL) | : 14.72 % |
| Unit Capability Factor (UCF) | : 85.08 % | Planned Unavailability Factor (PUF) | : 0.21 % |
| Load Factor (LF) | : 77.2 % | Externally cause unavailability (XUF) | : 6.56 % |
| Operating Factor (OF) | : 85.49 % | Total off-line time | : 1271 hours |

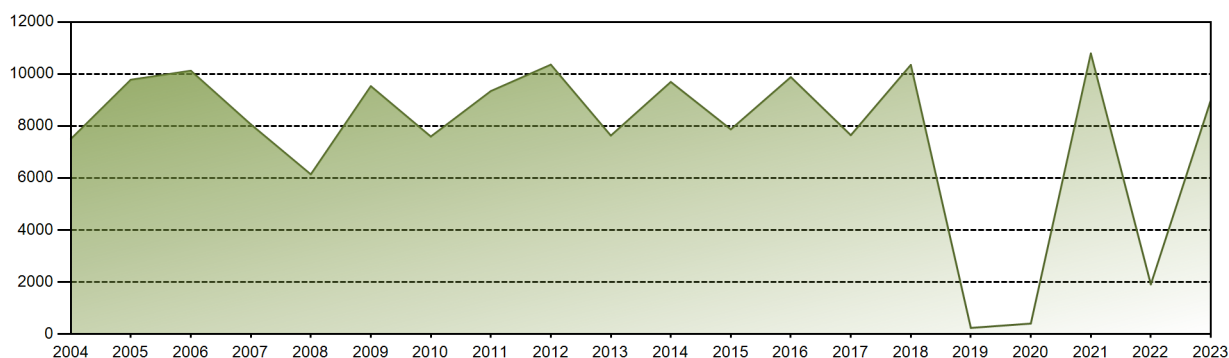


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 910.55 | 875.53 | 874.81 | 944.71 | 809.20 | 917.65 | 665.65 | 582.19 | 761.51 | 944.17 | 107.22 | 600.73 | 8993.91 |
| EAF [%] | 94.08 | 98.03 | 90.01 | 98.69 | 82.07 | 98.44 | 69.32 | 58.86 | 82.71 | 97.34 | 13.17 | 60.73 | 78.52 |
| UCF [%] | 94.08 | 98.68 | 98.76 | 98.69 | 82.08 | 98.69 | 70.28 | 59.42 | 83.25 | 98.07 | 80.17 | 60.73 | 85.08 |
| LF [%] | 92.02 | 97.96 | 88.53 | 98.65 | 81.78 | 95.83 | 67.27 | 58.84 | 79.52 | 95.29 | 11.20 | 60.71 | 77.20 |
| OF [%] | 97.98 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 72.04 | 69.35 | 99.58 | 99.87 | 16.67 | 70.97 | 85.49 |
| FLR [%] | 5.80 | 1.19 | 0.47 | 1.11 | 17.89 | 1.03 | 29.61 | 40.45 | 16.48 | 1.75 | 19.83 | 39.26 | 14.75 |
| UCL [%] | 5.79 | 1.19 | 0.46 | 1.10 | 17.88 | 1.03 | 29.56 | 40.36 | 16.43 | 1.74 | 19.83 | 39.25 | 14.72 |
| PUF [%] | 0.13 | 0.13 | 0.77 | 0.20 | 0.04 | 0.29 | 0.16 | 0.23 | 0.32 | 0.18 | 0.00 | 0.02 | 0.21 |
| XUF [%] | 0.00 | 0.66 | 8.75 | 0.00 | 0.01 | 0.24 | 0.97 | 0.56 | 0.54 | 0.73 | 67.00 | 0.00 | 6.56 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 292318.29 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 9.59 % |
| Cumulative Energy Availability Factor (EAF) | : 72.28 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 12.29 % |
| Cumulative Unit Capability Factor (UCF) | : 74.32 % | Cumulative Planned Unavailability Factor (PUF) | : 13.38 % |
| Cumulative Load Factor (LF) | : 67.38 % | Cumulative Externally cause unavailability (XUF) | : 2.05 % |
| Cumulative Operating Factor (OF) | : 73.29 % | | |

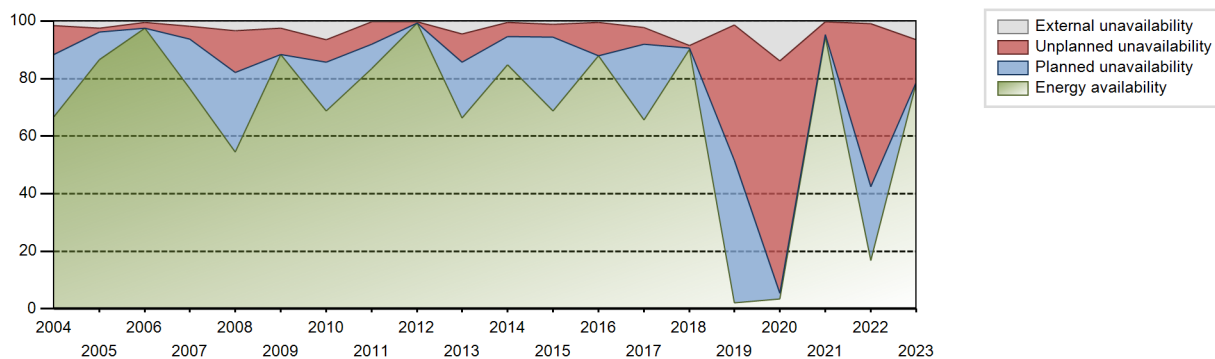
Electricity Production (net) [GWh]



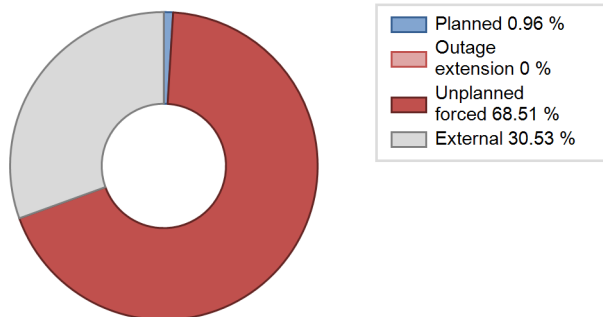
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 7140.20 | 6310 | 1290 | 88.69 | 88.92 | 58.89 | 69.36 | 11.08 | 11.08 | 0.00 | 0.23 |
| 1988 | 7106.00 | 5674 | 1330 | 65.40 | 67.44 | 60.82 | 64.59 | 8.21 | 6.03 | 26.53 | 2.04 |
| 1989 | 4824.50 | 3836 | 1330 | 48.67 | 50.57 | 41.41 | 43.79 | 38.47 | 31.61 | 17.82 | 1.89 |
| 1990 | 7819.60 | 6392 | 1330 | 75.74 | 76.63 | 67.12 | 72.97 | 22.84 | 22.68 | 0.69 | 0.89 |
| 1991 | 7965.71 | 6432 | 1330 | 70.59 | 72.34 | 68.37 | 73.42 | 10.85 | 8.80 | 18.86 | 1.75 |
| 1992 | 8842.44 | 6962 | 1330 | 77.96 | 78.17 | 75.69 | 79.26 | 6.18 | 5.15 | 16.68 | 0.21 |
| 1993 | 7985.20 | 6338 | 1330 | 69.15 | 71.43 | 68.54 | 72.35 | 10.51 | 8.39 | 20.18 | 2.28 |
| 1994 | 8384.27 | 6711 | 1330 | 75.34 | 75.40 | 71.96 | 76.61 | 10.72 | 9.06 | 15.54 | 0.06 |
| 1995 | 8962.41 | 7264 | 1330 | 81.40 | 82.14 | 76.93 | 82.92 | 5.55 | 4.83 | 13.03 | 0.74 |
| 1996 | 9387.50 | 7685 | 1330 | 86.62 | 87.51 | 80.35 | 87.49 | 1.62 | 1.44 | 11.05 | 0.89 |
| 1997 | 8546.04 | 7351 | 1330 | 95.30 | 95.36 | 73.35 | 83.92 | 4.22 | 4.20 | 0.43 | 0.06 |
| 1998 | 5656.61 | 4880 | 1330 | 55.37 | 55.40 | 48.55 | 55.71 | 9.47 | 5.79 | 38.81 | 0.03 |
| 1999 | 7248.90 | 6034 | 1330 | 65.22 | 67.42 | 62.22 | 68.88 | 12.53 | 9.65 | 22.92 | 2.20 |
| 2000 | 9907.94 | 8122 | 1330 | 93.75 | 94.20 | 84.81 | 92.46 | 4.93 | 4.89 | 0.91 | 0.45 |
| 2001 | 8565.10 | 6863 | 1330 | 76.22 | 77.88 | 73.52 | 78.34 | 8.51 | 7.24 | 14.88 | 1.66 |
| 2002 | 8502.35 | 6839 | 1330 | 77.94 | 78.05 | 72.98 | 78.07 | 11.37 | 10.02 | 11.93 | 0.12 |
| 2003 | 10065.35 | 8365 | 1330 | 93.39 | 93.64 | 86.39 | 95.49 | 5.35 | 5.29 | 1.07 | 0.25 |
| 2004 | 7499.84 | 6125 | 1330 | 66.76 | 68.31 | 64.20 | 69.73 | 12.84 | 10.06 | 21.63 | 1.55 |
| 2005 | 9779.11 | 7894 | 1330 | 86.69 | 89.11 | 83.94 | 90.11 | 1.25 | 1.37 | 9.52 | 2.42 |
| 2006 | 10125.81 | 8438 | 1330 | 97.55 | 98.01 | 86.91 | 96.32 | 1.97 | 1.97 | 0.01 | 0.47 |
| 2007 | 8063.02 | 7021 | 1330 | 76.52 | 78.31 | 69.21 | 80.15 | 2.12 | 4.44 | 17.25 | 1.79 |
| 2008 | 6140.92 | 5052 | 1330 | 54.39 | 57.86 | 52.56 | 57.51 | 6.63 | 14.49 | 27.65 | 3.47 |
| 2009 | 9531.78 | 8016 | 1330 | 88.36 | 90.94 | 81.81 | 91.51 | 9.04 | 9.03 | 0.03 | 2.57 |
| 2010 | 7594.30 | 6329 | 1330 | 68.79 | 75.21 | 65.18 | 72.25 | 3.69 | 7.81 | 16.97 | 6.42 |
| 2011 | 9342.70 | 7438 | 1330 | 83.49 | 83.83 | 80.19 | 84.91 | 3.44 | 7.77 | 8.39 | 0.34 |
| 2012 | 10359.02 | 8733 | 1330 | 99.27 | 99.52 | 88.67 | 99.42 | 0.47 | 0.47 | 0.02 | 0.25 |
| 2013 | 7631.58 | 6183 | 1330 | 66.34 | 70.74 | 65.50 | 70.58 | 2.11 | 9.95 | 19.31 | 4.40 |
| 2014 | 9693.92 | 7610 | 1330 | 84.82 | 85.27 | 83.20 | 86.87 | 3.88 | 5.01 | 9.72 | 0.45 |
| 2015 | 7869.45 | 6149 | 1330 | 68.68 | 69.94 | 67.54 | 70.19 | 3.76 | 4.32 | 25.75 | 1.26 |
| 2016 | 9880.46 | 8013 | 1330 | 87.97 | 88.51 | 84.57 | 91.22 | 11.45 | 11.45 | 0.04 | 0.54 |
| 2017 | 7646.67 | 6107 | 1330 | 65.67 | 68.03 | 65.63 | 69.71 | 7.65 | 5.63 | 26.33 | 2.36 |
| 2018 | 10350.78 | 8415 | 1330 | 90.14 | 98.71 | 88.84 | 96.06 | 0.84 | 0.84 | 0.45 | 8.57 |
| 2019 | 236.76 | 217 | 1330 | 2.04 | 3.40 | 2.03 | 2.48 | 0.00 | 47.00 | 49.60 | 1.36 |
| 2020 | 404.48 | 479 | 1330 | 3.47 | 17.25 | 3.46 | 5.45 | 0.70 | 80.83 | 1.91 | 13.79 |
| 2021 | 10791.47 | 8547 | 1330 | 94.33 | 94.55 | 92.62 | 97.57 | 4.62 | 4.58 | 0.87 | 0.22 |
| 2022 | 1910.62 | 1577 | 1330 | 16.75 | 17.65 | 16.40 | 18.00 | 76.25 | 56.69 | 25.66 | 0.91 |
| 2023 | 8993.91 | 7489 | 1330 | 78.52 | 85.08 | 77.20 | 85.49 | 14.75 | 14.72 | 0.21 | 6.56 |

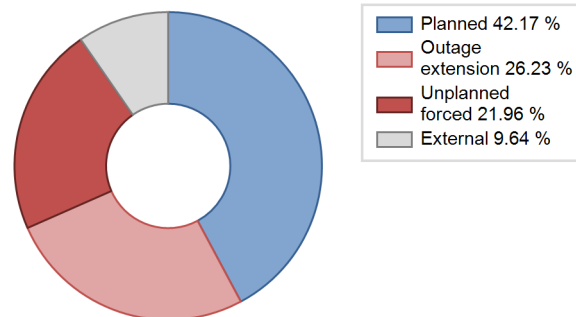
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 807 | | | 986 | |
| B. Refuelling without maintenance | | | | 121 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 933 | 21 | |
| D. Inspection, maintenance or repair without refuelling | | | | 63 | | |
| E. Testing of plant systems or components | | | | 16 | 1 | 0 |
| H. Nuclear regulatory requirements | | | | | 13 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 7 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 459 | | | 56 |
| O. Load dispatching, prioritization | | | 15 | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 1 | 22 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 1 | | 8 |
| Z. Other | | | | | 15 | |
| Subtotal | | 807 | 474 | 1134 | 1043 | 94 |
| Total | | 1281 | | | 2271 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 9 |
| 12. Reactor I&C Systems | 135 | 33 |
| 13. Reactor Auxiliary Systems | | 36 |
| 14. Safety Systems | | 142 |
| 15. Reactor Cooling Systems | | 125 |
| 16. Steam generation systems | 11 | 47 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 21. Fuel Handling and Storage Facilities | | 6 |
| 31. Turbine and auxiliaries | | 75 |
| 32. Feedwater and Main Steam System | 226 | 35 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 330 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | 390 | 48 |
| 42. Electrical Power Supply Systems | 46 | 78 |
| Total | 808 | 972 |

2023 Operating Experience

FR-61

GOLFECH-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1363 MWe
 Reference unit power (net) : 1310 MWe

Key Dates

Construction Date : 1982-11-17
 Grid Date : 1990-06-07
 Commercial Date : 1991-02-01
 Age at end of year : 33 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.5
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

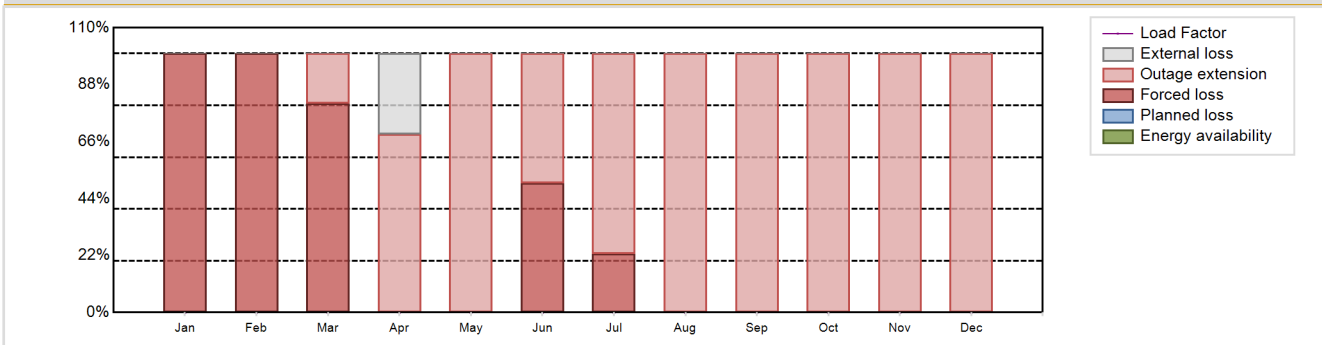
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 0 GW(e).h
 Energy Availability Factor (EAF) : 0 %
 Unit Capability Factor (UCF) : 2.55 %
 Load Factor (LF) : 0 %
 Operating Factor (OF) : 0 %
 Forced Loss Rate (FLR) : 91.92 %
 Unplanned Capability Loss Factor (UCL) : 97.45 %
 Planned Unavailability Factor (PUF) : 0 %
 Externally cause unavailability (XUF) : 2.55 %
 Total off-line time : 8760 hours

Annual Summary

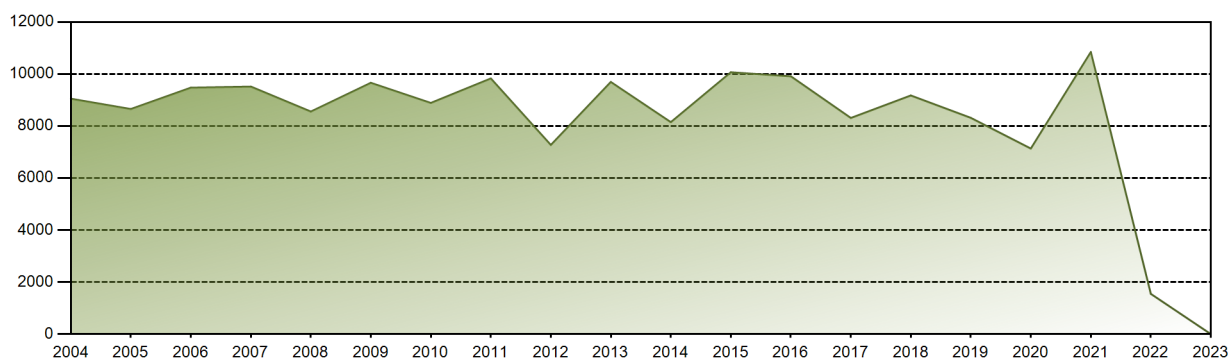


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCF [%] | 0.00 | 0.00 | 0.00 | 31.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.55 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| FLR [%] | 100.00 | 100.00 | 100.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 91.92 |
| UCL [%] | 100.00 | 100.00 | 100.00 | 68.96 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.45 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 31.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.55 |

Historical Summary

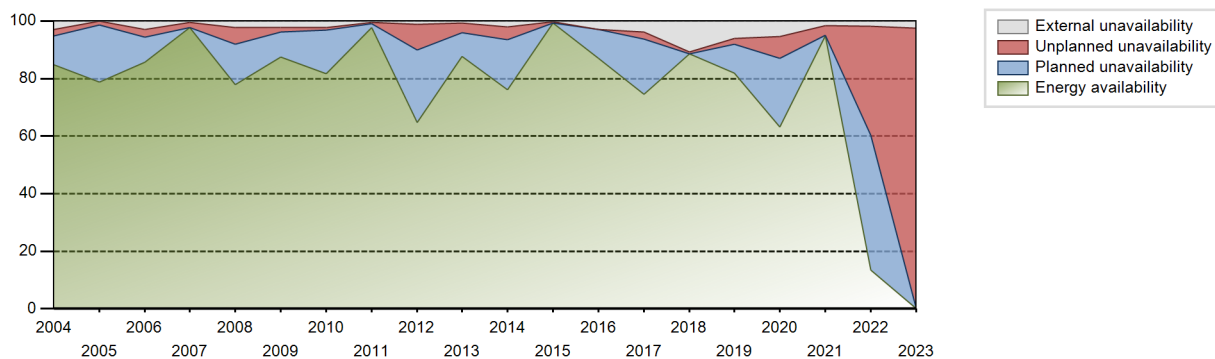
| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 276227.3 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.42 % |
| Cumulative Energy Availability Factor (EAF) | : 78.23 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.85 % |
| Cumulative Unit Capability Factor (UCF) | : 81.14 % | Cumulative Planned Unavailability Factor (PUF) | : 12.02 % |
| Cumulative Load Factor (LF) | : 72.48 % | Cumulative Externally cause unavailability (XUF) | : 2.9 % |
| Cumulative Operating Factor (OF) | : 80.17 % | | |

Electricity Production (net) [GWh]

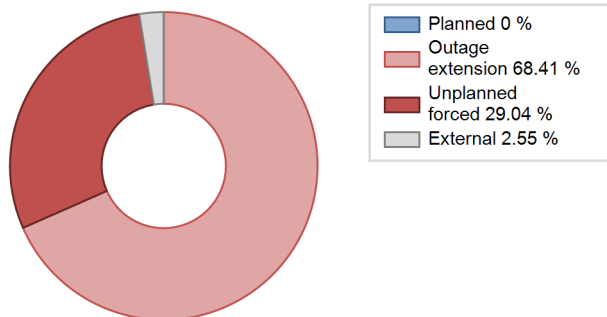


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1991 | 9536.95 | 8167 | 1310 | 96.09 | 97.76 | 84.48 | 94.91 | 2.21 | 2.21 | 0.02 | 1.68 |
| 1992 | 7065.89 | 6128 | 1310 | 64.35 | 67.86 | 61.40 | 69.76 | 4.27 | 3.02 | 29.11 | 3.51 |
| 1993 | 7925.62 | 7143 | 1310 | 72.66 | 82.63 | 69.06 | 81.54 | 1.85 | 1.55 | 15.81 | 9.98 |
| 1994 | 7756.13 | 7215 | 1310 | 77.76 | 81.29 | 67.59 | 82.36 | 5.91 | 5.10 | 13.61 | 3.53 |
| 1995 | 7897.84 | 7005 | 1310 | 75.60 | 83.48 | 68.82 | 79.97 | 2.12 | 1.81 | 14.71 | 7.89 |
| 1996 | 8862.41 | 7598 | 1310 | 83.25 | 84.83 | 77.02 | 86.50 | 1.33 | 1.14 | 14.02 | 1.58 |
| 1997 | 9151.57 | 8000 | 1310 | 94.51 | 94.63 | 79.75 | 91.32 | 5.19 | 5.18 | 0.19 | 0.12 |
| 1998 | 8576.56 | 7472 | 1310 | 81.11 | 84.75 | 74.74 | 85.30 | 1.96 | 1.69 | 13.56 | 3.64 |
| 1999 | 7926.35 | 6837 | 1310 | 77.23 | 80.77 | 69.07 | 78.05 | 6.76 | 5.86 | 13.37 | 3.54 |
| 2000 | 8766.29 | 7901 | 1310 | 93.90 | 94.09 | 76.18 | 89.95 | 5.59 | 5.57 | 0.34 | 0.19 |
| 2001 | 7511.92 | 6147 | 1310 | 68.41 | 69.14 | 65.46 | 70.17 | 4.63 | 3.36 | 27.50 | 0.74 |
| 2002 | 9242.42 | 7301 | 1310 | 81.36 | 82.54 | 80.54 | 83.34 | 4.01 | 3.45 | 14.01 | 1.19 |
| 2003 | 10342.73 | 8252 | 1310 | 93.92 | 99.20 | 90.13 | 94.20 | 0.76 | 0.76 | 0.04 | 5.28 |
| 2004 | 9051.07 | 7721 | 1310 | 84.75 | 87.60 | 78.66 | 87.90 | 2.63 | 2.36 | 10.04 | 2.85 |
| 2005 | 8653.53 | 7014 | 1310 | 78.73 | 78.73 | 75.40 | 80.06 | 1.77 | 1.42 | 19.85 | 0.00 |
| 2006 | 9475.13 | 7848 | 1310 | 85.72 | 88.74 | 82.57 | 89.59 | 0.14 | 2.57 | 8.69 | 3.02 |
| 2007 | 9517.60 | 8554 | 1310 | 97.73 | 98.16 | 82.94 | 97.65 | 1.82 | 1.82 | 0.02 | 0.43 |
| 2008 | 8556.94 | 7104 | 1310 | 77.81 | 80.02 | 74.36 | 80.87 | 0.58 | 5.81 | 14.17 | 2.22 |
| 2009 | 9662.38 | 7932 | 1310 | 87.58 | 89.93 | 84.20 | 90.55 | 1.13 | 1.43 | 8.63 | 2.36 |
| 2010 | 8888.69 | 7290 | 1310 | 81.68 | 83.88 | 77.46 | 83.22 | 0.76 | 0.93 | 15.19 | 2.19 |
| 2011 | 9830.09 | 8546 | 1310 | 97.79 | 98.34 | 85.66 | 97.56 | 0.25 | 0.41 | 1.25 | 0.54 |
| 2012 | 7272.39 | 5889 | 1310 | 64.64 | 65.74 | 63.20 | 67.04 | 0.27 | 8.88 | 25.38 | 1.10 |
| 2013 | 9694.33 | 7793 | 1310 | 87.80 | 88.49 | 84.48 | 88.96 | 1.25 | 3.45 | 8.05 | 0.69 |
| 2014 | 8149.57 | 6728 | 1310 | 76.10 | 78.18 | 71.02 | 76.80 | 0.16 | 4.40 | 17.41 | 2.08 |
| 2015 | 10067.40 | 8721 | 1310 | 99.33 | 99.69 | 87.73 | 99.55 | 0.24 | 0.24 | 0.06 | 0.36 |
| 2016 | 9913.55 | 7917 | 1310 | 87.08 | 89.93 | 86.15 | 90.13 | 0.01 | 0.00 | 10.06 | 2.85 |
| 2017 | 8310.56 | 6654 | 1310 | 74.48 | 78.36 | 72.42 | 75.96 | 0.47 | 2.39 | 19.25 | 3.88 |
| 2018 | 9174.78 | 8075 | 1310 | 88.51 | 99.32 | 79.95 | 92.18 | 0.58 | 0.58 | 0.09 | 10.81 |
| 2019 | 8314.41 | 7199 | 1310 | 81.91 | 88.03 | 72.45 | 82.18 | 2.01 | 1.97 | 10.00 | 6.12 |
| 2020 | 7133.37 | 5836 | 1310 | 63.14 | 68.53 | 61.99 | 66.44 | 0.12 | 7.54 | 23.93 | 5.39 |
| 2021 | 10847.21 | 8542 | 1310 | 94.88 | 96.43 | 94.52 | 97.51 | 3.45 | 3.44 | 0.12 | 1.55 |
| 2022 | 1546.16 | 1346 | 1310 | 13.47 | 15.33 | 13.47 | 15.37 | 71.14 | 37.80 | 46.87 | 1.86 |
| 2023 | 0.00 | 0 | 1310 | 0.00 | 2.55 | 0.00 | 0.00 | 91.92 | 97.45 | 0.00 | 2.55 |

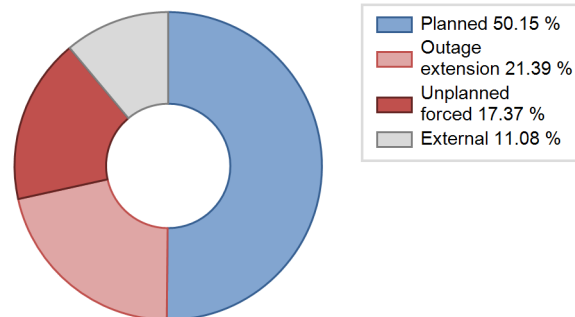
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1991 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 8536 | | | 545 | |
| B. Refuelling without maintenance | | | | 91 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 901 | 1 | |
| D. Inspection, maintenance or repair without refuelling | | | | 34 | | |
| E. Testing of plant systems or components | | | | 37 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 3 | | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 3 |
| L. Human factor related | | | | | 21 | 1 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 23 |
| O. Load dispatching, prioritization | | | | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 224 | | 0 | 30 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 31 |
| Z. Other | | | | | 9 | 3 |
| Subtotal | | 8536 | 224 | 1066 | 579 | 93 |
| Total | | 8760 | | | 1738 | |

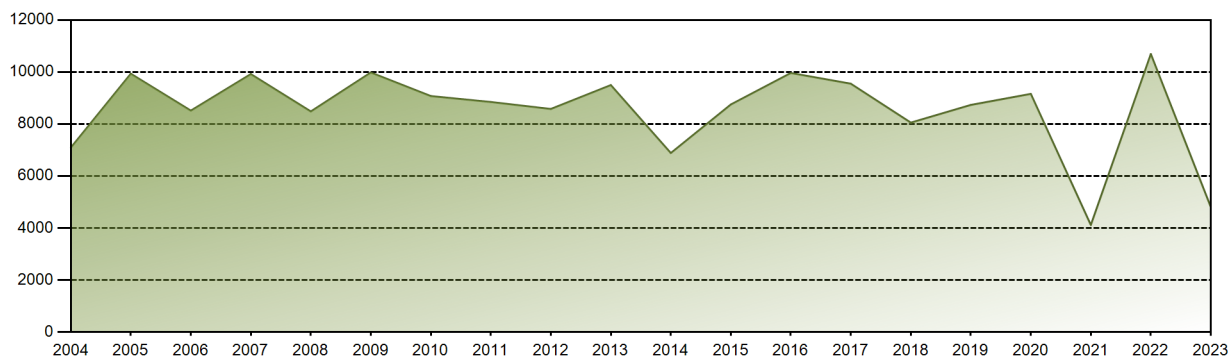
Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1991 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 15 |
| 12. Reactor I&C Systems | 528 | 24 |
| 13. Reactor Auxiliary Systems | | 4 |
| 14. Safety Systems | 2016 | 166 |
| 15. Reactor Cooling Systems | | 16 |
| 16. Steam generation systems | | 11 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 31. Turbine and auxiliaries | | 7 |
| 32. Feedwater and Main Steam System | | 8 |
| 33. Circulating Water System | | 4 |
| 34. Miscellaneous Systems | 5992 | 253 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 26 |
| 42. Electrical Power Supply Systems | | 6 |
| Total | 8536 | 545 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 258214.23 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.53 % |
| Cumulative Energy Availability Factor (EAF) | : 81.45 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.55 % |
| Cumulative Unit Capability Factor (UCF) | : 83.42 % | Cumulative Planned Unavailability Factor (PUF) | : 12.03 % |
| Cumulative Load Factor (LF) | : 74.43 % | Cumulative Externally cause unavailability (XUF) | : 1.97 % |
| Cumulative Operating Factor (OF) | : 82.83 % | | |

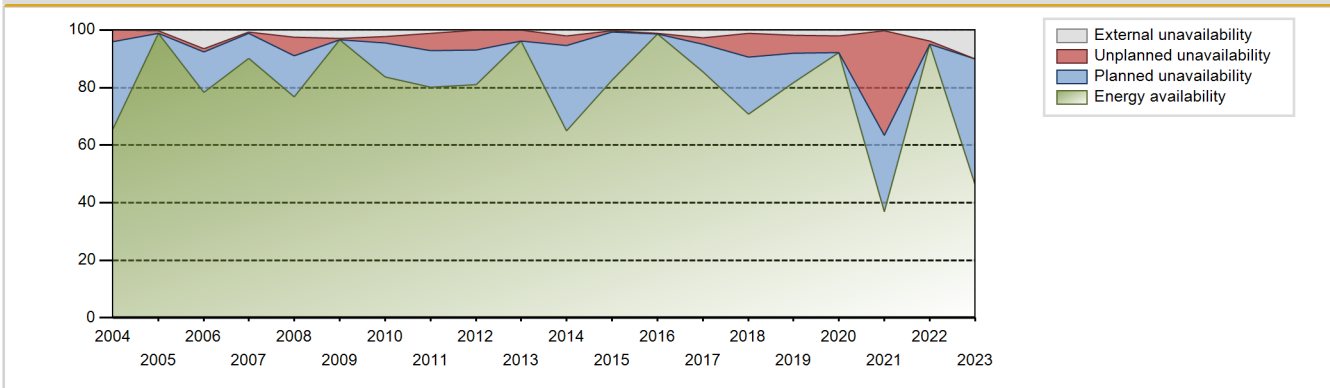
Electricity Production (net) [GWh]



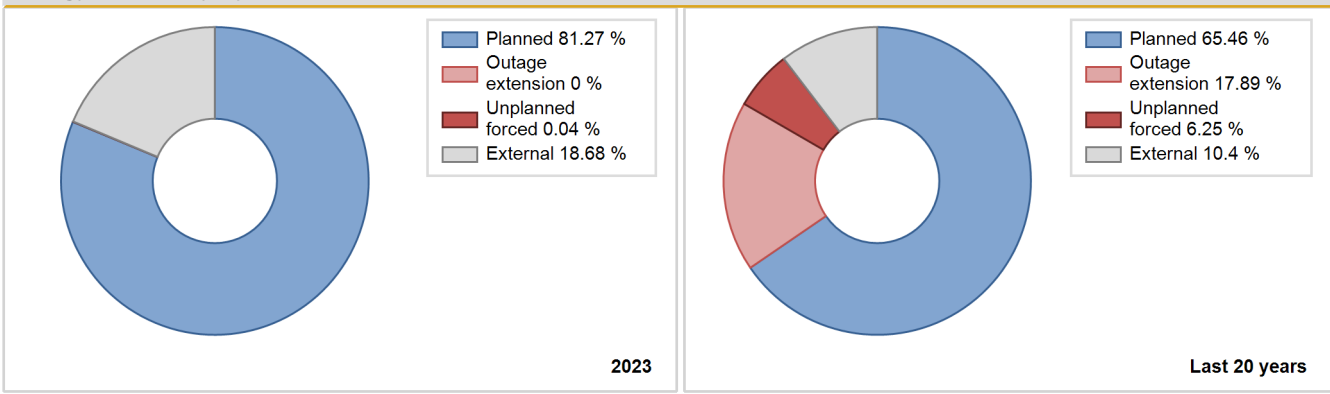
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1994 | 7281.51 | 6577 | 1310 | 99.45 | 99.75 | 67.64 | 80.50 | 0.25 | 0.25 | 0.01 | 0.30 |
| 1995 | 7030.15 | 6002 | 1310 | 62.92 | 66.66 | 61.26 | 68.52 | 12.67 | 9.67 | 23.66 | 3.75 |
| 1996 | 9016.38 | 7549 | 1310 | 83.58 | 84.69 | 78.36 | 85.94 | 3.50 | 3.07 | 12.24 | 1.11 |
| 1997 | 8649.91 | 7414 | 1310 | 80.22 | 83.68 | 75.38 | 84.63 | 5.05 | 4.45 | 11.87 | 3.47 |
| 1998 | 8359.56 | 7222 | 1310 | 82.89 | 85.07 | 72.85 | 82.44 | 6.43 | 5.84 | 9.09 | 2.17 |
| 1999 | 9516.92 | 8407 | 1310 | 97.70 | 98.02 | 82.93 | 95.97 | 1.16 | 1.15 | 0.82 | 0.32 |
| 2000 | 8877.61 | 7535 | 1310 | 81.82 | 84.45 | 77.15 | 85.78 | 1.43 | 1.23 | 14.32 | 2.64 |
| 2001 | 8958.29 | 7586 | 1310 | 84.33 | 85.31 | 78.06 | 86.60 | 2.14 | 1.87 | 12.82 | 0.98 |
| 2002 | 9847.13 | 8553 | 1310 | 97.32 | 97.32 | 85.81 | 97.64 | 2.30 | 2.29 | 0.40 | 0.00 |
| 2003 | 7614.92 | 7115 | 1310 | 75.24 | 77.69 | 66.36 | 81.22 | 11.19 | 9.79 | 12.52 | 2.45 |
| 2004 | 7093.66 | 6129 | 1310 | 65.70 | 65.72 | 61.65 | 69.77 | 5.74 | 4.00 | 30.28 | 0.02 |
| 2005 | 9936.28 | 8715 | 1310 | 98.89 | 99.19 | 86.58 | 99.47 | 0.79 | 0.79 | 0.02 | 0.30 |
| 2006 | 8516.61 | 7150 | 1310 | 78.24 | 84.83 | 74.21 | 81.62 | 1.10 | 0.94 | 14.23 | 6.59 |
| 2007 | 9922.05 | 8026 | 1310 | 90.15 | 90.86 | 86.46 | 91.62 | 0.49 | 0.48 | 8.66 | 0.71 |
| 2008 | 8484.22 | 7095 | 1310 | 76.69 | 79.15 | 73.73 | 80.77 | 2.28 | 6.43 | 14.41 | 2.46 |
| 2009 | 9982.79 | 8301 | 1310 | 96.63 | 99.53 | 86.99 | 94.76 | 0.45 | 0.45 | 0.02 | 2.90 |
| 2010 | 9076.12 | 7574 | 1310 | 83.62 | 85.83 | 79.09 | 86.46 | 0.56 | 2.20 | 11.98 | 2.21 |
| 2011 | 8848.37 | 7177 | 1310 | 80.20 | 81.36 | 77.11 | 81.93 | 0.60 | 5.97 | 12.68 | 1.16 |
| 2012 | 8580.05 | 7152 | 1310 | 81.00 | 81.03 | 74.56 | 81.42 | 0.07 | 6.90 | 12.07 | 0.03 |
| 2013 | 9498.61 | 8292 | 1310 | 96.15 | 96.15 | 82.77 | 94.66 | 3.83 | 3.82 | 0.03 | 0.00 |
| 2014 | 6885.14 | 5885 | 1310 | 64.88 | 66.94 | 60.00 | 67.18 | 0.42 | 3.33 | 29.73 | 2.05 |
| 2015 | 8751.76 | 7332 | 1310 | 82.56 | 82.90 | 76.26 | 83.70 | 0.40 | 0.33 | 16.77 | 0.34 |
| 2016 | 9963.09 | 8765 | 1310 | 98.52 | 99.60 | 86.58 | 99.78 | 0.36 | 0.36 | 0.04 | 1.08 |
| 2017 | 9551.16 | 7756 | 1310 | 85.41 | 88.04 | 83.23 | 88.54 | 1.73 | 2.33 | 9.63 | 2.63 |
| 2018 | 8054.15 | 6380 | 1310 | 70.73 | 71.79 | 70.19 | 72.83 | 1.27 | 8.38 | 19.84 | 1.06 |
| 2019 | 8734.82 | 7205 | 1310 | 81.66 | 83.43 | 76.12 | 82.25 | 1.22 | 6.40 | 10.17 | 1.77 |
| 2020 | 9160.17 | 8145 | 1310 | 92.18 | 94.17 | 79.60 | 92.73 | 5.76 | 5.75 | 0.08 | 1.99 |
| 2021 | 4117.16 | 3319 | 1310 | 36.85 | 37.20 | 35.88 | 37.89 | 0.58 | 36.30 | 26.49 | 0.35 |
| 2022 | 10693.10 | 8662 | 1310 | 95.03 | 98.79 | 93.18 | 98.88 | 1.10 | 1.10 | 0.11 | 3.76 |
| 2023 | 4805.98 | 4279 | 1310 | 45.92 | 56.02 | 41.88 | 48.85 | 0.04 | 0.02 | 43.96 | 10.10 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1994 to 2023 | | |
|---|-------------|-------------|------------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 374 | |
| B. Refuelling without maintenance | 3806 | | | 246 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 747 | 1 | |
| D. Inspection, maintenance or repair without refuelling | | | | 5 | | |
| E. Testing of plant systems or components | | | | 30 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 15 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 84 | | | 14 |
| O. Load dispatching, prioritization | | | | | | 4 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 589 | | 22 | 23 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 1 | | 3 | 5 |
| Z. Other | | | | | 8 | 16 |
| Subtotal | 3806 | | 674 | 1028 | 424 | 63 |
| Total | | 4480 | | | 1515 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1994 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 1 |
| 12. Reactor I&C Systems | | 34 |
| 13. Reactor Auxiliary Systems | | 4 |
| 14. Safety Systems | | 11 |
| 15. Reactor Cooling Systems | | 6 |
| 16. Steam generation systems | | 2 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 25 |
| 32. Feedwater and Main Steam System | | 1 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 180 |
| 41. Main Generator Systems | | 93 |
| 42. Electrical Power Supply Systems | | 7 |
| Total | | 366 |

2023 Operating Experience

FR-20 GRAVELINES-1 FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP1 | Construction Date | : 1975-02-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1980-03-13 |
| Gross electrical power | : 951 MWe | Commercial Date | : 1980-11-25 |
| Reference unit power (net) | : 910 MWe | Age at end of year | : 43 years |

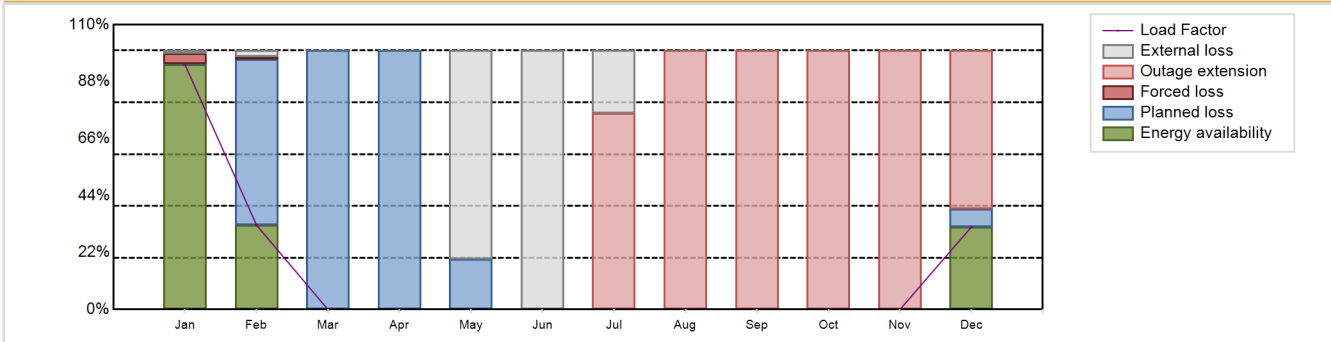
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.8 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 321 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : - |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 5 |
| Refuelling frequency [month] | : 12 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 33735 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 41 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 1055.48 GW(e).h | Forced Loss Rate (FLR) | : 1.34 % |
| Energy Availability Factor (EAF) | : 13.26 % | Unplanned Capability Loss Factor (UCL) | : 45.47 % |
| Unit Capability Factor (UCF) | : 30.68 % | Planned Unavailability Factor (PUF) | : 23.85 % |
| Load Factor (LF) | : 13.24 % | Externally cause unavailability (XUF) | : 17.42 % |
| Operating Factor (OF) | : 14.58 % | Total off-line time | : 7483 hours |

Annual Summary

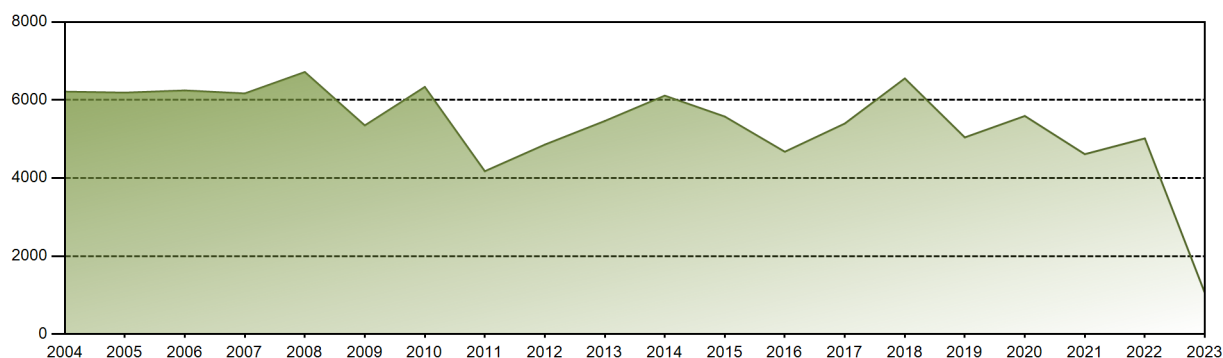


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual | |
|---------|--------|--------|--------|--------|-------|--------|-------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 640.47 | 199.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 215.58 | 1055.48 |
| EAF [%] | 94.77 | 32.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 31.84 | 13.26 |
| UCF [%] | 95.94 | 35.06 | 0.00 | 0.00 | 80.65 | 100.00 | 24.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 31.84 | 30.68 |
| LF [%] | 94.60 | 32.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 31.84 | 13.24 |
| OF [%] | 100.00 | 36.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 38.84 | 14.58 |
| FLR [%] | 4.00 | 2.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.34 |
| UCL [%] | 4.00 | 1.02 | 0.00 | 0.00 | 0.00 | 0.00 | 75.67 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 61.10 | 45.47 |
| PUF [%] | 0.06 | 63.93 | 100.00 | 100.00 | 19.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.06 | 23.85 |
| XUF [%] | 1.17 | 2.44 | 0.00 | 0.00 | 80.64 | 100.00 | 24.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 17.42 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 235820.01 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.62 % |
| Cumulative Energy Availability Factor (EAF) | : 72.47 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 10.04 % |
| Cumulative Unit Capability Factor (UCF) | : 74.73 % | Cumulative Planned Unavailability Factor (PUF) | : 15.22 % |
| Cumulative Load Factor (LF) | : 68.13 % | Cumulative Externally cause unavailability (XUF) | : 2.27 % |
| Cumulative Operating Factor (OF) | : 74.25 % | | |

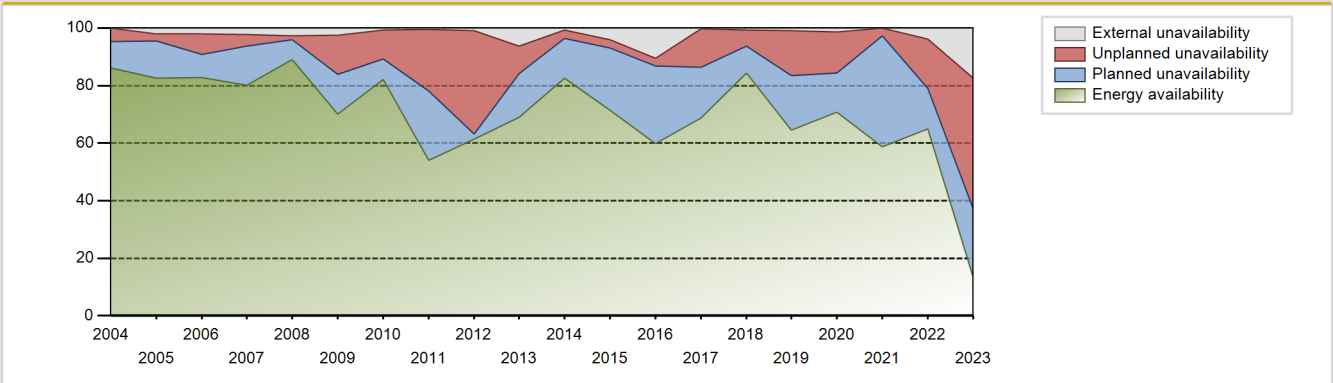
Electricity Production (net) [GWh]



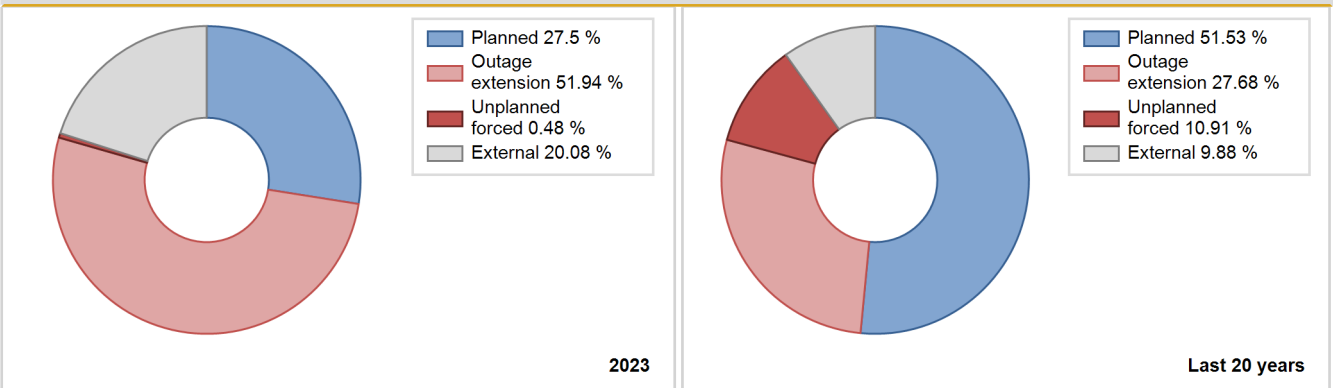
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | 1466.00 | 2477 | 918 | 72.30 | 72.30 | 72.03 | 74.06 | 21.78 | 20.13 | 7.57 | 0.00 |
| 1981 | 5001.80 | 5785 | 920 | 63.25 | 63.25 | 62.06 | 66.04 | 11.18 | 7.96 | 28.79 | 0.00 |
| 1982 | 2987.50 | 3602 | 910 | 38.24 | 38.24 | 37.48 | 41.12 | 59.89 | 57.10 | 4.65 | 0.00 |
| 1983 | 5537.00 | 6237 | 910 | 69.92 | 69.92 | 69.46 | 71.20 | 4.66 | 3.42 | 26.66 | 0.00 |
| 1984 | 6617.00 | 7654 | 910 | 86.22 | 86.22 | 82.78 | 87.14 | 5.90 | 5.40 | 8.38 | 0.00 |
| 1985 | 6211.70 | 7218 | 910 | 80.31 | 81.27 | 77.92 | 82.40 | 3.98 | 3.37 | 15.36 | 0.96 |
| 1986 | 5725.50 | 6508 | 910 | 73.40 | 74.80 | 71.82 | 74.29 | 10.69 | 8.95 | 16.24 | 1.40 |
| 1987 | 4650.10 | 5895 | 910 | 89.01 | 89.34 | 58.33 | 67.29 | 4.67 | 4.38 | 6.28 | 0.33 |
| 1988 | 4289.00 | 5306 | 910 | 56.96 | 57.63 | 53.66 | 60.41 | 34.00 | 29.69 | 12.69 | 0.66 |
| 1989 | 5109.64 | 6224 | 910 | 67.66 | 67.68 | 64.10 | 71.05 | 22.39 | 19.52 | 12.80 | 0.02 |
| 1990 | 4463.57 | 5425 | 910 | 59.17 | 61.27 | 55.99 | 61.93 | 14.31 | 10.23 | 28.50 | 2.10 |
| 1991 | 5675.04 | 6619 | 910 | 73.35 | 74.00 | 71.19 | 75.56 | 14.90 | 12.96 | 13.05 | 0.64 |
| 1992 | 5834.68 | 7250 | 910 | 80.65 | 84.00 | 72.99 | 82.54 | 3.31 | 2.88 | 13.12 | 3.35 |
| 1993 | 5866.85 | 7794 | 910 | 80.54 | 93.84 | 73.60 | 88.97 | 2.71 | 2.62 | 3.54 | 13.30 |
| 1994 | 4657.72 | 5729 | 910 | 67.67 | 68.60 | 58.43 | 65.40 | 3.77 | 2.69 | 28.71 | 0.93 |
| 1995 | 6123.14 | 7461 | 910 | 82.76 | 83.75 | 76.81 | 85.17 | 6.18 | 5.52 | 10.73 | 0.99 |
| 1996 | 6089.15 | 7357 | 910 | 80.34 | 83.55 | 76.18 | 83.75 | 4.70 | 4.12 | 12.33 | 3.21 |
| 1997 | 5860.44 | 7236 | 910 | 81.72 | 82.89 | 73.52 | 82.60 | 5.61 | 4.93 | 12.18 | 1.17 |
| 1998 | 6321.38 | 7622 | 910 | 83.74 | 87.05 | 79.30 | 87.01 | 3.19 | 2.87 | 10.07 | 3.32 |
| 1999 | 5841.29 | 7116 | 910 | 78.55 | 80.27 | 73.28 | 81.23 | 2.16 | 1.78 | 17.95 | 1.72 |
| 2000 | 6531.94 | 7705 | 910 | 88.11 | 88.20 | 81.72 | 87.72 | 0.99 | 0.88 | 10.91 | 0.09 |
| 2001 | 5289.37 | 6034 | 910 | 66.69 | 67.59 | 66.35 | 68.88 | 7.47 | 5.46 | 26.96 | 0.90 |
| 2002 | 5769.34 | 7057 | 910 | 86.32 | 88.64 | 72.37 | 80.56 | 0.63 | 0.56 | 10.80 | 2.32 |
| 2003 | 5919.51 | 7420 | 910 | 85.05 | 85.70 | 74.26 | 84.70 | 0.99 | 0.85 | 13.44 | 0.65 |
| 2004 | 6213.89 | 7664 | 910 | 86.23 | 86.35 | 77.74 | 87.25 | 5.06 | 4.60 | 9.04 | 0.13 |
| 2005 | 6188.68 | 7400 | 910 | 82.51 | 84.55 | 77.63 | 84.47 | 1.18 | 2.46 | 12.99 | 2.04 |
| 2006 | 6244.37 | 7567 | 910 | 82.81 | 84.92 | 78.33 | 86.38 | 2.54 | 7.15 | 7.93 | 2.11 |
| 2007 | 6168.23 | 7312 | 910 | 80.11 | 82.37 | 77.38 | 83.47 | 1.38 | 4.00 | 13.64 | 2.26 |
| 2008 | 6716.74 | 8146 | 910 | 89.12 | 91.78 | 84.03 | 92.74 | 0.35 | 1.30 | 6.92 | 2.66 |
| 2009 | 5348.22 | 6527 | 910 | 70.03 | 72.56 | 67.09 | 74.51 | 0.53 | 13.64 | 13.80 | 2.54 |
| 2010 | 6334.91 | 7348 | 910 | 82.04 | 82.67 | 79.47 | 83.88 | 9.70 | 10.14 | 7.19 | 0.63 |
| 2011 | 4173.88 | 4827 | 910 | 53.96 | 54.47 | 52.36 | 55.10 | 4.82 | 21.39 | 24.15 | 0.50 |
| 2012 | 4856.13 | 5711 | 910 | 61.43 | 62.36 | 60.75 | 65.02 | 18.32 | 35.99 | 1.65 | 0.93 |
| 2013 | 5462.13 | 6283 | 910 | 68.89 | 75.07 | 68.52 | 71.72 | 5.15 | 9.73 | 15.20 | 6.18 |
| 2014 | 6111.90 | 7416 | 910 | 82.59 | 83.30 | 76.67 | 84.66 | 3.26 | 2.81 | 13.89 | 0.71 |
| 2015 | 5575.19 | 6554 | 910 | 71.34 | 75.34 | 69.94 | 74.82 | 3.19 | 2.93 | 21.73 | 3.99 |
| 2016 | 4673.39 | 5763 | 910 | 59.92 | 70.41 | 58.47 | 65.61 | 2.00 | 2.73 | 26.86 | 10.49 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|-------|-------|-------|
| 2017 | 5397.15 | 6249 | 910 | 68.65 | 68.97 | 67.70 | 71.34 | 1.77 | 13.22 | 17.81 | 0.32 |
| 2018 | 6553.27 | 7548 | 910 | 84.31 | 84.97 | 82.21 | 86.16 | 2.50 | 5.72 | 9.31 | 0.65 |
| 2019 | 5041.04 | 5827 | 910 | 64.56 | 65.44 | 63.24 | 66.52 | 2.62 | 15.61 | 18.95 | 0.87 |
| 2020 | 5590.40 | 6736 | 910 | 70.87 | 72.30 | 69.94 | 76.68 | 9.14 | 14.13 | 13.58 | 1.42 |
| 2021 | 4611.67 | 5312 | 910 | 58.82 | 58.83 | 57.85 | 60.64 | 4.41 | 2.72 | 38.45 | 0.01 |
| 2022 | 5015.76 | 6131 | 910 | 64.99 | 68.73 | 62.92 | 69.99 | 5.67 | 17.18 | 14.10 | 3.74 |
| 2023 | 1055.48 | 1277 | 910 | 13.26 | 30.68 | 13.24 | 14.58 | 1.34 | 45.47 | 23.85 | 17.42 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|---|-------------|-------------|-------------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 3946 | | | 712 | |
| B. Refuelling without maintenance | | | | 156 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2035 | | | 1108 | 11 | |
| D. Inspection, maintenance or repair without refuelling | | | | 18 | 3 | |
| E. Testing of plant systems or components | | | | 10 | 4 | |
| H. Nuclear regulatory requirements | | | | | 5 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 7 |
| L. Human factor related | | | | | 12 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 3 |
| O. Load dispatching, prioritization | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 1501 | | 0 | 58 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 15 |
| Z. Other | | | | | 33 | 2 |
| Subtotal | 2035 | 3946 | 1501 | 1292 | 780 | 86 |
| Total | | 7482 | | | 2158 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1980 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 183 |
| 12. Reactor I&C Systems | | 9 |
| 13. Reactor Auxiliary Systems | | 15 |
| 14. Safety Systems | | 7 |
| 15. Reactor Cooling Systems | | 68 |
| 16. Steam generation systems | | 66 |
| 21. Fuel Handling and Storage Facilities | | 0 |
| 31. Turbine and auxiliaries | | 46 |
| 32. Feedwater and Main Steam System | | 43 |
| 33. Circulating Water System | | 8 |
| 34. Miscellaneous Systems | 3946 | 227 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 10 |
| 42. Electrical Power Supply Systems | | 24 |
| Total | 3946 | 706 |

2023 Operating Experience

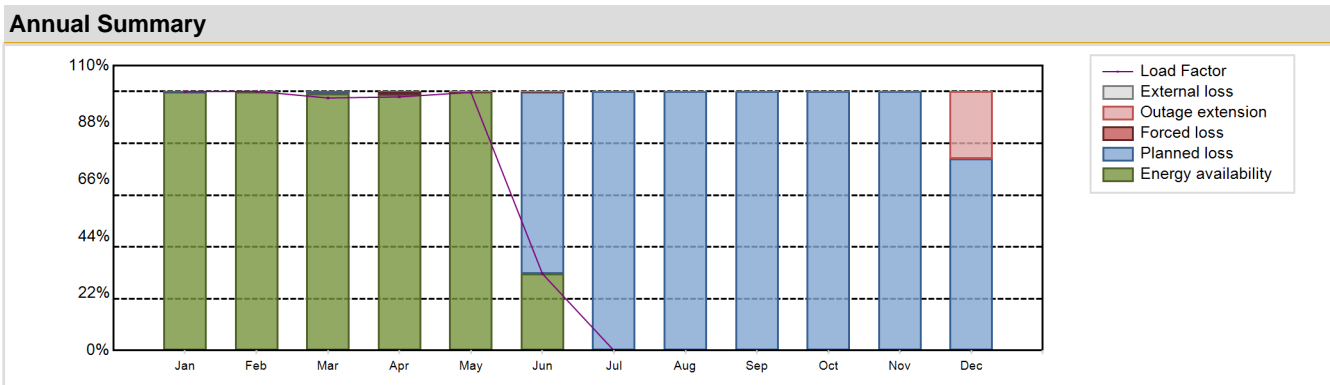
FR-21 GRAVELINES-2 FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP1 | Construction Date | : 1975-03-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1980-08-26 |
| Gross electrical power | : 951 MWe | Commercial Date | : 1980-12-01 |
| Reference unit power (net) | : 910 MWe | Age at end of year | : 43 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 321 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33735 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 41 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 3459.28 GW(e).h | Forced Loss Rate (FLR) | : 0.29 % |
| Energy Availability Factor (EAF) | : 43.6 % | Unplanned Capability Loss Factor (UCL) | : 2.33 % |
| Unit Capability Factor (UCF) | : 43.62 % | Planned Unavailability Factor (PUF) | : 54.05 % |
| Load Factor (LF) | : 43.4 % | Externally cause unavailability (XUF) | : 0.02 % |
| Operating Factor (OF) | : 43.82 % | Total off-line time | : 4921 hours |

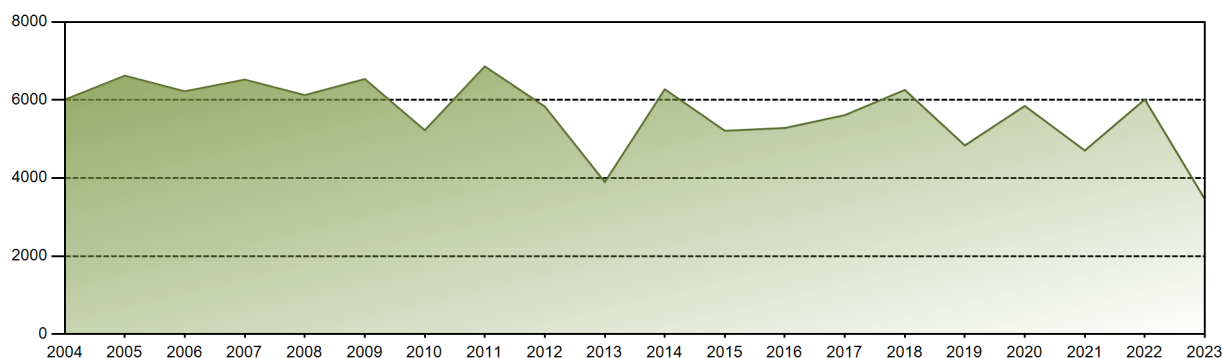


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|---------|
| GW(e)-h | 676.75 | 612.08 | 659.42 | 641.69 | 675.05 | 194.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3459.28 |
| EAF [%] | 99.84 | 99.96 | 99.19 | 98.87 | 99.80 | 29.69 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 43.60 |
| UCF [%] | 99.84 | 99.96 | 99.19 | 98.87 | 99.89 | 29.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 43.62 |
| LF [%] | 99.96 | 100.09 | 97.53 | 97.94 | 99.71 | 29.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 43.40 |
| OF [%] | 100.00 | 100.00 | 99.87 | 100.00 | 100.00 | 30.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 43.82 |
| FLR [%] | 0.04 | 0.00 | 0.25 | 1.08 | 0.03 | 0.37 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 |
| UCL [%] | 0.04 | 0.00 | 0.25 | 1.08 | 0.03 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.96 | 2.33 |
| PUF [%] | 0.12 | 0.04 | 0.56 | 0.05 | 0.08 | 70.08 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 74.04 | 54.05 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 247954.77 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.79 % |
| Cumulative Energy Availability Factor (EAF) | : 76.02 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.45 % |
| Cumulative Unit Capability Factor (UCF) | : 78.07 % | Cumulative Planned Unavailability Factor (PUF) | : 15.48 % |
| Cumulative Load Factor (LF) | : 71.82 % | Cumulative Externally cause unavailability (XUF) | : 2.05 % |
| Cumulative Operating Factor (OF) | : 77.95 % | | |

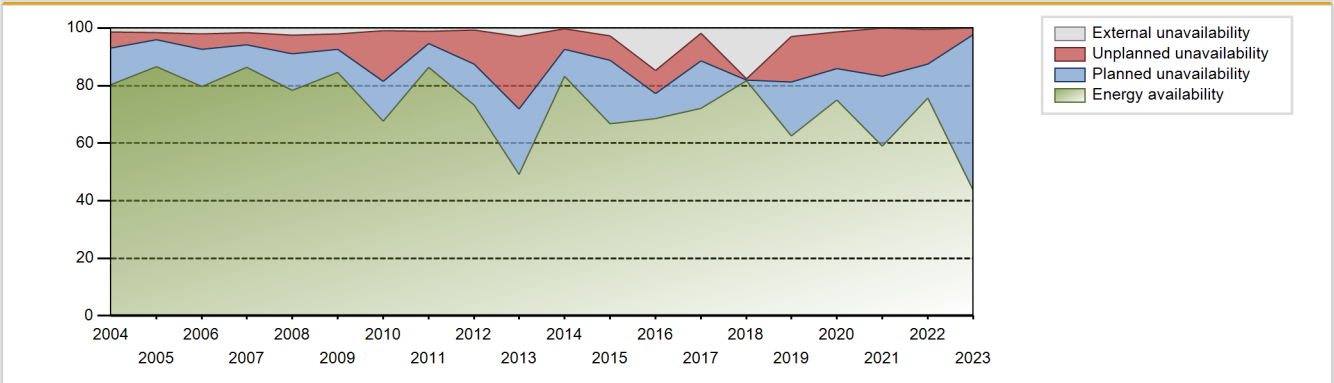
Electricity Production (net) [GWh]



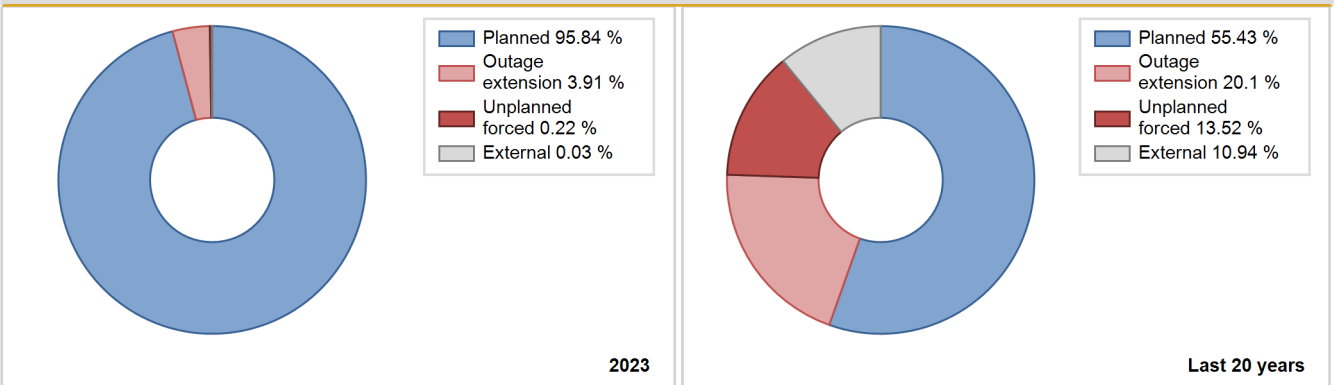
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | 1282.00 | 1916 | 914 | 74.70 | 74.70 | 75.24 | 76.75 | 25.30 | 25.30 | 0.00 | 0.00 |
| 1981 | 5949.20 | 7276 | 920 | 81.21 | 81.21 | 73.82 | 83.06 | 2.26 | 1.88 | 16.91 | 0.00 |
| 1982 | 2118.50 | 2732 | 910 | 29.21 | 29.21 | 26.58 | 31.19 | 37.78 | 17.73 | 53.06 | 0.00 |
| 1983 | 6130.00 | 6917 | 910 | 77.92 | 77.92 | 76.90 | 78.96 | 2.89 | 2.32 | 19.76 | 0.00 |
| 1984 | 5749.00 | 6751 | 910 | 82.03 | 82.03 | 71.92 | 76.86 | 5.46 | 4.74 | 13.23 | 0.00 |
| 1985 | 6829.70 | 7950 | 910 | 89.65 | 90.22 | 85.68 | 90.75 | 3.69 | 3.45 | 6.33 | 0.56 |
| 1986 | 6422.00 | 7956 | 910 | 96.41 | 96.56 | 80.56 | 90.82 | 3.44 | 3.44 | 0.00 | 0.14 |
| 1987 | 5357.90 | 6807 | 910 | 75.18 | 77.39 | 67.21 | 77.71 | 7.43 | 6.21 | 16.40 | 2.22 |
| 1988 | 5577.00 | 7227 | 910 | 77.16 | 81.27 | 69.77 | 82.27 | 7.78 | 6.86 | 11.87 | 4.12 |
| 1989 | 6412.93 | 7460 | 910 | 83.57 | 84.61 | 80.45 | 85.16 | 3.29 | 2.88 | 12.51 | 1.04 |
| 1990 | 6143.08 | 7164 | 910 | 79.64 | 80.59 | 77.06 | 81.78 | 5.17 | 4.39 | 15.01 | 0.96 |
| 1991 | 4915.91 | 5648 | 910 | 62.98 | 63.55 | 61.67 | 64.47 | 9.87 | 6.96 | 29.49 | 0.58 |
| 1992 | 6124.15 | 7149 | 910 | 78.18 | 80.61 | 76.61 | 81.39 | 1.08 | 0.88 | 18.51 | 2.43 |
| 1993 | 6219.87 | 7297 | 910 | 79.28 | 82.31 | 78.03 | 83.30 | 5.01 | 4.34 | 13.34 | 3.03 |
| 1994 | 6293.68 | 7638 | 910 | 82.69 | 86.25 | 78.95 | 87.19 | 2.15 | 1.90 | 11.86 | 3.56 |
| 1995 | 5599.66 | 6735 | 910 | 74.61 | 75.59 | 70.25 | 76.88 | 14.78 | 13.11 | 11.30 | 0.98 |
| 1996 | 5235.92 | 6361 | 910 | 69.71 | 70.72 | 65.50 | 72.42 | 1.04 | 0.74 | 28.54 | 1.01 |
| 1997 | 6641.23 | 8006 | 910 | 97.85 | 97.96 | 83.31 | 91.39 | 2.03 | 2.03 | 0.01 | 0.11 |
| 1998 | 5531.44 | 6896 | 910 | 82.10 | 82.22 | 69.39 | 78.72 | 2.16 | 1.81 | 15.97 | 0.11 |
| 1999 | 6394.43 | 7705 | 910 | 85.34 | 87.76 | 80.22 | 87.96 | 1.37 | 1.22 | 11.02 | 2.42 |
| 2000 | 5582.71 | 6952 | 910 | 77.30 | 80.54 | 69.84 | 79.14 | 2.81 | 2.33 | 17.13 | 3.24 |
| 2001 | 5984.52 | 7601 | 910 | 85.00 | 85.49 | 75.07 | 86.77 | 3.62 | 3.21 | 11.30 | 0.49 |
| 2002 | 5254.30 | 6658 | 910 | 72.30 | 74.31 | 65.91 | 76.00 | 0.34 | 0.25 | 25.44 | 2.01 |
| 2003 | 6553.92 | 7986 | 910 | 89.20 | 89.61 | 82.22 | 91.16 | 1.65 | 1.50 | 8.89 | 0.41 |
| 2004 | 6009.04 | 7262 | 910 | 80.44 | 81.80 | 75.17 | 82.67 | 6.42 | 5.61 | 12.59 | 1.36 |
| 2005 | 6622.59 | 7880 | 910 | 86.64 | 88.22 | 83.07 | 89.94 | 2.62 | 2.53 | 9.26 | 1.58 |
| 2006 | 6222.36 | 7369 | 910 | 79.61 | 81.73 | 78.06 | 84.12 | 3.93 | 5.18 | 13.09 | 2.13 |
| 2007 | 6522.56 | 7796 | 910 | 86.44 | 87.98 | 81.82 | 89.00 | 2.20 | 4.21 | 7.81 | 1.54 |
| 2008 | 6124.09 | 7271 | 910 | 78.32 | 80.70 | 76.61 | 82.78 | 2.30 | 6.57 | 12.73 | 2.38 |
| 2009 | 6537.36 | 7696 | 910 | 84.50 | 86.53 | 82.01 | 87.85 | 2.00 | 5.28 | 8.20 | 2.03 |
| 2010 | 5223.13 | 6149 | 910 | 67.71 | 68.74 | 65.52 | 70.19 | 11.95 | 17.41 | 13.85 | 1.03 |
| 2011 | 6861.91 | 7723 | 910 | 86.35 | 87.50 | 86.08 | 88.16 | 0.30 | 4.31 | 8.18 | 1.15 |
| 2012 | 5832.88 | 6776 | 910 | 73.13 | 73.81 | 72.97 | 77.14 | 8.56 | 11.94 | 14.25 | 0.68 |
| 2013 | 3895.35 | 4421 | 910 | 49.04 | 51.94 | 48.87 | 50.47 | 3.09 | 25.15 | 22.91 | 2.90 |
| 2014 | 6274.40 | 7318 | 910 | 83.17 | 83.47 | 78.71 | 83.54 | 4.72 | 7.14 | 9.40 | 0.30 |
| 2015 | 5211.80 | 5969 | 910 | 66.65 | 69.37 | 65.38 | 68.14 | 1.07 | 8.57 | 22.06 | 2.72 |
| 2016 | 5282.11 | 6349 | 910 | 68.63 | 83.43 | 66.08 | 72.28 | 1.99 | 7.89 | 8.68 | 14.80 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2017 | 5611.13 | 6531 | 910 | 72.19 | 74.06 | 70.39 | 74.55 | 1.30 | 9.61 | 16.33 | 1.87 |
| 2018 | 6258.08 | 7767 | 910 | 81.64 | 99.35 | 78.50 | 88.66 | 0.32 | 0.32 | 0.33 | 17.71 |
| 2019 | 4834.97 | 5890 | 910 | 62.58 | 65.56 | 60.65 | 67.24 | 11.33 | 15.73 | 18.71 | 2.98 |
| 2020 | 5847.85 | 6666 | 910 | 75.06 | 76.38 | 73.16 | 75.89 | 9.10 | 12.86 | 10.76 | 1.32 |
| 2021 | 4704.52 | 5336 | 910 | 59.00 | 59.00 | 59.02 | 60.91 | 13.71 | 16.84 | 24.17 | 0.00 |
| 2022 | 6014.85 | 6926 | 910 | 75.71 | 76.23 | 75.45 | 79.06 | 5.47 | 11.96 | 11.81 | 0.52 |
| 2023 | 3459.28 | 3839 | 910 | 43.60 | 43.62 | 43.40 | 43.82 | 0.29 | 2.33 | 54.05 | 0.02 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|--|-------------|-------------|----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 193 | | | 387 | |
| B. Refuelling without maintenance | | | | 138 | | |
| C. Inspection, maintenance or repair combined with refuelling | 4726 | | | 1060 | 30 | |
| D. Inspection, maintenance or repair without refuelling | | | | 52 | | |
| E. Testing of plant systems or components | 1 | | | 18 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 7 |
| L. Human factor related | | | | | 10 | |
| M. Governmental requirements or court decisions | | | | | | 2 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 3 |
| O. Load dispatching, prioritization | | | | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant , spare part delivery problems etc.) | | | | | | 38 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 23 |
| Z. Other | | | | 14 | 42 | 38 |
| Subtotal | 4727 | 193 | | 1282 | 470 | 116 |
| Total | | 4920 | | | 1868 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1980 to 2023 | |
|--|------------|------------|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 24 |
| 12. Reactor I&C Systems | | | | 22 |
| 13. Reactor Auxiliary Systems | | | | 10 |
| 14. Safety Systems | | | | 12 |
| 15. Reactor Cooling Systems | | | | 17 |
| 16. Steam generation systems | | | | 42 |
| 21. Fuel Handling and Storage Facilities | | | | 9 |
| 31. Turbine and auxiliaries | | | | 19 |
| 32. Feedwater and Main Steam System | | | | 18 |
| 33. Circulating Water System | | | | 11 |
| 34. Miscellaneous Systems | | 193 | | 174 |
| 35. All other I&C Systems | | | | 0 |
| 41. Main Generator Systems | | | | 26 |
| 42. Electrical Power Supply Systems | | | | 26 |
| Total | | 193 | | 410 |

2023 Operating Experience

FR-27

GRAVELINES-3

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2785 MWth
 Gross electrical power : 951 MWe
 Reference unit power (net) : 910 MWe

Key Dates

Construction Date : 1975-12-01
 Grid Date : 1980-12-12
 Commercial Date : 1981-06-01
 Age at end of year : 43 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 45
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.2
 Reactor outlet temperature [°C] : 323
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.5
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

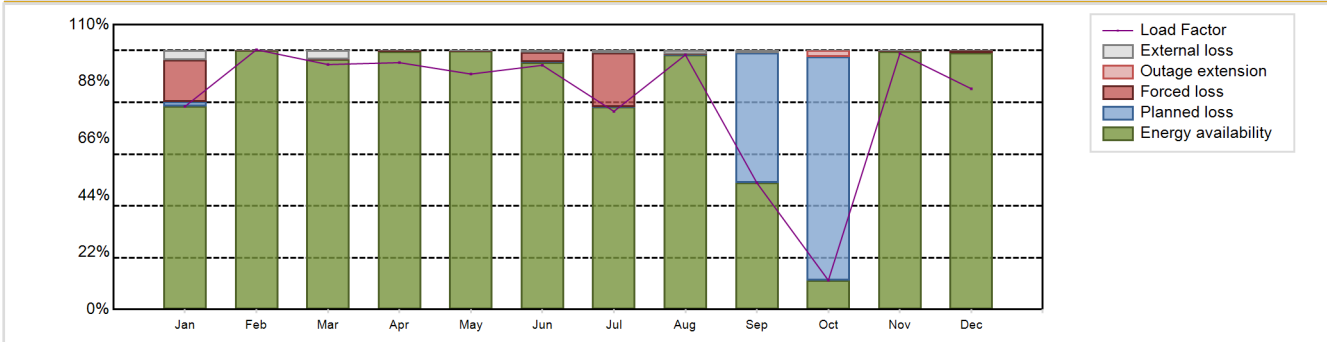
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6448.18 GW(e).h
 Energy Availability Factor (EAF) : 83.6 %
 Unit Capability Factor (UCF) : 84.52 %
 Load Factor (LF) : 80.89 %
 Operating Factor (OF) : 86.69 %
 Forced Loss Rate (FLR) : 4.09 %
 Unplanned Capability Loss Factor (UCL) : 3.81 %
 Planned Unavailability Factor (PUF) : 11.66 %
 Externally cause unavailability (XUF) : 0.93 %
 Total off-line time : 1166 hours

Annual Summary

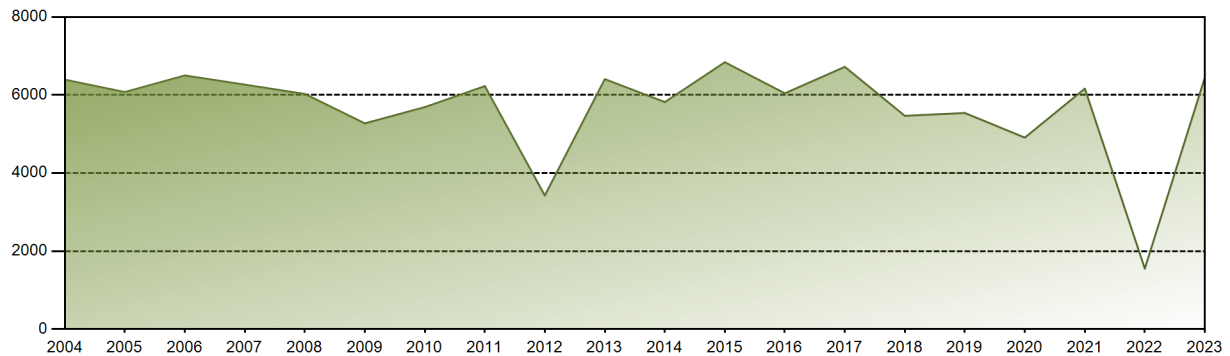


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 531.00 | 613.49 | 639.70 | 624.65 | 615.66 | 618.03 | 518.06 | 665.70 | 320.46 | 76.40 | 647.81 | 577.21 | 6448.18 |
| EAF [%] | 78.42 | 100.00 | 96.53 | 99.55 | 99.79 | 95.52 | 78.26 | 98.36 | 48.93 | 11.27 | 99.53 | 99.02 | 83.60 |
| UCF [%] | 82.02 | 100.00 | 99.91 | 99.55 | 99.88 | 96.26 | 79.12 | 99.78 | 49.76 | 11.27 | 99.58 | 99.02 | 84.52 |
| LF [%] | 78.43 | 100.32 | 94.61 | 95.34 | 90.93 | 94.33 | 76.52 | 98.33 | 48.91 | 11.27 | 98.87 | 85.25 | 80.89 |
| OF [%] | 91.67 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 82.93 | 100.00 | 50.00 | 17.18 | 100.00 | 100.00 | 86.69 |
| FLR [%] | 16.52 | 0.00 | 0.09 | 0.45 | 0.07 | 3.65 | 20.86 | 0.08 | 0.00 | 0.00 | 0.13 | 0.98 | 4.09 |
| UCL [%] | 16.24 | 0.00 | 0.09 | 0.45 | 0.07 | 3.65 | 20.85 | 0.08 | 0.00 | 2.48 | 0.13 | 0.98 | 3.81 |
| PUF [%] | 1.75 | 0.00 | 0.00 | 0.00 | 0.05 | 0.09 | 0.03 | 0.14 | 50.24 | 86.25 | 0.29 | 0.00 | 11.66 |
| XUF [%] | 3.60 | 0.00 | 3.37 | 0.00 | 0.09 | 0.75 | 0.86 | 1.42 | 0.84 | 0.00 | 0.05 | 0.00 | 0.93 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 247670.07 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.42 % |
| Cumulative Energy Availability Factor (EAF) | : 76.19 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.78 % |
| Cumulative Unit Capability Factor (UCF) | : 77.75 % | Cumulative Planned Unavailability Factor (PUF) | : 14.47 % |
| Cumulative Load Factor (LF) | : 72.46 % | Cumulative Externally cause unavailability (XUF) | : 1.56 % |
| Cumulative Operating Factor (OF) | : 77.91 % | | |

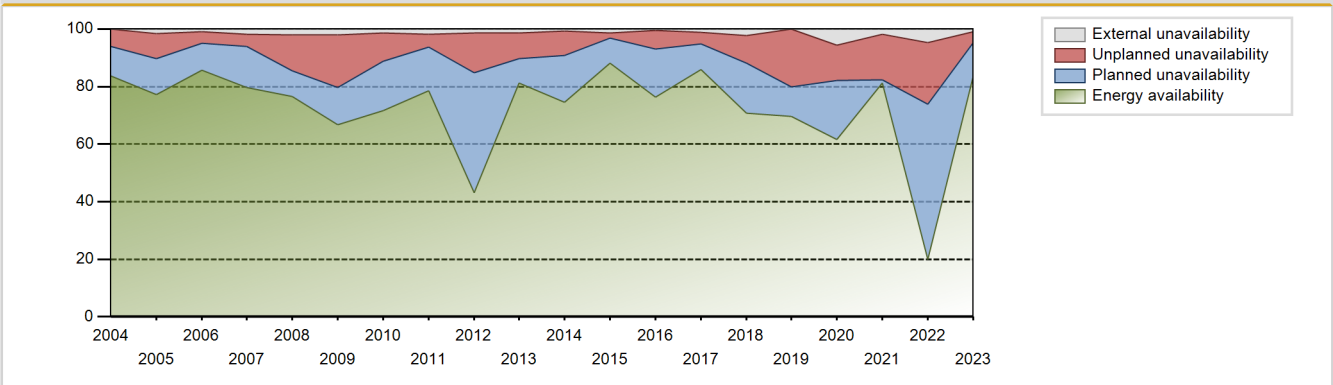
Electricity Production (net) [GWh]



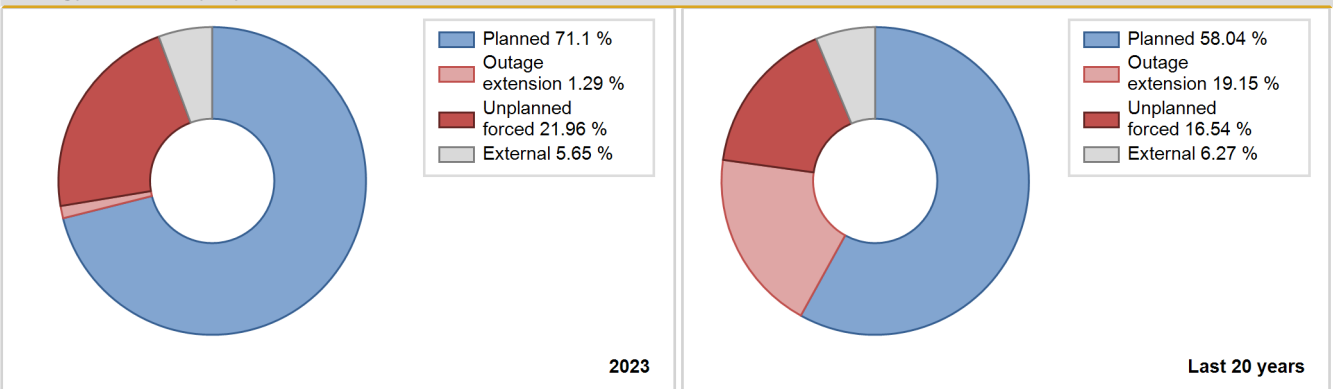
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 5170.10 | 6405 | 920 | 84.42 | 84.42 | 78.30 | 86.88 | 14.93 | 14.82 | 0.76 | 0.00 |
| 1982 | 3445.00 | 4260 | 910 | 47.62 | 47.62 | 43.22 | 48.63 | 27.74 | 18.28 | 34.10 | 0.00 |
| 1983 | 6006.00 | 7194 | 910 | 78.49 | 78.58 | 75.34 | 82.12 | 10.51 | 9.23 | 12.19 | 0.08 |
| 1984 | 6746.00 | 7505 | 910 | 83.87 | 83.87 | 84.39 | 85.44 | 5.25 | 4.65 | 11.48 | 0.00 |
| 1985 | 6294.40 | 7151 | 910 | 80.09 | 80.13 | 78.96 | 81.63 | 9.61 | 8.52 | 11.36 | 0.04 |
| 1986 | 6504.50 | 7335 | 910 | 81.73 | 81.73 | 81.60 | 83.73 | 10.22 | 9.30 | 8.97 | 0.00 |
| 1987 | 5382.90 | 6188 | 910 | 74.28 | 75.54 | 67.53 | 70.64 | 9.24 | 7.69 | 16.76 | 1.27 |
| 1988 | 4819.00 | 6724 | 910 | 95.45 | 96.20 | 60.29 | 76.55 | 3.80 | 3.80 | 0.00 | 0.75 |
| 1989 | 6307.71 | 7320 | 910 | 79.49 | 82.34 | 79.13 | 83.56 | 5.72 | 5.00 | 12.66 | 2.85 |
| 1990 | 6121.52 | 7114 | 910 | 77.61 | 80.65 | 76.79 | 81.21 | 7.42 | 6.47 | 12.89 | 3.03 |
| 1991 | 6306.28 | 7086 | 910 | 80.52 | 81.34 | 79.11 | 80.89 | 6.85 | 5.98 | 12.67 | 0.82 |
| 1992 | 4772.40 | 5388 | 910 | 59.96 | 60.35 | 59.70 | 61.34 | 15.94 | 11.44 | 28.21 | 0.39 |
| 1993 | 6588.06 | 7567 | 910 | 82.87 | 85.16 | 82.64 | 86.38 | 4.38 | 3.90 | 10.95 | 2.29 |
| 1994 | 6308.88 | 7116 | 910 | 82.95 | 83.80 | 79.14 | 81.23 | 3.56 | 3.09 | 13.10 | 0.85 |
| 1995 | 6221.69 | 7326 | 910 | 83.00 | 84.33 | 78.05 | 83.63 | 5.09 | 4.53 | 11.15 | 1.33 |
| 1996 | 5937.24 | 7377 | 910 | 83.00 | 85.91 | 74.28 | 83.98 | 2.37 | 2.08 | 12.01 | 2.91 |
| 1997 | 5752.68 | 6938 | 910 | 78.88 | 81.12 | 72.16 | 79.20 | 5.88 | 5.06 | 13.81 | 2.24 |
| 1998 | 6152.36 | 7330 | 910 | 82.99 | 83.86 | 77.18 | 83.68 | 2.09 | 1.79 | 14.35 | 0.86 |
| 1999 | 5412.92 | 6709 | 910 | 76.90 | 79.13 | 67.90 | 76.59 | 10.46 | 9.24 | 11.63 | 2.23 |
| 2000 | 6112.36 | 7396 | 910 | 82.92 | 84.60 | 76.47 | 84.20 | 2.99 | 2.60 | 12.79 | 1.69 |
| 2001 | 6198.04 | 7597 | 910 | 83.91 | 92.64 | 77.75 | 86.72 | 2.14 | 2.02 | 5.34 | 8.73 |
| 2002 | 5282.46 | 6401 | 910 | 76.78 | 76.80 | 66.27 | 73.07 | 2.52 | 1.98 | 21.22 | 0.01 |
| 2003 | 6045.52 | 7482 | 910 | 85.79 | 85.79 | 75.84 | 85.41 | 1.88 | 1.64 | 12.57 | 0.00 |
| 2004 | 6393.08 | 7499 | 910 | 83.78 | 83.86 | 79.98 | 85.37 | 6.69 | 6.01 | 10.13 | 0.08 |
| 2005 | 6075.92 | 7126 | 910 | 77.24 | 78.93 | 76.21 | 81.34 | 2.84 | 8.64 | 12.44 | 1.69 |
| 2006 | 6501.20 | 7834 | 910 | 85.66 | 86.65 | 81.55 | 89.43 | 3.94 | 4.03 | 9.32 | 0.99 |
| 2007 | 6265.62 | 7267 | 910 | 79.59 | 81.38 | 78.59 | 82.95 | 1.02 | 4.26 | 14.36 | 1.79 |
| 2008 | 6027.10 | 7335 | 910 | 76.49 | 78.58 | 75.40 | 83.50 | 10.88 | 12.43 | 8.99 | 2.08 |
| 2009 | 5272.78 | 6303 | 910 | 66.68 | 68.82 | 66.14 | 71.95 | 18.00 | 18.22 | 12.97 | 2.13 |
| 2010 | 5689.33 | 6550 | 910 | 71.72 | 73.16 | 71.37 | 74.77 | 6.04 | 9.83 | 17.01 | 1.44 |
| 2011 | 6227.87 | 7117 | 910 | 78.51 | 80.39 | 78.13 | 81.24 | 4.80 | 4.33 | 15.27 | 1.89 |
| 2012 | 3423.44 | 4028 | 910 | 43.10 | 44.54 | 42.83 | 45.86 | 3.38 | 13.66 | 41.80 | 1.44 |
| 2013 | 6407.37 | 7268 | 910 | 81.27 | 82.58 | 80.38 | 82.97 | 0.83 | 8.92 | 8.50 | 1.30 |
| 2014 | 5818.43 | 6694 | 910 | 74.63 | 75.40 | 72.99 | 76.42 | 5.71 | 8.50 | 16.10 | 0.76 |
| 2015 | 6840.51 | 7929 | 910 | 88.19 | 89.51 | 85.81 | 90.51 | 1.75 | 1.82 | 8.68 | 1.32 |
| 2016 | 6043.29 | 7044 | 910 | 76.35 | 76.78 | 75.60 | 80.19 | 4.10 | 6.57 | 16.65 | 0.42 |
| 2017 | 6722.26 | 7620 | 910 | 85.99 | 87.22 | 84.33 | 86.99 | 0.73 | 4.00 | 8.79 | 1.23 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2018 | 5466.29 | 6525 | 910 | 70.81 | 73.03 | 68.57 | 74.49 | 3.18 | 9.66 | 17.31 | 2.22 |
| 2019 | 5539.99 | 6877 | 910 | 69.60 | 69.61 | 69.50 | 78.50 | 19.25 | 20.06 | 10.33 | 0.02 |
| 2020 | 4907.62 | 5881 | 910 | 61.51 | 67.15 | 61.40 | 66.95 | 5.88 | 12.30 | 20.54 | 5.64 |
| 2021 | 6162.84 | 7395 | 910 | 81.23 | 83.15 | 77.31 | 84.42 | 5.33 | 15.80 | 1.05 | 1.92 |
| 2022 | 1550.09 | 1983 | 910 | 19.97 | 24.77 | 19.45 | 22.64 | 0.06 | 21.35 | 53.88 | 4.79 |
| 2023 | 6448.18 | 7594 | 910 | 83.60 | 84.52 | 80.89 | 86.69 | 4.09 | 3.81 | 11.66 | 0.93 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 207 | | | 470 | |
| B. Refuelling without maintenance | 958 | | | 161 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1043 | 18 | |
| D. Inspection, maintenance or repair without refuelling | | | | 1 | | |
| E. Testing of plant systems or components | | | | 6 | 1 | 2 |
| H. Nuclear regulatory requirements | | | | | 2 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 5 |
| L. Human factor related | | | | | 10 | 1 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| O. Load dispatching, prioritization | | | | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 14 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 2 |
| Z. Other | | | | | 35 | 44 |
| Subtotal | 958 | 207 | | 1211 | 536 | 72 |
| Total | | 1165 | | | 1819 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 9 |
| 12. Reactor I&C Systems | 62 | 21 |
| 13. Reactor Auxiliary Systems | | 17 |
| 14. Safety Systems | | 10 |
| 15. Reactor Cooling Systems | | 26 |
| 16. Steam generation systems | | 49 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 5 |
| 21. Fuel Handling and Storage Facilities | | 9 |
| 31. Turbine and auxiliaries | | 29 |
| 32. Feedwater and Main Steam System | | 22 |
| 34. Miscellaneous Systems | 146 | 171 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 78 |
| 42. Electrical Power Supply Systems | | 26 |
| Total | 208 | 473 |

2023 Operating Experience

FR-28

GRAVELINES-4

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2785 MWth
 Gross electrical power : 951 MWe
 Reference unit power (net) : 910 MWe

Key Dates

Construction Date : 1976-04-01
 Grid Date : 1981-06-14
 Commercial Date : 1981-10-01
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 45
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.2
 Reactor outlet temperature [°C] : 323
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.5
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

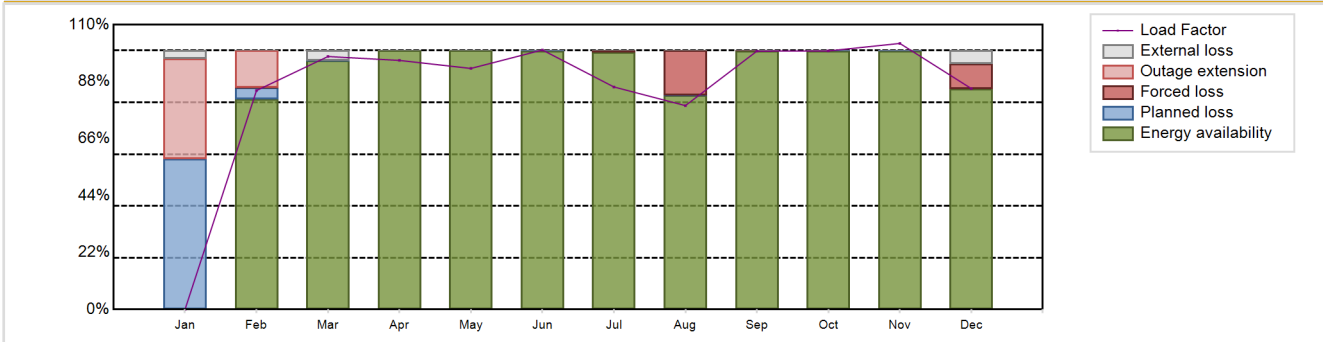
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 6792.53 GW(e).h
 Energy Availability Factor (EAF) : 86.96 %
 Unit Capability Factor (UCF) : 87.96 %
 Load Factor (LF) : 85.21 %
 Operating Factor (OF) : 89.34 %
 Forced Loss Rate (FLR) : 2.58 %
 Unplanned Capability Loss Factor (UCL) : 6.71 %
 Planned Unavailability Factor (PUF) : 5.33 %
 Externally cause unavailability (XUF) : 1.01 %
 Total off-line time : 934 hours

Annual Summary

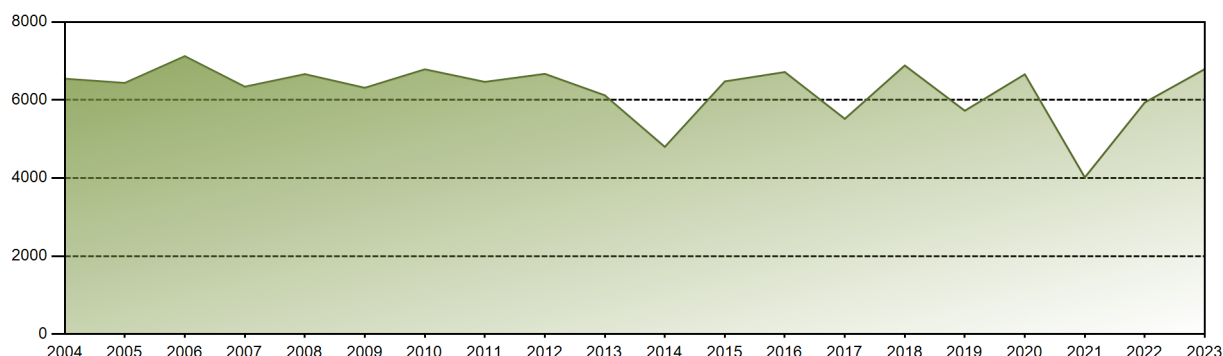


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 517.14 | 660.67 | 630.35 | 630.41 | 656.73 | 581.96 | 533.19 | 653.87 | 677.11 | 673.39 | 577.71 | 6792.53 |
| EAF [%] | 0.00 | 81.27 | 96.09 | 100.00 | 100.00 | 99.94 | 99.46 | 82.73 | 99.91 | 99.95 | 99.98 | 85.30 | 86.96 |
| UCF [%] | 3.07 | 81.27 | 99.90 | 100.00 | 100.00 | 99.94 | 99.46 | 82.73 | 99.91 | 99.95 | 99.98 | 90.28 | 87.96 |
| LF [%] | 0.00 | 84.57 | 97.71 | 96.21 | 93.11 | 100.23 | 85.96 | 78.75 | 99.80 | 99.88 | 102.78 | 85.33 | 85.21 |
| OF [%] | 0.00 | 85.86 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.95 | 100.00 | 99.87 | 100.00 | 93.41 | 89.34 |
| FLR [%] | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.54 | 17.21 | 0.00 | 0.00 | 0.00 | 9.72 | 2.58 |
| UCL [%] | 38.71 | 14.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.54 | 17.20 | 0.00 | 0.00 | 0.00 | 9.72 | 6.71 |
| PUF [%] | 58.23 | 4.56 | 0.10 | 0.00 | 0.00 | 0.06 | 0.00 | 0.07 | 0.09 | 0.05 | 0.02 | 0.00 | 5.33 |
| XUF [%] | 3.06 | 0.00 | 3.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.98 | 1.01 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 255138.58 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.35 % |
| Cumulative Energy Availability Factor (EAF) | : 78.12 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.45 % |
| Cumulative Unit Capability Factor (UCF) | : 79.56 % | Cumulative Planned Unavailability Factor (PUF) | : 13.99 % |
| Cumulative Load Factor (LF) | : 75.4 % | Cumulative Externally cause unavailability (XUF) | : 1.44 % |
| Cumulative Operating Factor (OF) | : 79.63 % | | |

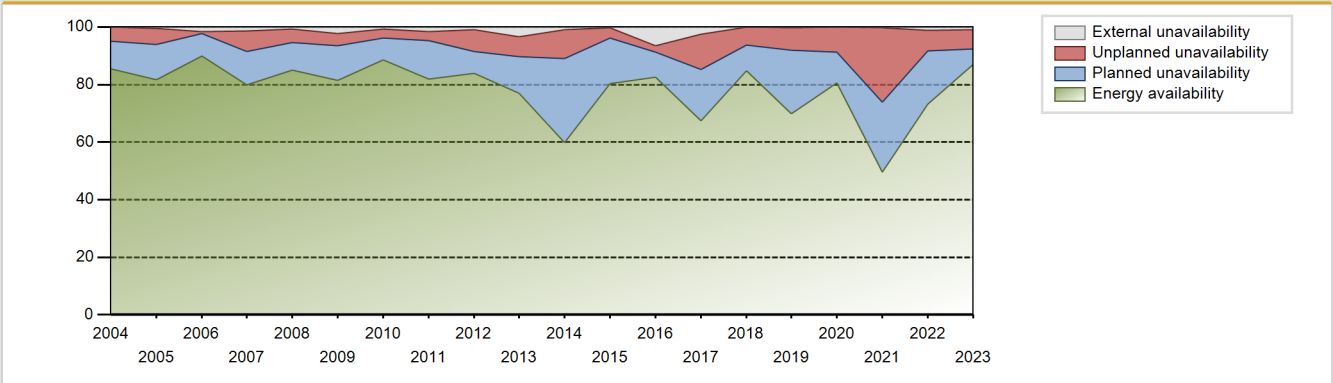
Electricity Production (net) [GWh]



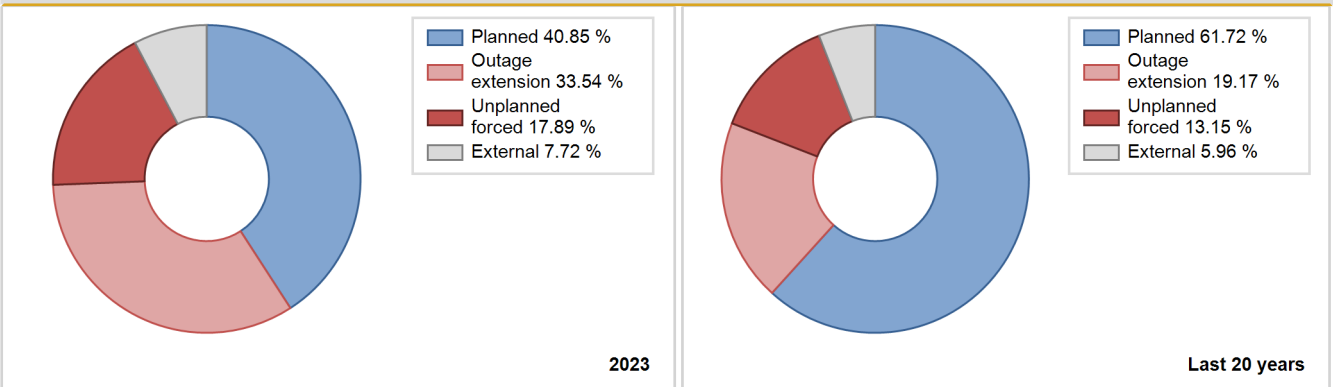
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 2636.60 | 3434 | 915 | 85.39 | 85.39 | 84.78 | 91.98 | 2.84 | 2.50 | 12.12 | 0.00 |
| 1982 | 5498.20 | 7193 | 910 | 80.76 | 80.76 | 68.97 | 82.11 | 19.24 | 19.24 | 0.00 | 0.00 |
| 1983 | 4062.00 | 4986 | 910 | 54.50 | 54.50 | 50.96 | 56.92 | 12.53 | 7.81 | 37.69 | 0.01 |
| 1984 | 6006.00 | 7173 | 910 | 82.77 | 82.77 | 75.14 | 81.66 | 7.35 | 6.57 | 10.67 | 0.00 |
| 1985 | 6178.80 | 7387 | 910 | 80.87 | 83.60 | 77.51 | 84.33 | 5.89 | 5.23 | 11.17 | 2.74 |
| 1986 | 6556.60 | 7862 | 910 | 88.64 | 88.70 | 82.25 | 89.75 | 2.14 | 1.94 | 9.35 | 0.06 |
| 1987 | 5472.80 | 6787 | 910 | 75.78 | 77.16 | 68.65 | 77.48 | 7.48 | 6.24 | 16.61 | 1.37 |
| 1988 | 6221.00 | 7789 | 910 | 85.93 | 87.85 | 77.83 | 88.67 | 1.83 | 1.64 | 10.51 | 1.93 |
| 1989 | 4982.33 | 6025 | 910 | 66.86 | 67.37 | 62.50 | 68.78 | 16.17 | 12.99 | 19.64 | 0.50 |
| 1990 | 6151.73 | 7058 | 910 | 77.18 | 79.44 | 77.17 | 80.57 | 9.13 | 7.98 | 12.58 | 2.26 |
| 1991 | 6261.99 | 7067 | 910 | 80.47 | 81.82 | 78.55 | 80.67 | 6.36 | 5.55 | 12.63 | 1.35 |
| 1992 | 6419.80 | 7137 | 910 | 80.20 | 81.01 | 80.31 | 81.25 | 2.41 | 2.00 | 16.98 | 0.82 |
| 1993 | 4680.57 | 6112 | 910 | 75.31 | 76.47 | 58.72 | 69.77 | 13.65 | 12.08 | 11.45 | 1.16 |
| 1994 | 6039.34 | 6824 | 910 | 82.47 | 83.27 | 75.76 | 77.90 | 6.37 | 5.67 | 11.07 | 0.80 |
| 1995 | 6289.53 | 7313 | 910 | 85.42 | 86.42 | 78.90 | 83.48 | 3.40 | 3.04 | 10.54 | 1.00 |
| 1996 | 6288.41 | 7552 | 910 | 83.16 | 85.50 | 78.67 | 85.97 | 4.28 | 3.82 | 10.68 | 2.34 |
| 1997 | 5986.68 | 7206 | 910 | 80.46 | 81.31 | 75.10 | 82.26 | 2.57 | 2.15 | 16.54 | 0.85 |
| 1998 | 6519.35 | 7570 | 910 | 84.10 | 85.44 | 81.78 | 86.42 | 1.97 | 1.72 | 12.84 | 1.35 |
| 1999 | 5550.87 | 6734 | 910 | 74.28 | 76.41 | 69.63 | 76.87 | 11.82 | 10.24 | 13.35 | 2.13 |
| 2000 | 4563.64 | 5453 | 910 | 57.74 | 69.50 | 57.09 | 62.08 | 0.50 | 0.35 | 30.15 | 11.76 |
| 2001 | 5990.69 | 7094 | 910 | 78.26 | 79.76 | 75.15 | 80.98 | 8.38 | 7.29 | 12.95 | 1.50 |
| 2002 | 6028.10 | 7219 | 910 | 80.04 | 81.12 | 75.62 | 82.41 | 9.31 | 8.32 | 10.55 | 1.08 |
| 2003 | 5701.86 | 6589 | 910 | 74.19 | 74.19 | 71.53 | 75.22 | 1.28 | 0.96 | 24.84 | 0.00 |
| 2004 | 6544.62 | 7693 | 910 | 85.39 | 85.39 | 81.87 | 87.58 | 5.42 | 4.90 | 9.71 | 0.00 |
| 2005 | 6437.07 | 7354 | 910 | 81.75 | 82.20 | 80.75 | 83.95 | 4.33 | 5.72 | 12.09 | 0.45 |
| 2006 | 7123.08 | 8079 | 910 | 89.94 | 91.49 | 89.36 | 92.23 | 0.19 | 0.82 | 7.69 | 1.55 |
| 2007 | 6341.02 | 7164 | 910 | 79.79 | 81.07 | 79.54 | 81.77 | 3.88 | 7.20 | 11.73 | 1.28 |
| 2008 | 6663.01 | 7678 | 910 | 85.04 | 85.78 | 83.36 | 87.41 | 5.01 | 4.71 | 9.52 | 0.73 |
| 2009 | 6312.54 | 7342 | 910 | 81.40 | 83.61 | 79.19 | 83.81 | 0.60 | 4.37 | 12.02 | 2.22 |
| 2010 | 6785.73 | 7958 | 910 | 88.51 | 89.11 | 85.12 | 90.84 | 1.18 | 3.23 | 7.66 | 0.59 |
| 2011 | 6464.37 | 7383 | 910 | 82.01 | 83.66 | 81.09 | 84.28 | 0.22 | 3.16 | 13.18 | 1.66 |
| 2012 | 6669.67 | 7612 | 910 | 83.89 | 84.85 | 83.44 | 86.66 | 5.09 | 7.62 | 7.52 | 0.96 |
| 2013 | 6120.30 | 6967 | 910 | 77.10 | 80.44 | 76.78 | 79.53 | 1.80 | 7.01 | 12.55 | 3.34 |
| 2014 | 4797.97 | 5335 | 910 | 59.73 | 60.73 | 60.19 | 60.90 | 6.39 | 9.88 | 29.39 | 1.00 |
| 2015 | 6476.69 | 7127 | 910 | 80.29 | 80.52 | 81.25 | 81.36 | 1.96 | 3.57 | 15.91 | 0.22 |
| 2016 | 6716.29 | 7445 | 910 | 82.50 | 89.06 | 84.02 | 84.76 | 0.76 | 2.05 | 8.88 | 6.56 |
| 2017 | 5517.18 | 6063 | 910 | 67.52 | 69.95 | 69.21 | 69.21 | 2.19 | 12.36 | 17.69 | 2.43 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2018 | 6884.99 | 7474 | 910 | 84.81 | 84.81 | 86.37 | 85.32 | 4.34 | 6.19 | 9.00 | 0.00 |
| 2019 | 5724.80 | 6192 | 910 | 69.76 | 69.91 | 71.81 | 70.68 | 3.50 | 7.85 | 22.24 | 0.15 |
| 2020 | 6658.46 | 7155 | 910 | 80.63 | 80.75 | 83.30 | 81.45 | 0.12 | 8.53 | 10.72 | 0.12 |
| 2021 | 4015.61 | 4480 | 910 | 49.61 | 49.94 | 50.37 | 51.14 | 13.82 | 25.79 | 24.28 | 0.33 |
| 2022 | 5937.41 | 6452 | 910 | 73.21 | 74.25 | 74.48 | 73.65 | 9.00 | 7.34 | 18.41 | 1.04 |
| 2023 | 6792.53 | 7826 | 910 | 86.96 | 87.96 | 85.21 | 89.34 | 2.58 | 6.71 | 5.33 | 1.01 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|------------|-----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 477 | | | 476 | |
| B. Refuelling without maintenance | | | | 118 | | |
| C. Inspection, maintenance or repair combined with refuelling | 433 | | | 1035 | 7 | |
| D. Inspection, maintenance or repair without refuelling | | | | 5 | 3 | |
| E. Testing of plant systems or components | | | | 3 | 1 | 1 |
| H. Nuclear regulatory requirements | | | | | 7 | |
| I. Grid capacity limitation | | | | | | 0 |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 7 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 3 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 23 | | 0 | 28 |
| Z. Other | | | | | 15 | 21 |
| Subtotal | 433 | 477 | 23 | 1161 | 516 | 54 |
| Total | | 933 | | | 1731 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 24 |
| 12. Reactor I&C Systems | | 40 |
| 13. Reactor Auxiliary Systems | | 7 |
| 14. Safety Systems | | 13 |
| 15. Reactor Cooling Systems | | 23 |
| 16. Steam generation systems | | 61 |
| 21. Fuel Handling and Storage Facilities | | 3 |
| 31. Turbine and auxiliaries | 62 | 27 |
| 32. Feedwater and Main Steam System | | 21 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | 416 | 151 |
| 35. All other I&C Systems | | 6 |
| 41. Main Generator Systems | | 37 |
| 42. Electrical Power Supply Systems | | 72 |
| Total | 478 | 491 |

2023 Operating Experience

FR-51 GRAVELINES-5 FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP1 | Construction Date | : 1979-10-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1984-08-28 |
| Gross electrical power | : 951 MWe | Commercial Date | : 1985-01-15 |
| Reference unit power (net) | : 910 MWe | Age at end of year | : 39 years |

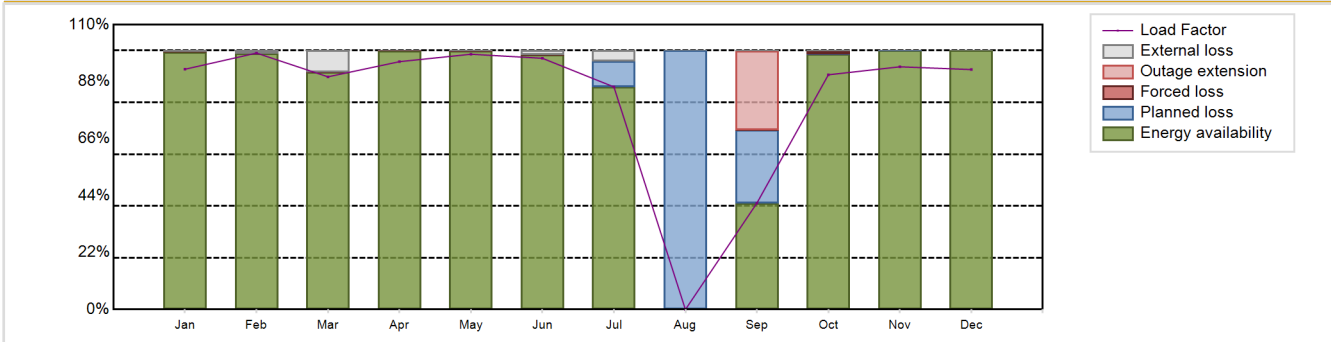
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.8 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 321 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 5 |
| Refuelling frequency [month] | : 12 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 47000 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.85 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 36 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 6479.71 GW(e).h | Forced Loss Rate (FLR) | : 0.12 % |
| Energy Availability Factor (EAF) | : 84.35 % | Unplanned Capability Loss Factor (UCL) | : 2.61 % |
| Unit Capability Factor (UCF) | : 85.69 % | Planned Unavailability Factor (PUF) | : 11.7 % |
| Load Factor (LF) | : 81.28 % | Externally cause unavailability (XUF) | : 1.34 % |
| Operating Factor (OF) | : 86.54 % | Total off-line time | : 1179 hours |

Annual Summary

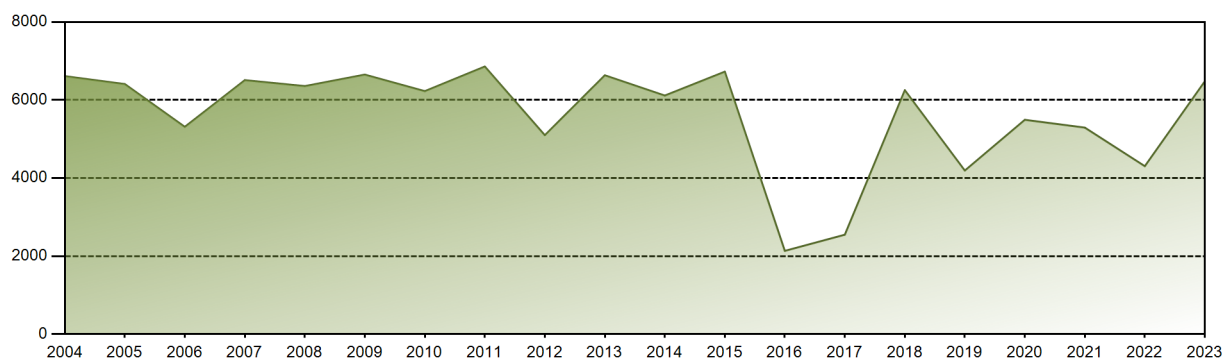


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 628.28 | 605.68 | 607.66 | 627.19 | 667.51 | 635.75 | 582.04 | 0.00 | 269.32 | 614.63 | 614.20 | 627.46 | 6479.71 |
| EAF [%] | 99.47 | 98.87 | 91.69 | 99.95 | 99.74 | 98.28 | 86.00 | 0.00 | 41.11 | 98.56 | 99.99 | 100.00 | 84.35 |
| UCF [%] | 99.89 | 100.00 | 99.99 | 99.95 | 99.76 | 100.00 | 90.13 | 0.00 | 41.15 | 98.72 | 99.99 | 100.00 | 85.69 |
| LF [%] | 92.80 | 99.04 | 89.87 | 95.72 | 98.59 | 97.03 | 85.97 | 0.00 | 41.10 | 90.66 | 93.74 | 92.68 | 81.28 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.32 | 0.00 | 49.72 | 99.87 | 100.00 | 100.00 | 86.54 |
| FLR [%] | 0.03 | 0.00 | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 1.11 | 0.00 | 0.00 | 0.12 |
| UCL [%] | 0.03 | 0.00 | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 30.56 | 1.11 | 0.00 | 0.00 | 2.61 |
| PUF [%] | 0.08 | 0.00 | 0.00 | 0.00 | 0.24 | 0.00 | 9.87 | 100.00 | 28.29 | 0.17 | 0.01 | 0.00 | 11.70 |
| XUF [%] | 0.42 | 1.13 | 8.30 | 0.00 | 0.02 | 1.72 | 4.14 | 0.00 | 0.05 | 0.15 | 0.00 | 0.00 | 1.34 |

Historical Summary

| | | | | | |
|---|---|-------------------|---|---|---------|
| Lifetime energy generation | : | 225820.41 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 4.85 % |
| Cumulative Energy Availability Factor (EAF) | : | 76.04 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 8.64 % |
| Cumulative Unit Capability Factor (UCF) | : | 77.73 % | Cumulative Planned Unavailability Factor (PUF) | : | 13.63 % |
| Cumulative Load Factor (LF) | : | 72.22 % | Cumulative Externally cause unavailability (XUF) | : | 1.69 % |
| Cumulative Operating Factor (OF) | : | 78.02 % | | | |

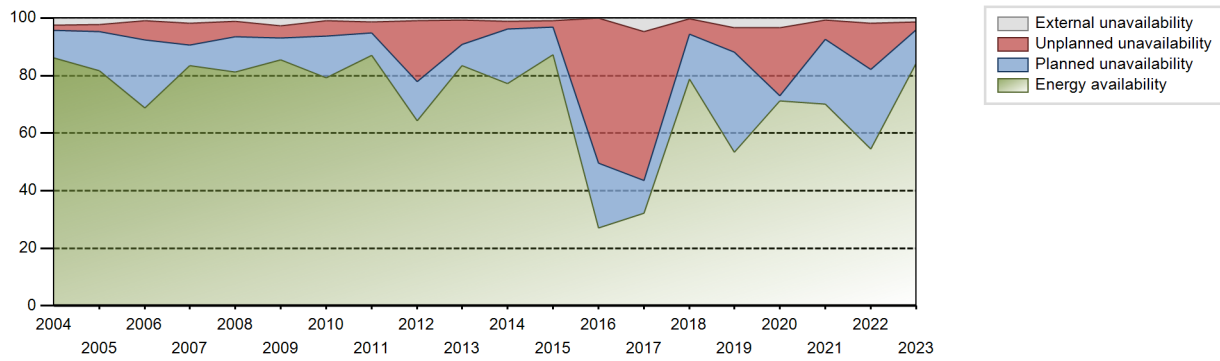
Electricity Production (net) [GWh]



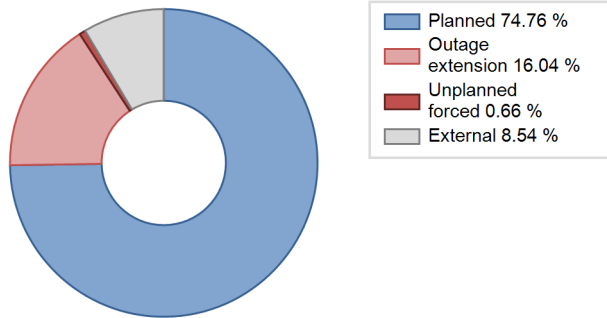
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 6768.40 | 7785 | 910 | 90.02 | 90.06 | 84.91 | 88.87 | 9.94 | 9.94 | 0.00 | 0.04 |
| 1986 | 5152.60 | 6673 | 910 | 75.24 | 77.10 | 64.64 | 76.18 | 3.23 | 2.57 | 20.33 | 1.86 |
| 1987 | 5236.50 | 6818 | 910 | 80.63 | 81.53 | 65.69 | 77.83 | 8.13 | 7.21 | 11.26 | 0.90 |
| 1988 | 4964.00 | 6306 | 910 | 71.75 | 75.25 | 62.10 | 71.79 | 7.10 | 5.75 | 18.99 | 3.50 |
| 1989 | 6020.57 | 7198 | 910 | 80.64 | 80.98 | 75.53 | 82.17 | 11.01 | 10.02 | 9.00 | 0.34 |
| 1990 | 5992.77 | 7367 | 910 | 80.68 | 83.24 | 75.18 | 84.10 | 4.58 | 3.99 | 12.77 | 2.56 |
| 1991 | 5276.17 | 6352 | 910 | 69.61 | 72.16 | 66.19 | 72.51 | 4.86 | 3.68 | 24.16 | 2.55 |
| 1992 | 6308.02 | 7361 | 910 | 82.64 | 82.65 | 78.91 | 83.80 | 3.06 | 2.61 | 14.74 | 0.00 |
| 1993 | 6180.53 | 7290 | 910 | 78.59 | 82.73 | 77.53 | 83.22 | 6.30 | 5.56 | 11.71 | 4.15 |
| 1994 | 5793.25 | 7147 | 910 | 83.21 | 84.37 | 72.67 | 81.59 | 3.60 | 3.15 | 12.48 | 1.16 |
| 1995 | 6180.98 | 7704 | 910 | 85.99 | 87.59 | 77.54 | 87.95 | 2.11 | 1.88 | 10.52 | 1.60 |
| 1996 | 5495.18 | 6652 | 910 | 72.12 | 75.29 | 68.75 | 75.73 | 6.30 | 5.06 | 19.65 | 3.17 |
| 1997 | 6429.86 | 7586 | 910 | 86.07 | 87.63 | 80.66 | 86.60 | 2.13 | 1.91 | 10.46 | 1.56 |
| 1998 | 6884.31 | 8286 | 910 | 95.83 | 97.34 | 86.36 | 94.59 | 2.05 | 2.04 | 0.62 | 1.52 |
| 1999 | 5124.26 | 6127 | 910 | 67.03 | 68.06 | 64.28 | 69.94 | 21.44 | 18.57 | 13.37 | 1.03 |
| 2000 | 5985.50 | 7444 | 910 | 81.45 | 84.37 | 74.88 | 84.74 | 4.94 | 4.38 | 11.25 | 2.92 |
| 2001 | 5762.64 | 6990 | 910 | 78.23 | 80.15 | 72.29 | 79.79 | 8.59 | 7.54 | 12.31 | 1.93 |
| 2002 | 6423.39 | 7662 | 910 | 84.68 | 85.83 | 80.58 | 87.47 | 4.07 | 3.64 | 10.52 | 1.15 |
| 2003 | 6473.43 | 7518 | 910 | 84.32 | 85.14 | 81.21 | 85.82 | 1.24 | 1.07 | 13.79 | 0.83 |
| 2004 | 6613.48 | 7836 | 910 | 86.25 | 88.79 | 82.74 | 89.21 | 2.01 | 1.82 | 9.38 | 2.55 |
| 2005 | 6410.04 | 7524 | 910 | 81.68 | 84.01 | 80.40 | 85.88 | 2.21 | 2.47 | 13.51 | 2.33 |
| 2006 | 5313.17 | 6313 | 910 | 68.84 | 69.82 | 66.65 | 72.07 | 7.46 | 6.54 | 23.64 | 0.97 |
| 2007 | 6510.19 | 7592 | 910 | 83.46 | 85.36 | 81.66 | 86.66 | 4.99 | 7.39 | 7.24 | 1.90 |
| 2008 | 6357.76 | 7352 | 910 | 81.16 | 82.33 | 79.54 | 83.70 | 4.48 | 5.29 | 12.38 | 1.17 |
| 2009 | 6652.21 | 7846 | 910 | 85.54 | 88.33 | 83.45 | 89.57 | 0.88 | 4.13 | 7.54 | 2.79 |
| 2010 | 6228.43 | 7120 | 910 | 79.28 | 80.20 | 78.13 | 81.28 | 2.02 | 5.32 | 14.47 | 0.92 |
| 2011 | 6859.22 | 7807 | 910 | 87.04 | 88.52 | 86.05 | 89.12 | 0.02 | 3.77 | 7.71 | 1.48 |
| 2012 | 5099.17 | 5943 | 910 | 64.29 | 65.27 | 63.79 | 67.66 | 7.74 | 21.09 | 13.64 | 0.99 |
| 2013 | 6635.01 | 7427 | 910 | 83.51 | 84.20 | 83.23 | 84.78 | 1.29 | 8.42 | 7.38 | 0.69 |
| 2014 | 6114.63 | 6972 | 910 | 77.24 | 78.28 | 76.71 | 79.59 | 1.17 | 2.71 | 19.01 | 1.04 |
| 2015 | 6727.72 | 7810 | 910 | 87.21 | 88.12 | 84.40 | 89.16 | 1.06 | 2.26 | 9.62 | 0.91 |
| 2016 | 2133.02 | 2378 | 910 | 26.98 | 26.99 | 26.68 | 27.07 | 0.11 | 50.31 | 22.70 | 0.01 |
| 2017 | 2547.59 | 3150 | 910 | 32.12 | 36.86 | 31.96 | 35.96 | 5.90 | 51.76 | 11.38 | 4.73 |
| 2018 | 6253.07 | 7131 | 910 | 78.87 | 79.07 | 78.44 | 81.40 | 1.64 | 5.31 | 15.62 | 0.20 |
| 2019 | 4192.74 | 4915 | 910 | 53.33 | 56.72 | 52.60 | 56.11 | 6.87 | 8.43 | 34.85 | 3.39 |
| 2020 | 5493.20 | 6571 | 910 | 71.15 | 74.50 | 68.72 | 74.81 | 11.28 | 23.73 | 1.77 | 3.35 |
| 2021 | 5293.14 | 6199 | 910 | 70.02 | 70.72 | 66.40 | 70.76 | 8.54 | 6.61 | 22.68 | 0.70 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|-------|-------|------|
| 2022 | 4304.69 | 4979 | 910 | 54.48 | 56.19 | 54.00 | 56.84 | 2.07 | 16.22 | 27.59 | 1.71 |
| 2023 | 6479.71 | 7581 | 910 | 84.35 | 85.69 | 81.28 | 86.54 | 0.12 | 2.61 | 11.70 | 1.34 |

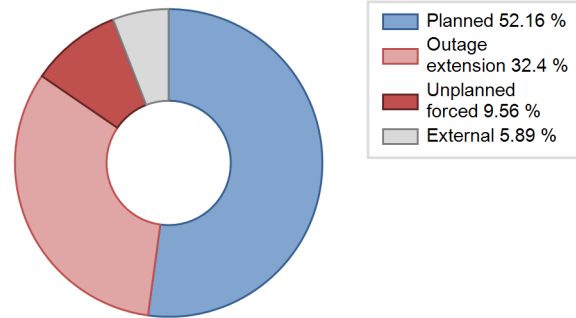
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 220 | | | 438 | |
| B. Refuelling without maintenance | 958 | | | 138 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 981 | 16 | |
| D. Inspection, maintenance or repair without refuelling | | | | 2 | | |
| E. Testing of plant systems or components | | | | 4 | 0 | |
| H. Nuclear regulatory requirements | | | | | 222 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 14 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| O. Load dispatching, prioritization | | | | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 19 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 2 |
| Z. Other | | | | | 13 | |
| Subtotal | 958 | 220 | | 1125 | 703 | 27 |
| Total | | 1178 | | | 1855 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 16 |
| 12. Reactor I&C Systems | | 17 |
| 13. Reactor Auxiliary Systems | | 23 |
| 14. Safety Systems | | 16 |
| 15. Reactor Cooling Systems | | 58 |
| 16. Steam generation systems | | 235 |
| 21. Fuel Handling and Storage Facilities | | 5 |
| 31. Turbine and auxiliaries | | 43 |
| 32. Feedwater and Main Steam System | | 13 |
| 33. Circulating Water System | | 4 |
| 34. Miscellaneous Systems | 220 | 135 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 48 |
| 42. Electrical Power Supply Systems | | 49 |
| Total | 220 | 662 |

2023 Operating Experience

FR-52

GRAVELINES-6

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2785 MWth
 Gross electrical power : 951 MWe
 Reference unit power (net) : 910 MWe

Key Dates

Construction Date : 1979-10-01
 Grid Date : 1985-08-01
 Commercial Date : 1985-10-25
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 47000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.85
 Number of control rod assemblies : 36
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

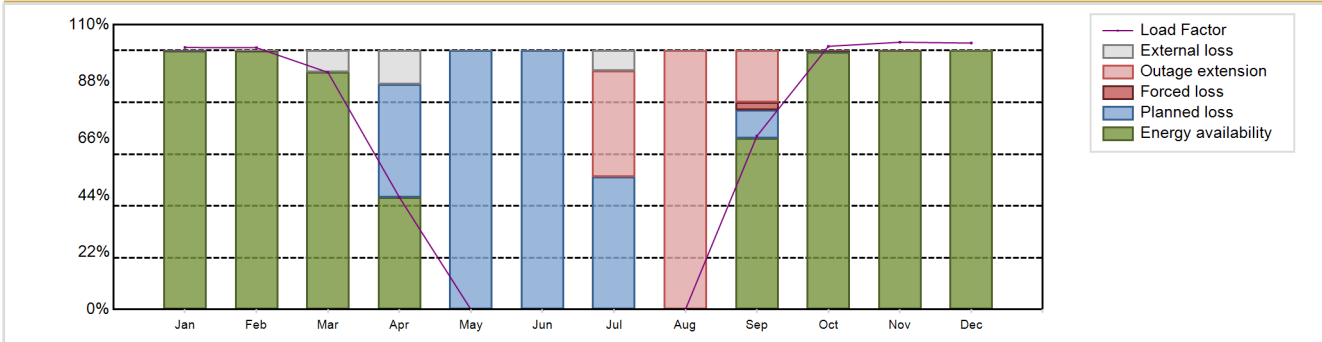
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 4707.2 GW(e).h
 Energy Availability Factor (EAF) : 58.06 %
 Unit Capability Factor (UCF) : 60.51 %
 Load Factor (LF) : 59.05 %
 Operating Factor (OF) : 60.87 %
 Forced Loss Rate (FLR) : 0.51 %
 Unplanned Capability Loss Factor (UCL) : 13.93 %
 Planned Unavailability Factor (PUF) : 25.56 %
 Externally cause unavailability (XUF) : 2.46 %
 Total off-line time : 3428 hours

Annual Summary

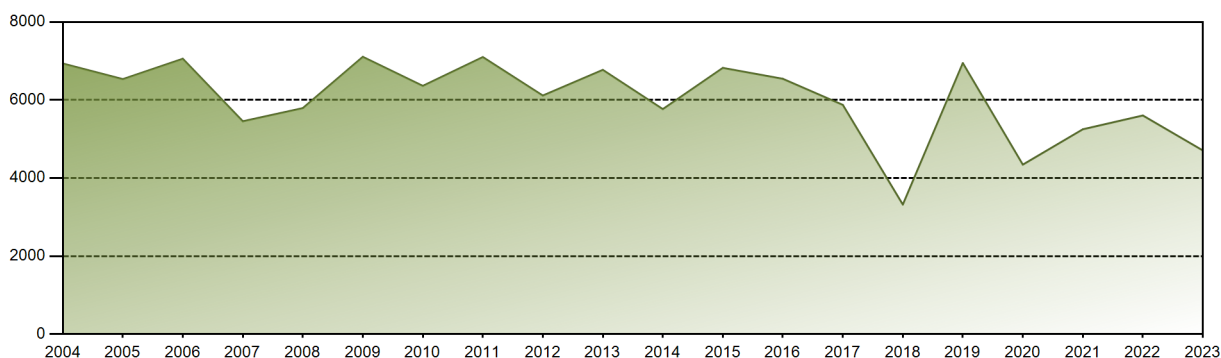


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 685.10 | 618.33 | 619.18 | 283.62 | 0.00 | 0.00 | 0.00 | 0.00 | 438.90 | 689.11 | 676.27 | 696.70 | 4707.20 |
| EAF [%] | 99.82 | 99.82 | 91.58 | 43.29 | 0.00 | 0.00 | 0.00 | 0.00 | 66.11 | 99.35 | 100.00 | 100.00 | 58.06 |
| UCF [%] | 99.82 | 99.90 | 100.00 | 56.44 | 0.00 | 0.00 | 7.73 | 0.00 | 66.11 | 99.35 | 100.00 | 100.00 | 60.51 |
| LF [%] | 101.19 | 101.11 | 91.58 | 43.29 | 0.00 | 0.00 | 0.00 | 0.00 | 66.99 | 101.65 | 103.22 | 102.90 | 59.05 |
| OF [%] | 100.00 | 100.00 | 100.00 | 56.81 | 0.00 | 0.00 | 0.00 | 0.00 | 77.22 | 99.87 | 100.00 | 100.00 | 60.87 |
| FLR [%] | 0.14 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.44 | 0.44 | 0.00 | 0.00 | 0.51 |
| UCL [%] | 0.14 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 40.95 | 100.00 | 23.08 | 0.44 | 0.00 | 0.00 | 13.93 |
| PUF [%] | 0.04 | 0.00 | 0.00 | 43.56 | 100.00 | 100.00 | 51.32 | 0.00 | 10.80 | 0.21 | 0.00 | 0.00 | 25.56 |
| XUF [%] | 0.00 | 0.08 | 8.42 | 13.15 | 0.00 | 0.00 | 7.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.46 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 230833.98 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.82 % |
| Cumulative Energy Availability Factor (EAF) | : 77.56 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.54 % |
| Cumulative Unit Capability Factor (UCF) | : 79.16 % | Cumulative Planned Unavailability Factor (PUF) | : 14.3 % |
| Cumulative Load Factor (LF) | : 75.4 % | Cumulative Externally cause unavailability (XUF) | : 1.6 % |
| Cumulative Operating Factor (OF) | : 79.31 % | | |

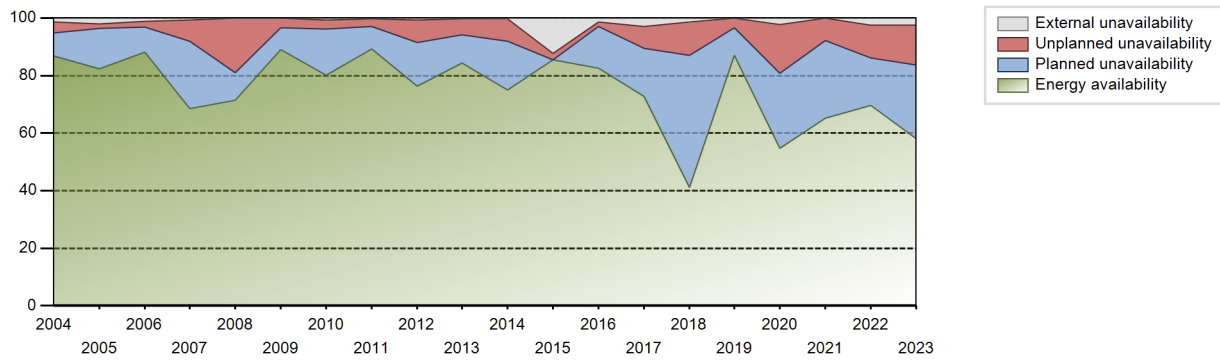
Electricity Production (net) [GWh]



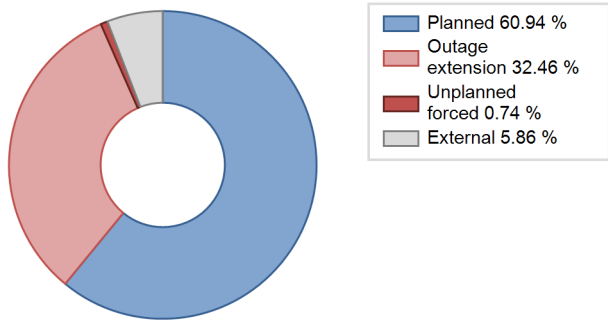
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 2337.10 | 3111 | 910 | 97.26 | 97.26 | 94.68 | 97.61 | 2.74 | 2.74 | 0.00 | 0.00 |
| 1986 | 5540.40 | 6677 | 910 | 75.88 | 76.32 | 69.50 | 76.22 | 3.96 | 3.15 | 20.53 | 0.44 |
| 1987 | 5583.90 | 7031 | 910 | 80.14 | 80.57 | 70.05 | 80.26 | 9.39 | 8.34 | 11.09 | 0.42 |
| 1988 | 6490.00 | 7453 | 910 | 81.43 | 83.77 | 81.19 | 84.85 | 14.30 | 13.97 | 2.25 | 2.34 |
| 1989 | 5177.26 | 6274 | 910 | 71.08 | 71.17 | 64.95 | 71.62 | 9.18 | 7.19 | 21.63 | 0.09 |
| 1990 | 6120.26 | 7553 | 910 | 87.07 | 87.56 | 76.78 | 86.22 | 12.41 | 12.41 | 0.03 | 0.49 |
| 1991 | 5888.22 | 6953 | 910 | 77.47 | 78.53 | 73.86 | 79.37 | 9.62 | 8.36 | 13.11 | 1.06 |
| 1992 | 5085.13 | 6246 | 910 | 69.03 | 70.27 | 63.62 | 71.11 | 11.78 | 9.38 | 20.35 | 1.24 |
| 1993 | 5293.57 | 6751 | 910 | 73.42 | 82.03 | 66.41 | 77.07 | 7.24 | 6.40 | 11.57 | 8.61 |
| 1994 | 6053.73 | 7487 | 910 | 83.89 | 86.00 | 75.94 | 85.47 | 1.80 | 1.58 | 12.42 | 2.11 |
| 1995 | 6769.36 | 7922 | 910 | 88.83 | 89.78 | 84.92 | 90.43 | 0.95 | 0.86 | 9.36 | 0.95 |
| 1996 | 6609.47 | 7755 | 910 | 86.39 | 86.77 | 82.69 | 88.29 | 3.48 | 3.13 | 10.11 | 0.37 |
| 1997 | 4545.45 | 5437 | 910 | 59.49 | 60.58 | 57.02 | 62.07 | 23.50 | 18.61 | 20.81 | 1.09 |
| 1998 | 6531.81 | 7746 | 910 | 86.08 | 88.53 | 81.94 | 88.42 | 1.63 | 1.47 | 10.00 | 2.45 |
| 1999 | 6141.43 | 7222 | 910 | 80.29 | 80.92 | 77.04 | 82.44 | 4.70 | 3.99 | 15.10 | 0.63 |
| 2000 | 6720.94 | 7887 | 910 | 87.03 | 88.68 | 84.08 | 89.79 | 0.35 | 0.32 | 11.01 | 1.65 |
| 2001 | 6148.66 | 7265 | 910 | 80.24 | 82.23 | 77.13 | 82.93 | 5.74 | 5.01 | 12.76 | 1.99 |
| 2002 | 6690.91 | 7784 | 910 | 86.02 | 87.49 | 83.93 | 88.86 | 3.39 | 3.07 | 9.44 | 1.48 |
| 2003 | 6462.57 | 7410 | 910 | 82.50 | 83.26 | 81.07 | 84.59 | 1.98 | 1.69 | 15.05 | 0.76 |
| 2004 | 6936.10 | 7850 | 910 | 86.85 | 88.32 | 86.77 | 89.37 | 4.00 | 3.68 | 8.00 | 1.47 |
| 2005 | 6536.49 | 7511 | 910 | 82.35 | 84.30 | 82.00 | 85.74 | 1.97 | 1.69 | 14.01 | 1.95 |
| 2006 | 7058.37 | 7907 | 910 | 88.25 | 89.35 | 88.54 | 90.26 | 1.41 | 1.98 | 8.68 | 1.09 |
| 2007 | 5455.66 | 6087 | 910 | 68.42 | 69.10 | 68.44 | 69.49 | 1.42 | 7.46 | 23.44 | 0.68 |
| 2008 | 5792.75 | 6383 | 910 | 71.49 | 71.53 | 72.47 | 72.67 | 2.96 | 18.85 | 9.62 | 0.04 |
| 2009 | 7108.24 | 7866 | 910 | 88.95 | 89.00 | 89.17 | 89.79 | 0.12 | 3.34 | 7.66 | 0.04 |
| 2010 | 6363.90 | 7125 | 910 | 80.15 | 80.86 | 79.83 | 81.34 | 1.53 | 3.12 | 16.02 | 0.71 |
| 2011 | 7101.91 | 7859 | 910 | 89.19 | 89.51 | 89.09 | 89.71 | 0.11 | 2.52 | 7.97 | 0.32 |
| 2012 | 6115.18 | 6810 | 910 | 76.26 | 76.97 | 76.50 | 77.53 | 1.43 | 7.81 | 15.22 | 0.71 |
| 2013 | 6773.04 | 7544 | 910 | 84.27 | 84.52 | 84.96 | 86.12 | 3.46 | 5.58 | 9.90 | 0.26 |
| 2014 | 5768.07 | 6619 | 910 | 74.93 | 75.30 | 72.36 | 75.56 | 9.21 | 7.64 | 17.06 | 0.37 |
| 2015 | 6824.41 | 7703 | 910 | 85.51 | 97.72 | 85.61 | 87.93 | 2.25 | 2.25 | 0.04 | 12.21 |
| 2016 | 6544.45 | 7506 | 910 | 82.51 | 83.79 | 81.87 | 85.45 | 1.87 | 1.60 | 14.61 | 1.28 |
| 2017 | 5875.43 | 6627 | 910 | 72.85 | 75.77 | 73.70 | 75.65 | 1.93 | 7.68 | 16.54 | 2.93 |
| 2018 | 3320.31 | 3714 | 910 | 41.15 | 42.63 | 41.65 | 42.40 | 1.19 | 11.55 | 45.82 | 1.48 |
| 2019 | 6947.55 | 7703 | 910 | 87.09 | 87.16 | 87.15 | 87.93 | 1.39 | 3.38 | 9.47 | 0.07 |
| 2020 | 4343.71 | 4880 | 910 | 54.60 | 56.84 | 54.34 | 55.56 | 3.90 | 16.86 | 26.30 | 2.23 |
| 2021 | 5250.30 | 5755 | 910 | 65.23 | 65.29 | 65.86 | 65.70 | 10.63 | 7.76 | 26.95 | 0.06 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|-------|-------|------|
| 2022 | 5604.12 | 6290 | 910 | 69.65 | 72.05 | 70.30 | 71.80 | 4.16 | 11.52 | 16.43 | 2.40 |
| 2023 | 4707.20 | 5332 | 910 | 58.06 | 60.51 | 59.05 | 60.87 | 0.51 | 13.93 | 25.56 | 2.46 |

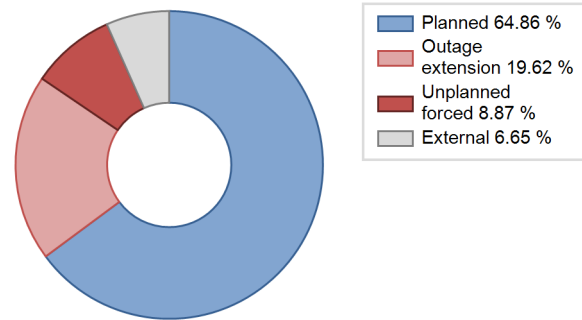
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|-------------|-------------|-----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1213 | | | 444 | |
| B. Refuelling without maintenance | | | | 187 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2157 | | | 993 | 20 | |
| D. Inspection, maintenance or repair without refuelling | | | | | 14 | |
| E. Testing of plant systems or components | | | | 8 | | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 2 |
| L. Human factor related | | | | | 24 | 1 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 10 |
| O. Load dispatching, prioritization | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 58 | | 3 | 11 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 23 |
| Z. Other | | | | | 29 | 1 |
| Subtotal | 2157 | 1213 | 58 | 1188 | 537 | 49 |
| Total | | 3428 | | | 1774 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 31 |
| 13. Reactor Auxiliary Systems | | 57 |
| 14. Safety Systems | | 12 |
| 15. Reactor Cooling Systems | | 22 |
| 16. Steam generation systems | | 5 |
| 21. Fuel Handling and Storage Facilities | | 4 |
| 31. Turbine and auxiliaries | 20 | 58 |
| 32. Feedwater and Main Steam System | | 17 |
| 33. Circulating Water System | | 8 |
| 34. Miscellaneous Systems | 1193 | 171 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 14 |
| 42. Electrical Power Supply Systems | | 42 |
| Total | 1213 | 443 |

2023 Operating Experience

FR-58

NOGENT-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1363 MWe
 Reference unit power (net) : 1310 MWe

Key Dates

Construction Date : 1981-05-26
 Grid Date : 1987-10-21
 Commercial Date : 1988-02-24
 Age at end of year : 36 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.5
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.05
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

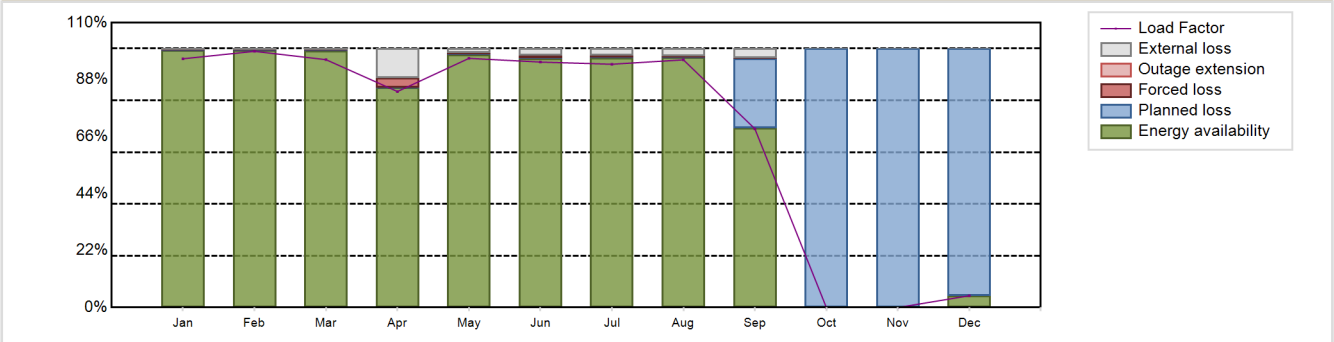
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 7901.27 GW(e).h | Forced Loss Rate (FLR) | : 0.82 % |
| Energy Availability Factor (EAF) | : 70.14 % | Unplanned Capability Loss Factor (UCL) | : 0.6 % |
| Unit Capability Factor (UCF) | : 72.3 % | Planned Unavailability Factor (PUF) | : 27.1 % |
| Load Factor (LF) | : 68.85 % | Externally cause unavailability (XUF) | : 2.16 % |
| Operating Factor (OF) | : 72.29 % | Total off-line time | : 2427 hours |

Annual Summary

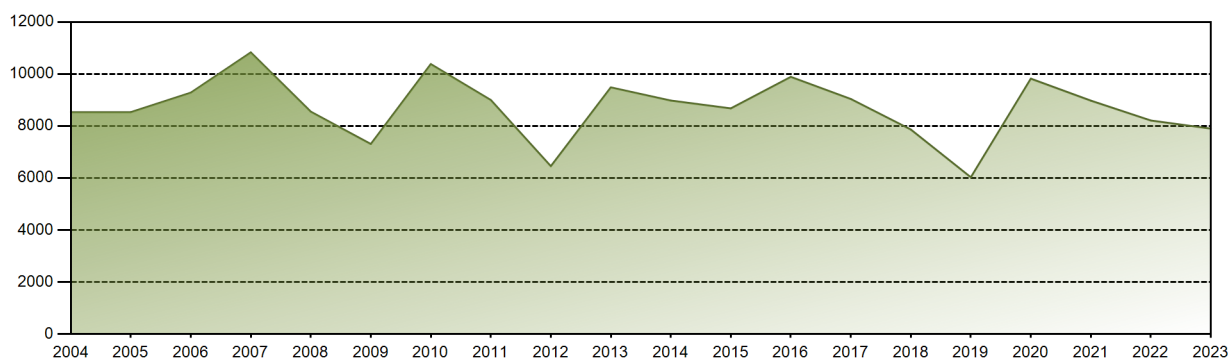


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|---------|
| GW(e)-h | 936.28 | 870.94 | 931.76 | 786.78 | 937.85 | 894.15 | 915.84 | 932.28 | 651.04 | 0.00 | 0.00 | 44.36 | 7901.27 |
| EAF [%] | 99.36 | 99.35 | 99.23 | 84.87 | 97.71 | 96.22 | 96.38 | 96.58 | 69.39 | 0.00 | 0.00 | 4.55 | 70.14 |
| UCF [%] | 99.75 | 99.76 | 99.69 | 96.13 | 99.38 | 98.96 | 99.10 | 99.47 | 72.91 | 0.00 | 0.00 | 4.55 | 72.30 |
| LF [%] | 96.06 | 98.93 | 95.73 | 83.42 | 96.23 | 94.80 | 93.97 | 95.65 | 69.02 | 0.00 | 0.00 | 4.55 | 68.85 |
| OF [%] | 100.00 | 100.00 | 100.00 | 86.53 | 100.00 | 100.00 | 100.00 | 100.00 | 73.33 | 0.00 | 0.00 | 9.54 | 72.29 |
| FLR [%] | 0.23 | 0.14 | 0.29 | 3.73 | 0.58 | 0.76 | 0.63 | 0.47 | 0.55 | 0.00 | 0.00 | 0.00 | 0.82 |
| UCL [%] | 0.23 | 0.14 | 0.29 | 3.72 | 0.58 | 0.76 | 0.63 | 0.47 | 0.40 | 0.00 | 0.00 | 0.00 | 0.60 |
| PUF [%] | 0.01 | 0.10 | 0.03 | 0.15 | 0.04 | 0.28 | 0.27 | 0.06 | 26.69 | 100.00 | 100.00 | 95.45 | 27.10 |
| XUF [%] | 0.40 | 0.41 | 0.46 | 11.26 | 1.67 | 2.74 | 2.72 | 2.89 | 3.52 | 0.00 | 0.00 | 0.00 | 2.16 |

Historical Summary

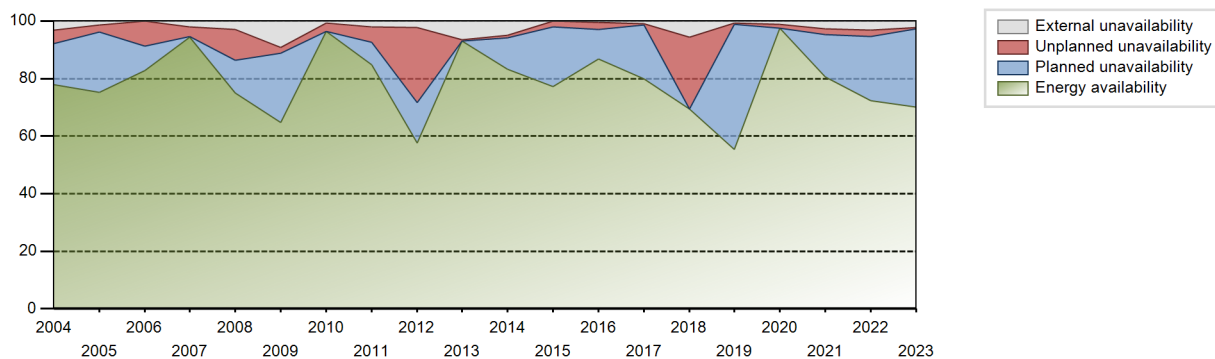
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 281985.87 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.05 % |
| Cumulative Energy Availability Factor (EAF) | : 77.3 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.13 % |
| Cumulative Unit Capability Factor (UCF) | : 79.39 % | Cumulative Planned Unavailability Factor (PUF) | : 13.48 % |
| Cumulative Load Factor (LF) | : 72.43 % | Cumulative Externally cause unavailability (XUF) | : 2.09 % |
| Cumulative Operating Factor (OF) | : 79.57 % | | |

Electricity Production (net) [GWh]

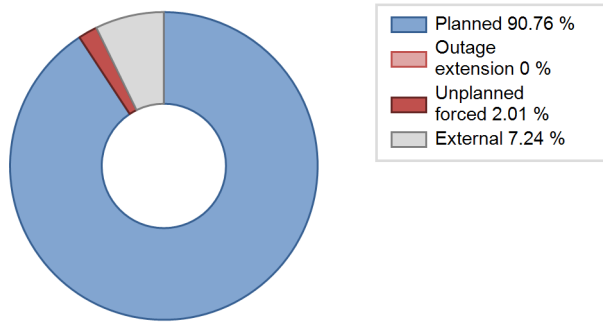


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 7715.00 | 7324 | 1310 | 86.78 | 87.76 | 63.93 | 81.77 | 12.24 | 12.24 | 0.00 | 0.98 |
| 1989 | 3172.66 | 2663 | 1310 | 28.26 | 30.25 | 27.65 | 30.40 | 57.21 | 40.43 | 29.32 | 1.99 |
| 1990 | 6614.12 | 5590 | 1310 | 67.54 | 67.68 | 57.64 | 63.81 | 23.93 | 21.29 | 11.03 | 0.14 |
| 1991 | 6868.61 | 5768 | 1310 | 62.93 | 64.20 | 59.85 | 65.84 | 12.05 | 8.79 | 27.00 | 1.27 |
| 1992 | 7812.47 | 6386 | 1310 | 70.41 | 71.52 | 67.89 | 72.70 | 12.10 | 9.85 | 18.63 | 1.10 |
| 1993 | 7705.63 | 6432 | 1310 | 68.47 | 72.17 | 67.15 | 73.42 | 16.38 | 14.14 | 13.70 | 3.69 |
| 1994 | 8292.35 | 7429 | 1310 | 80.05 | 83.16 | 72.26 | 84.81 | 1.39 | 1.17 | 15.67 | 3.11 |
| 1995 | 7358.33 | 6946 | 1310 | 83.91 | 84.35 | 64.12 | 79.29 | 15.64 | 15.63 | 0.02 | 0.44 |
| 1996 | 8227.87 | 7222 | 1310 | 79.58 | 81.08 | 71.50 | 82.22 | 2.34 | 1.94 | 16.98 | 1.50 |
| 1997 | 8571.62 | 7488 | 1310 | 81.11 | 83.70 | 74.69 | 85.48 | 3.33 | 2.89 | 13.41 | 2.59 |
| 1998 | 6585.51 | 5334 | 1310 | 57.17 | 59.18 | 57.39 | 60.89 | 21.82 | 16.52 | 24.30 | 2.01 |
| 1999 | 9704.97 | 8284 | 1310 | 91.77 | 92.53 | 84.57 | 94.57 | 5.53 | 5.42 | 2.05 | 0.76 |
| 2000 | 9088.25 | 7626 | 1310 | 83.03 | 85.17 | 78.98 | 86.82 | 0.64 | 0.54 | 14.28 | 2.15 |
| 2001 | 9142.69 | 7580 | 1310 | 83.82 | 84.71 | 79.67 | 86.53 | 1.51 | 1.30 | 13.99 | 0.89 |
| 2002 | 9010.98 | 7738 | 1310 | 87.13 | 87.25 | 78.52 | 88.33 | 0.45 | 0.39 | 12.36 | 0.12 |
| 2003 | 9974.35 | 8621 | 1310 | 98.03 | 98.28 | 86.92 | 98.41 | 1.11 | 1.10 | 0.62 | 0.25 |
| 2004 | 8535.34 | 7152 | 1310 | 77.82 | 80.97 | 74.17 | 81.42 | 5.44 | 4.66 | 14.37 | 3.15 |
| 2005 | 8534.36 | 6803 | 1310 | 75.13 | 76.47 | 74.37 | 77.66 | 0.72 | 2.46 | 21.07 | 1.34 |
| 2006 | 9284.82 | 7331 | 1310 | 82.89 | 82.89 | 80.91 | 83.69 | 7.77 | 8.62 | 8.49 | 0.00 |
| 2007 | 10831.76 | 8484 | 1310 | 94.48 | 96.54 | 94.39 | 96.85 | 3.37 | 3.37 | 0.09 | 2.06 |
| 2008 | 8553.25 | 7052 | 1310 | 74.93 | 77.96 | 74.33 | 80.28 | 5.79 | 10.52 | 11.52 | 3.03 |
| 2009 | 7308.98 | 5871 | 1310 | 64.72 | 73.79 | 63.69 | 67.02 | 1.07 | 2.16 | 24.05 | 9.07 |
| 2010 | 10382.38 | 8482 | 1310 | 96.38 | 97.19 | 90.47 | 96.83 | 2.78 | 2.78 | 0.03 | 0.81 |
| 2011 | 9001.39 | 7562 | 1310 | 84.76 | 86.91 | 78.44 | 86.32 | 2.50 | 5.14 | 7.95 | 2.15 |
| 2012 | 6456.97 | 5429 | 1310 | 57.68 | 60.02 | 56.11 | 61.81 | 4.10 | 25.93 | 14.05 | 2.34 |
| 2013 | 9487.59 | 8116 | 1310 | 92.95 | 99.38 | 82.68 | 92.65 | 0.59 | 0.59 | 0.03 | 6.43 |
| 2014 | 8980.03 | 7826 | 1310 | 83.31 | 88.17 | 78.25 | 89.34 | 0.75 | 1.08 | 10.75 | 4.86 |
| 2015 | 8678.84 | 6948 | 1310 | 77.18 | 77.21 | 75.63 | 79.32 | 1.01 | 2.01 | 20.78 | 0.02 |
| 2016 | 9891.23 | 7916 | 1310 | 86.86 | 87.29 | 85.96 | 90.12 | 1.54 | 2.58 | 10.13 | 0.43 |
| 2017 | 9040.03 | 7190 | 1310 | 79.92 | 80.83 | 78.78 | 82.08 | 0.54 | 0.44 | 18.73 | 0.91 |
| 2018 | 7865.33 | 6508 | 1310 | 69.43 | 74.96 | 68.54 | 74.29 | 25.00 | 24.98 | 0.06 | 5.53 |
| 2019 | 6030.72 | 5050 | 1310 | 55.31 | 55.96 | 52.55 | 57.65 | 0.93 | 0.53 | 43.51 | 0.66 |
| 2020 | 9822.26 | 8696 | 1310 | 97.52 | 98.71 | 85.36 | 99.00 | 1.24 | 1.24 | 0.06 | 1.19 |
| 2021 | 8977.03 | 7509 | 1310 | 80.55 | 83.22 | 78.23 | 85.72 | 2.48 | 2.14 | 14.65 | 2.67 |
| 2022 | 8212.68 | 6602 | 1310 | 72.36 | 75.60 | 71.57 | 75.37 | 2.78 | 2.16 | 22.24 | 3.24 |
| 2023 | 7901.27 | 6333 | 1310 | 70.14 | 72.30 | 68.85 | 72.29 | 0.82 | 0.60 | 27.10 | 2.16 |

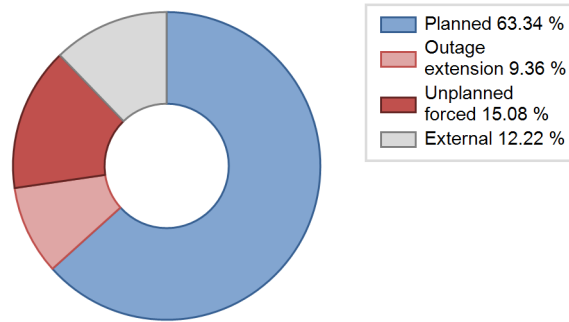
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 21 | | | 462 | |
| B. Refuelling without maintenance | | | | 80 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2329 | | | 1006 | 1 | |
| D. Inspection, maintenance or repair without refuelling | | | | 49 | | |
| E. Testing of plant systems or components | | | | 43 | | 2 |
| H. Nuclear regulatory requirements | | | | | 10 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 42 | 1 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 76 | | | 41 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 19 |
| Z. Other | | | | | 6 | 1 |
| Subtotal | 2329 | 21 | 76 | 1178 | 521 | 65 |
| Total | | 2426 | | | 1764 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 46 |
| 12. Reactor I&C Systems | | 88 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 18 |
| 16. Steam generation systems | | 71 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 9 |
| 21. Fuel Handling and Storage Facilities | | 5 |
| 31. Turbine and auxiliaries | 13 | 44 |
| 32. Feedwater and Main Steam System | | 14 |
| 33. Circulating Water System | | 47 |
| 34. Miscellaneous Systems | | 20 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | 8 | 77 |
| 42. Electrical Power Supply Systems | | 16 |
| Total | 21 | 460 |

2023 Operating Experience

FR-59

NOGENT-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1363 MWe
 Reference unit power (net) : 1310 MWe

Key Dates

Construction Date : 1982-01-01
 Grid Date : 1988-12-14
 Commercial Date : 1989-05-01
 Age at end of year : 35 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.5
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

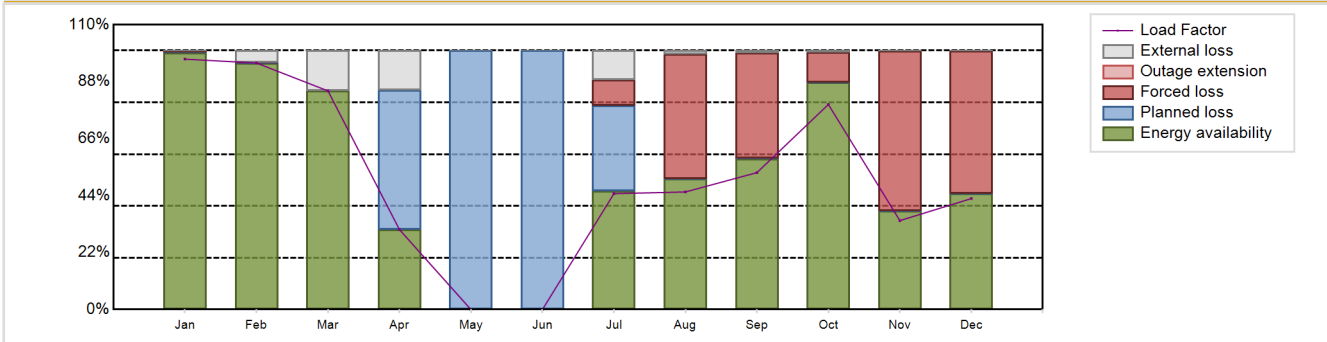
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5785.29 GW(e).h
 Energy Availability Factor (EAF) : 52.78 %
 Unit Capability Factor (UCF) : 56.95 %
 Load Factor (LF) : 50.41 %
 Operating Factor (OF) : 56.76 %
 Forced Loss Rate (FLR) : 25.13 %
 Unplanned Capability Loss Factor (UCL) : 19.12 %
 Planned Unavailability Factor (PUF) : 23.94 %
 Externally cause unavailability (XUF) : 4.16 %
 Total off-line time : 3788 hours

Annual Summary

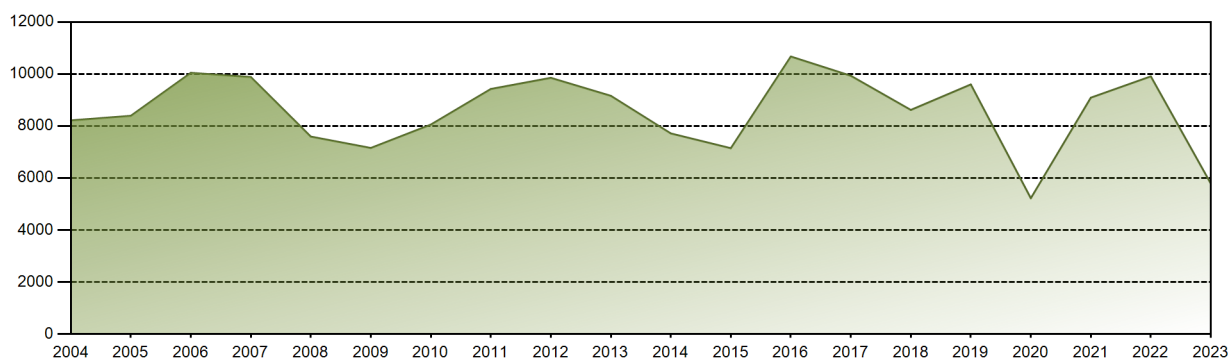


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 942.46 | 838.08 | 821.89 | 291.12 | 0.00 | 0.00 | 436.06 | 442.62 | 498.65 | 772.81 | 323.92 | 417.68 | 5785.29 |
| EAF [%] | 99.23 | 95.21 | 84.43 | 30.87 | 0.00 | 0.00 | 45.88 | 50.44 | 58.26 | 87.64 | 38.11 | 44.74 | 52.78 |
| UCF [%] | 99.36 | 99.89 | 100.00 | 46.18 | 0.00 | 0.00 | 57.30 | 51.71 | 59.09 | 88.28 | 38.21 | 44.81 | 56.95 |
| LF [%] | 96.70 | 95.20 | 84.44 | 30.87 | 0.00 | 0.00 | 44.74 | 45.41 | 52.87 | 79.19 | 34.34 | 42.85 | 50.41 |
| OF [%] | 100.00 | 100.00 | 100.00 | 46.67 | 0.00 | 0.00 | 54.17 | 48.39 | 59.44 | 88.86 | 39.58 | 45.56 | 56.76 |
| FLR [%] | 0.62 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 14.75 | 48.27 | 40.88 | 11.68 | 61.79 | 55.19 | 25.13 |
| UCL [%] | 0.62 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 9.91 | 48.25 | 40.86 | 11.67 | 61.78 | 55.18 | 19.12 |
| PUF [%] | 0.02 | 0.00 | 0.00 | 53.82 | 100.00 | 100.00 | 32.79 | 0.03 | 0.05 | 0.05 | 0.01 | 0.02 | 23.94 |
| XUF [%] | 0.12 | 4.67 | 15.57 | 15.31 | 0.00 | 0.00 | 11.42 | 1.27 | 0.83 | 0.64 | 0.10 | 0.07 | 4.16 |

Historical Summary

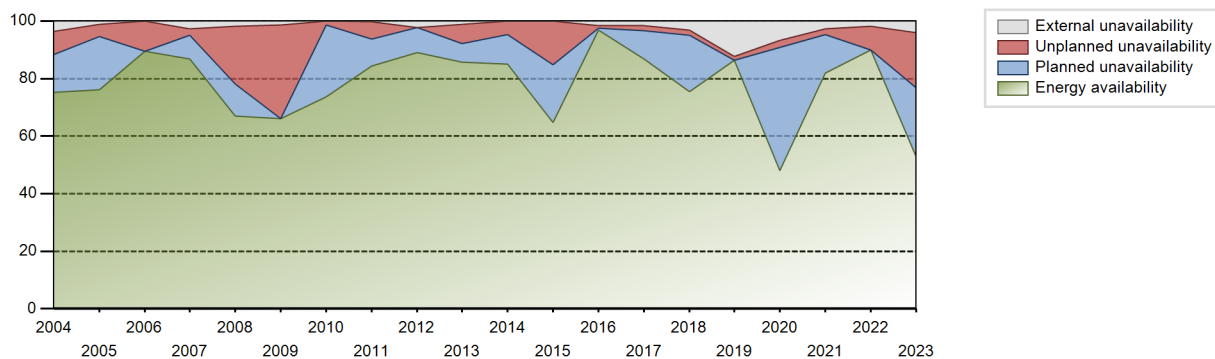
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 297468.12 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.6 % |
| Cumulative Energy Availability Factor (EAF) | : 79.51 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.87 % |
| Cumulative Unit Capability Factor (UCF) | : 81.85 % | Cumulative Planned Unavailability Factor (PUF) | : 12.28 % |
| Cumulative Load Factor (LF) | : 74.19 % | Cumulative Externally cause unavailability (XUF) | : 2.34 % |
| Cumulative Operating Factor (OF) | : 80.57 % | | |

Electricity Production (net) [GWh]

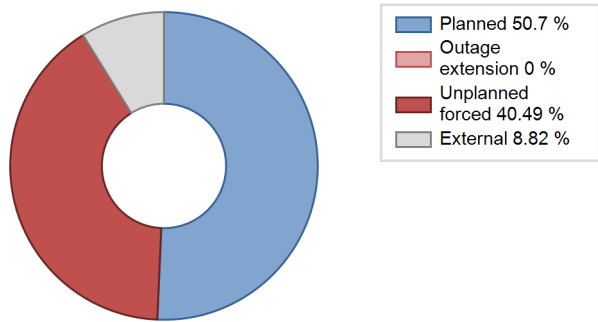


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 7470.05 | 6660 | 1310 | 78.93 | 78.94 | 72.84 | 80.67 | 21.06 | 21.05 | 0.01 | 0.01 |
| 1990 | 7532.95 | 6094 | 1310 | 68.29 | 69.37 | 65.64 | 69.57 | 3.95 | 2.85 | 27.78 | 1.07 |
| 1991 | 8331.15 | 7008 | 1310 | 73.49 | 78.80 | 72.60 | 80.00 | 7.15 | 6.07 | 15.12 | 5.31 |
| 1992 | 8312.33 | 6937 | 1310 | 74.10 | 77.44 | 72.24 | 78.97 | 5.17 | 4.22 | 18.34 | 3.34 |
| 1993 | 9191.68 | 7594 | 1310 | 80.77 | 85.85 | 80.10 | 86.69 | 1.34 | 1.17 | 12.98 | 5.08 |
| 1994 | 6483.02 | 6027 | 1310 | 94.82 | 98.01 | 56.49 | 68.80 | 1.95 | 1.95 | 0.05 | 3.19 |
| 1995 | 7545.41 | 6862 | 1310 | 75.87 | 78.45 | 65.75 | 78.33 | 9.48 | 8.22 | 13.33 | 2.58 |
| 1996 | 8477.02 | 7229 | 1310 | 76.95 | 80.52 | 73.67 | 82.30 | 5.35 | 4.55 | 14.93 | 3.57 |
| 1997 | 8925.81 | 7656 | 1310 | 81.96 | 85.98 | 77.78 | 87.40 | 1.49 | 1.30 | 12.72 | 4.02 |
| 1998 | 8830.03 | 7386 | 1310 | 97.77 | 98.00 | 76.95 | 84.32 | 1.67 | 1.67 | 0.33 | 0.23 |
| 1999 | 7957.34 | 6732 | 1310 | 74.70 | 76.24 | 69.34 | 76.85 | 0.52 | 0.40 | 23.37 | 1.54 |
| 2000 | 9672.12 | 7654 | 1310 | 84.62 | 85.92 | 84.05 | 87.14 | 0.69 | 0.60 | 13.48 | 1.31 |
| 2001 | 9378.95 | 7589 | 1310 | 83.40 | 85.15 | 81.73 | 86.63 | 0.97 | 0.83 | 14.02 | 1.74 |
| 2002 | 8205.53 | 7241 | 1310 | 84.15 | 84.17 | 71.50 | 82.66 | 5.01 | 4.44 | 11.39 | 0.02 |
| 2003 | 9447.11 | 7954 | 1310 | 91.51 | 91.53 | 82.32 | 90.80 | 2.07 | 1.93 | 6.54 | 0.02 |
| 2004 | 8216.70 | 7044 | 1310 | 75.14 | 78.65 | 71.41 | 80.19 | 9.24 | 8.01 | 13.34 | 3.51 |
| 2005 | 8393.26 | 6907 | 1310 | 76.14 | 77.20 | 73.14 | 78.85 | 5.27 | 4.30 | 18.50 | 1.06 |
| 2006 | 10046.50 | 7854 | 1310 | 89.52 | 89.52 | 87.55 | 89.66 | 10.45 | 10.45 | 0.04 | 0.00 |
| 2007 | 9885.89 | 7918 | 1310 | 86.86 | 89.52 | 86.15 | 90.39 | 1.09 | 2.19 | 8.29 | 2.67 |
| 2008 | 7594.22 | 6175 | 1310 | 67.01 | 68.79 | 66.00 | 70.30 | 1.40 | 20.02 | 11.18 | 1.79 |
| 2009 | 7156.37 | 6227 | 1310 | 66.02 | 67.32 | 62.36 | 71.08 | 32.67 | 32.66 | 0.01 | 1.30 |
| 2010 | 8055.24 | 6576 | 1310 | 73.65 | 73.69 | 70.19 | 75.07 | 1.92 | 1.45 | 24.87 | 0.04 |
| 2011 | 9424.39 | 7468 | 1310 | 84.47 | 84.67 | 82.13 | 85.25 | 0.24 | 6.03 | 9.30 | 0.20 |
| 2012 | 9853.20 | 7964 | 1310 | 89.02 | 91.21 | 85.63 | 90.66 | 0.02 | 0.02 | 8.77 | 2.19 |
| 2013 | 9161.96 | 7595 | 1310 | 85.62 | 86.80 | 79.84 | 86.70 | 1.87 | 6.70 | 6.50 | 1.19 |
| 2014 | 7715.38 | 6584 | 1310 | 84.99 | 84.99 | 67.23 | 75.16 | 2.73 | 4.61 | 10.40 | 0.00 |
| 2015 | 7148.17 | 5730 | 1310 | 64.79 | 64.79 | 62.29 | 65.41 | 19.00 | 15.20 | 20.01 | 0.00 |
| 2016 | 10673.55 | 8665 | 1310 | 96.88 | 98.45 | 92.76 | 98.65 | 0.97 | 0.96 | 0.59 | 1.57 |
| 2017 | 9933.24 | 7797 | 1310 | 86.90 | 88.39 | 86.56 | 89.01 | 0.98 | 1.86 | 9.75 | 1.49 |
| 2018 | 8618.65 | 6984 | 1310 | 75.45 | 78.64 | 75.10 | 79.73 | 2.24 | 1.80 | 19.56 | 3.18 |
| 2019 | 9599.33 | 7762 | 1310 | 86.29 | 98.63 | 83.65 | 88.61 | 1.34 | 1.34 | 0.03 | 12.34 |
| 2020 | 5223.23 | 4455 | 1310 | 48.00 | 54.82 | 45.39 | 50.72 | 4.12 | 2.36 | 42.82 | 6.82 |
| 2021 | 9090.75 | 7397 | 1310 | 81.98 | 84.69 | 79.22 | 84.44 | 1.39 | 2.08 | 13.23 | 2.72 |
| 2022 | 9909.52 | 8092 | 1310 | 89.93 | 91.67 | 86.35 | 92.37 | 8.25 | 8.25 | 0.08 | 1.74 |
| 2023 | 5785.29 | 4972 | 1310 | 52.78 | 56.95 | 50.41 | 56.76 | 25.13 | 19.12 | 23.94 | 4.16 |

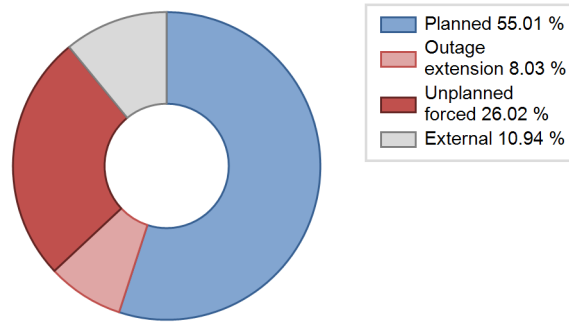
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1633 | | | 436 | |
| B. Refuelling without maintenance | | | | 76 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2028 | | | 916 | | |
| E. Testing of plant systems or components | | | | 24 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 28 |
| L. Human factor related | | | | | 8 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 15 |
| O. Load dispatching, prioritization | | | 38 | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 80 | | | 12 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 26 |
| Z. Other | | | | 1 | 32 | |
| Subtotal | 2028 | 1633 | 118 | 1017 | 476 | 85 |
| Total | | 3779 | | | 1578 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 12 |
| 12. Reactor I&C Systems | | 31 |
| 13. Reactor Auxiliary Systems | 794 | 31 |
| 14. Safety Systems | | 22 |
| 15. Reactor Cooling Systems | | 18 |
| 16. Steam generation systems | | 26 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 52 |
| 31. Turbine and auxiliaries | 839 | 44 |
| 32. Feedwater and Main Steam System | | 7 |
| 33. Circulating Water System | | 25 |
| 34. Miscellaneous Systems | | 9 |
| 35. All other I&C Systems | | 9 |
| 41. Main Generator Systems | | 127 |
| 42. Electrical Power Supply Systems | | 21 |
| Total | 1633 | 434 |

2023 Operating Experience

FR-36

PALUEL-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1382 MWe
 Reference unit power (net) : 1330 MWe

Key Dates

Construction Date : 1977-08-15
 Grid Date : 1984-06-22
 Commercial Date : 1985-12-01
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.2
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.2

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

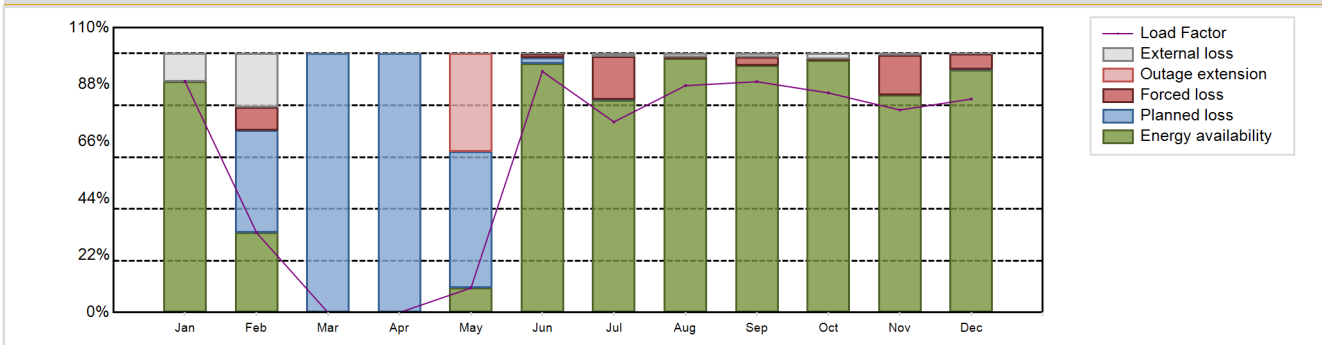
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6998.25 GW(e).h
 Energy Availability Factor (EAF) : 64.93 %
 Unit Capability Factor (UCF) : 68.03 %
 Load Factor (LF) : 60.07 %
 Operating Factor (OF) : 69.19 %
 Forced Loss Rate (FLR) : 5.98 %
 Unplanned Capability Loss Factor (UCL) : 7.55 %
 Planned Unavailability Factor (PUF) : 24.42 %
 Externally cause unavailability (XUF) : 3.1 %
 Total off-line time : 2699 hours

Annual Summary

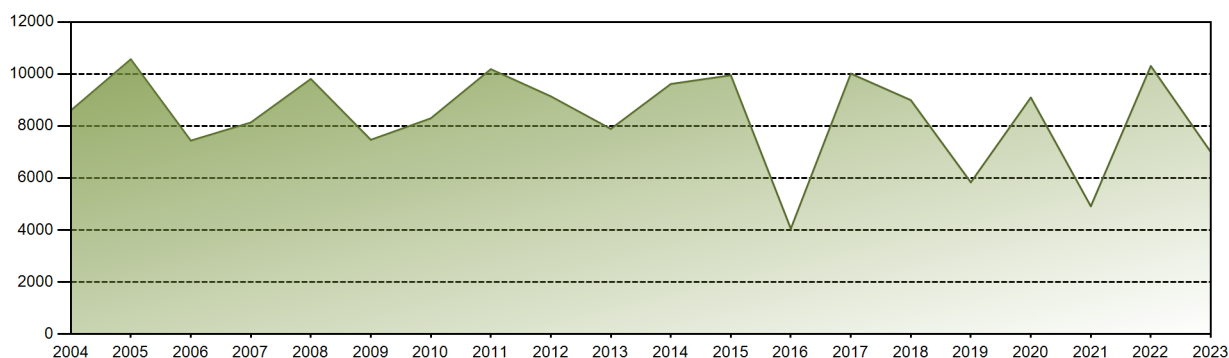


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 883.23 | 276.00 | 0.00 | 0.00 | 93.84 | 891.41 | 728.22 | 866.99 | 853.55 | 840.29 | 749.02 | 815.69 | 6998.25 |
| EAF [%] | 89.26 | 30.88 | 0.00 | 0.00 | 9.49 | 96.08 | 81.90 | 98.01 | 95.37 | 97.50 | 83.98 | 93.77 | 64.93 |
| UCF [%] | 100.00 | 51.62 | 0.00 | 0.00 | 9.49 | 96.31 | 83.07 | 99.28 | 96.81 | 99.64 | 84.62 | 94.00 | 68.03 |
| LF [%] | 89.26 | 30.88 | 0.00 | 0.00 | 9.48 | 93.09 | 73.59 | 87.62 | 89.13 | 84.81 | 78.22 | 82.43 | 60.07 |
| OF [%] | 100.00 | 43.60 | 0.00 | 0.00 | 13.44 | 99.17 | 84.01 | 100.00 | 100.00 | 99.87 | 87.92 | 100.00 | 69.19 |
| FLR [%] | 0.00 | 14.66 | 0.00 | 0.00 | 0.00 | 1.36 | 16.72 | 0.72 | 3.19 | 0.36 | 15.38 | 5.96 | 5.98 |
| UCL [%] | 0.00 | 8.87 | 0.00 | 0.00 | 37.87 | 1.32 | 16.68 | 0.72 | 3.19 | 0.36 | 15.38 | 5.95 | 7.55 |
| PUF [%] | 0.00 | 39.52 | 100.00 | 100.00 | 52.65 | 2.37 | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 24.42 |
| XUF [%] | 10.74 | 20.73 | 0.00 | 0.00 | 0.00 | 0.23 | 1.16 | 1.27 | 1.44 | 2.14 | 0.65 | 0.23 | 3.10 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 317400.84 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.32 % |
| Cumulative Energy Availability Factor (EAF) | : 75.66 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.03 % |
| Cumulative Unit Capability Factor (UCF) | : 78.31 % | Cumulative Planned Unavailability Factor (PUF) | : 13.66 % |
| Cumulative Load Factor (LF) | : 70.38 % | Cumulative Externally cause unavailability (XUF) | : 2.65 % |
| Cumulative Operating Factor (OF) | : 77.5 % | | |

Electricity Production (net) [GWh]

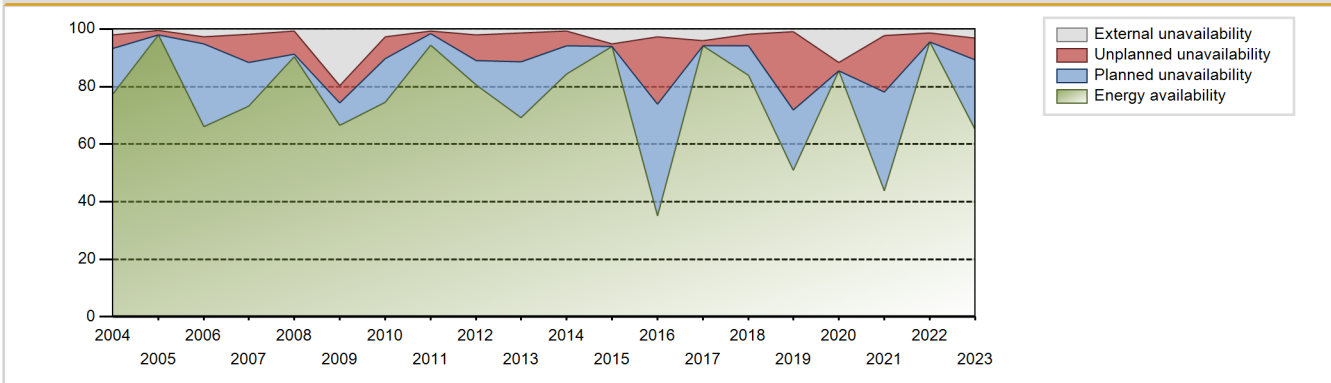


Performance for Years of Commercial Operation

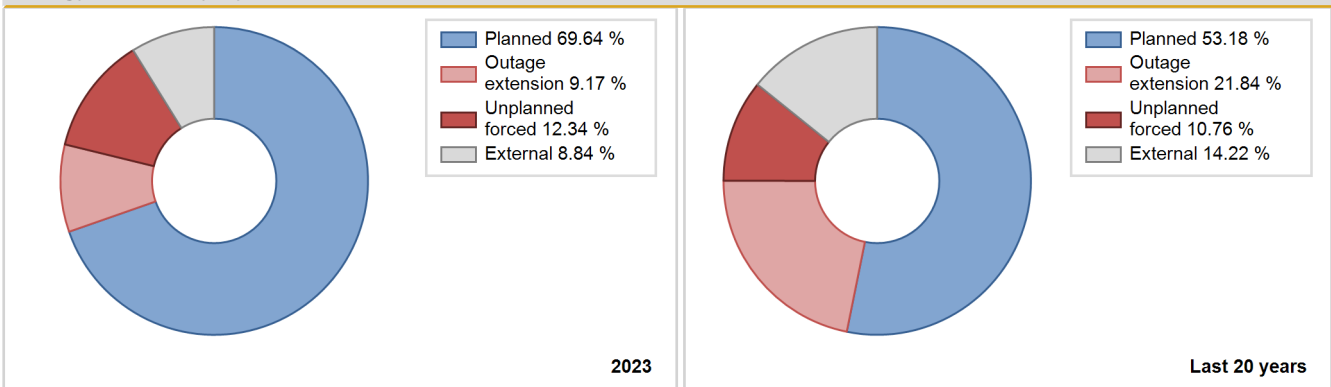
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 4685.80 | 4104 | 1290 | 94.92 | 94.92 | 98.72 | 98.25 | 5.08 | 5.08 | 0.00 | 0.00 |
| 1986 | 5169.70 | 4455 | 1290 | 50.23 | 52.32 | 45.75 | 50.86 | 26.61 | 18.97 | 28.71 | 2.09 |
| 1987 | 8184.80 | 6527 | 1330 | 76.58 | 76.96 | 70.25 | 74.51 | 7.69 | 6.41 | 16.63 | 0.38 |
| 1988 | 9291.00 | 7332 | 1330 | 95.28 | 96.82 | 79.53 | 83.47 | 3.13 | 3.12 | 0.05 | 1.55 |
| 1989 | 7902.78 | 6567 | 1330 | 70.38 | 72.57 | 67.83 | 74.97 | 9.49 | 7.61 | 19.82 | 2.19 |
| 1990 | 7323.87 | 6288 | 1330 | 66.40 | 70.07 | 62.86 | 71.78 | 15.18 | 12.54 | 17.39 | 3.67 |
| 1991 | 7159.94 | 5987 | 1330 | 63.19 | 66.65 | 61.45 | 68.34 | 13.16 | 10.10 | 23.25 | 3.47 |
| 1992 | 8640.41 | 6858 | 1330 | 76.61 | 76.62 | 73.96 | 78.07 | 5.82 | 4.74 | 18.65 | 0.01 |
| 1993 | 8068.09 | 6906 | 1330 | 70.88 | 77.24 | 69.25 | 78.84 | 4.94 | 4.02 | 18.74 | 6.36 |
| 1994 | 6549.93 | 5790 | 1330 | 76.95 | 77.10 | 56.22 | 66.10 | 22.88 | 22.88 | 0.02 | 0.15 |
| 1995 | 8768.17 | 7292 | 1330 | 79.61 | 82.18 | 75.26 | 83.24 | 4.24 | 3.64 | 14.18 | 2.58 |
| 1996 | 5483.15 | 4763 | 1330 | 48.69 | 52.72 | 46.93 | 54.22 | 26.24 | 18.76 | 28.52 | 4.04 |
| 1997 | 9019.66 | 7537 | 1330 | 83.76 | 84.49 | 77.42 | 86.04 | 5.67 | 5.08 | 10.43 | 0.72 |
| 1998 | 9718.11 | 8132 | 1330 | 91.25 | 91.28 | 83.41 | 92.83 | 5.26 | 5.07 | 3.65 | 0.03 |
| 1999 | 8181.87 | 6938 | 1330 | 76.15 | 78.56 | 70.23 | 79.20 | 4.32 | 3.55 | 17.89 | 2.41 |
| 2000 | 9088.99 | 7533 | 1330 | 83.48 | 83.97 | 77.80 | 85.76 | 2.13 | 1.83 | 14.20 | 0.49 |
| 2001 | 9752.15 | 8382 | 1330 | 97.58 | 98.29 | 83.70 | 95.68 | 1.51 | 1.51 | 0.20 | 0.72 |
| 2002 | 7153.91 | 6081 | 1330 | 66.55 | 68.27 | 61.40 | 69.42 | 12.86 | 10.07 | 21.66 | 1.72 |
| 2003 | 8526.18 | 6882 | 1330 | 77.18 | 77.59 | 73.18 | 78.56 | 11.48 | 10.06 | 12.35 | 0.41 |
| 2004 | 8596.32 | 7103 | 1330 | 77.37 | 79.37 | 73.58 | 80.86 | 5.53 | 4.64 | 15.99 | 1.99 |
| 2005 | 10565.55 | 8654 | 1330 | 97.86 | 98.39 | 90.69 | 98.79 | 1.49 | 1.49 | 0.12 | 0.53 |
| 2006 | 7437.70 | 6133 | 1330 | 65.98 | 68.61 | 63.84 | 70.01 | 1.80 | 2.61 | 28.79 | 2.63 |
| 2007 | 8135.11 | 6641 | 1330 | 73.26 | 75.11 | 69.82 | 75.81 | 3.73 | 9.76 | 15.13 | 1.84 |
| 2008 | 9808.67 | 8116 | 1330 | 90.35 | 91.10 | 83.96 | 92.40 | 2.16 | 8.06 | 0.84 | 0.75 |
| 2009 | 7469.32 | 6108 | 1330 | 66.51 | 86.13 | 64.11 | 69.73 | 1.75 | 6.06 | 7.81 | 19.61 |
| 2010 | 8295.24 | 6661 | 1330 | 74.55 | 77.25 | 71.20 | 76.04 | 0.75 | 7.55 | 15.20 | 2.70 |
| 2011 | 10184.08 | 8349 | 1330 | 94.32 | 94.98 | 87.41 | 95.31 | 1.04 | 1.00 | 4.02 | 0.66 |
| 2012 | 9140.88 | 7351 | 1330 | 80.57 | 82.60 | 78.24 | 83.69 | 4.02 | 9.04 | 8.36 | 2.03 |
| 2013 | 7888.06 | 6203 | 1330 | 69.21 | 70.62 | 67.70 | 70.81 | 0.12 | 9.95 | 19.43 | 1.41 |
| 2014 | 9615.90 | 7567 | 1330 | 84.41 | 85.21 | 82.53 | 86.38 | 4.29 | 4.98 | 9.82 | 0.79 |
| 2015 | 9949.97 | 8222 | 1330 | 93.87 | 99.04 | 85.40 | 93.86 | 0.91 | 0.91 | 0.05 | 5.17 |
| 2016 | 4050.04 | 3503 | 1330 | 35.15 | 37.84 | 34.67 | 39.88 | 4.48 | 23.46 | 38.70 | 2.70 |
| 2017 | 10013.99 | 8379 | 1330 | 94.17 | 98.22 | 85.95 | 95.65 | 1.71 | 1.71 | 0.07 | 4.05 |
| 2018 | 8993.47 | 7597 | 1330 | 83.95 | 85.74 | 77.19 | 86.72 | 3.08 | 4.15 | 10.11 | 1.79 |
| 2019 | 5834.12 | 4711 | 1330 | 50.93 | 51.95 | 50.07 | 53.78 | 4.45 | 27.16 | 20.89 | 1.03 |
| 2020 | 9093.82 | 7712 | 1330 | 85.42 | 97.03 | 77.84 | 87.80 | 2.88 | 2.87 | 0.10 | 11.61 |
| 2021 | 4912.69 | 4117 | 1330 | 43.76 | 46.00 | 42.17 | 47.00 | 16.06 | 19.71 | 34.29 | 2.23 |

| | | | | | | | | | | | |
|------|----------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 10306.63 | 8544 | 1330 | 95.57 | 96.88 | 88.46 | 97.53 | 3.09 | 3.09 | 0.03 | 1.31 |
| 2023 | 6998.25 | 6061 | 1330 | 64.93 | 68.03 | 60.07 | 69.19 | 5.98 | 7.55 | 24.42 | 3.10 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|-------------|-------------|-----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 543 | | | 510 | 2 |
| B. Refuelling without maintenance | 2090 | | | 115 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 991 | 37 | |
| D. Inspection, maintenance or repair without refuelling | | | | 95 | | |
| E. Testing of plant systems or components | | | | 18 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 9 | | |
| H. Nuclear regulatory requirements | | | | | 10 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 29 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| O. Load dispatching, prioritization | | | 9 | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 56 | | | 57 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 44 |
| Z. Other | | | | | 61 | |
| Subtotal | 2090 | 543 | 65 | 1228 | 648 | 108 |
| Total | | 2698 | | | 1984 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 16 |
| 12. Reactor I&C Systems | 222 | 42 |
| 13. Reactor Auxiliary Systems | | 25 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 10 |
| 16. Steam generation systems | | 14 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | | 40 |
| 32. Feedwater and Main Steam System | 40 | 26 |
| 33. Circulating Water System | | 13 |
| 34. Miscellaneous Systems | 282 | 195 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 87 |
| 42. Electrical Power Supply Systems | | 17 |
| Total | 544 | 497 |

2023 Operating Experience

FR-37

PALUEL-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1382 MWe
 Reference unit power (net) : 1330 MWe

Key Dates

Construction Date : 1978-01-01
 Grid Date : 1984-09-14
 Commercial Date : 1985-12-01
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.2
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.2

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

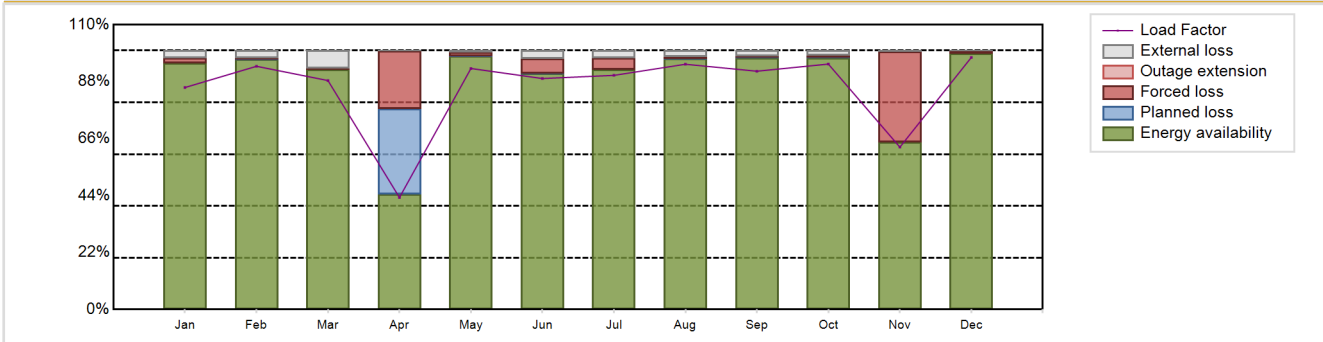
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 9968.67 GW(e).h
 Energy Availability Factor (EAF) : 88.87 %
 Unit Capability Factor (UCF) : 91.08 %
 Load Factor (LF) : 85.56 %
 Operating Factor (OF) : 92.83 %
 Forced Loss Rate (FLR) : 6.33 %
 Unplanned Capability Loss Factor (UCL) : 6.15 %
 Planned Unavailability Factor (PUF) : 2.77 %
 Externally cause unavailability (XUF) : 2.21 %
 Total off-line time : 628 hours

Annual Summary

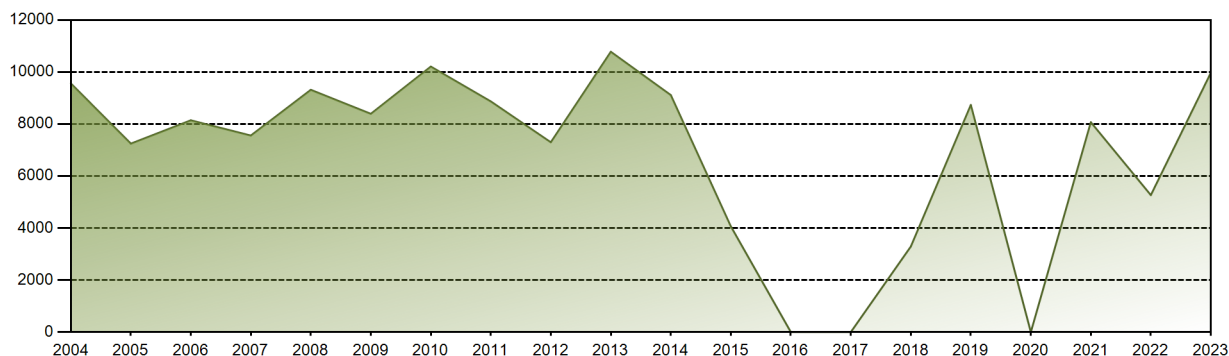


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 848.50 | 839.62 | 873.89 | 414.34 | 921.18 | 854.33 | 894.87 | 937.34 | 881.35 | 939.28 | 600.50 | 963.46 | 9968.67 |
| EAF [%] | 95.11 | 96.59 | 92.73 | 44.47 | 97.78 | 91.08 | 92.75 | 96.90 | 97.07 | 97.21 | 64.69 | 98.91 | 88.87 |
| UCF [%] | 97.97 | 99.49 | 99.47 | 44.57 | 98.49 | 94.31 | 95.67 | 99.26 | 99.16 | 99.19 | 65.16 | 99.07 | 91.08 |
| LF [%] | 85.75 | 93.94 | 88.43 | 43.27 | 93.09 | 89.22 | 90.43 | 94.73 | 92.04 | 94.80 | 62.71 | 97.37 | 85.56 |
| OF [%] | 100.00 | 100.00 | 100.00 | 50.97 | 100.00 | 96.25 | 100.00 | 100.00 | 100.00 | 99.87 | 65.69 | 100.00 | 92.83 |
| FLR [%] | 2.03 | 0.43 | 0.53 | 33.36 | 1.44 | 5.62 | 4.33 | 0.70 | 0.63 | 0.76 | 34.84 | 0.93 | 6.33 |
| UCL [%] | 2.03 | 0.43 | 0.53 | 22.31 | 1.44 | 5.62 | 4.33 | 0.70 | 0.63 | 0.76 | 34.84 | 0.93 | 6.15 |
| PUF [%] | 0.00 | 0.08 | 0.00 | 33.12 | 0.07 | 0.07 | 0.00 | 0.04 | 0.21 | 0.05 | 0.00 | 0.00 | 2.77 |
| XUF [%] | 2.86 | 2.90 | 6.74 | 0.09 | 0.72 | 3.23 | 2.92 | 2.36 | 2.09 | 1.99 | 0.47 | 0.16 | 2.21 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 282785.22 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.58 % |
| Cumulative Energy Availability Factor (EAF) | : 67.06 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 16.83 % |
| Cumulative Unit Capability Factor (UCF) | : 69.63 % | Cumulative Planned Unavailability Factor (PUF) | : 13.54 % |
| Cumulative Load Factor (LF) | : 62.62 % | Cumulative Externally cause unavailability (XUF) | : 2.57 % |
| Cumulative Operating Factor (OF) | : 69.45 % | | |

Electricity Production (net) [GWh]

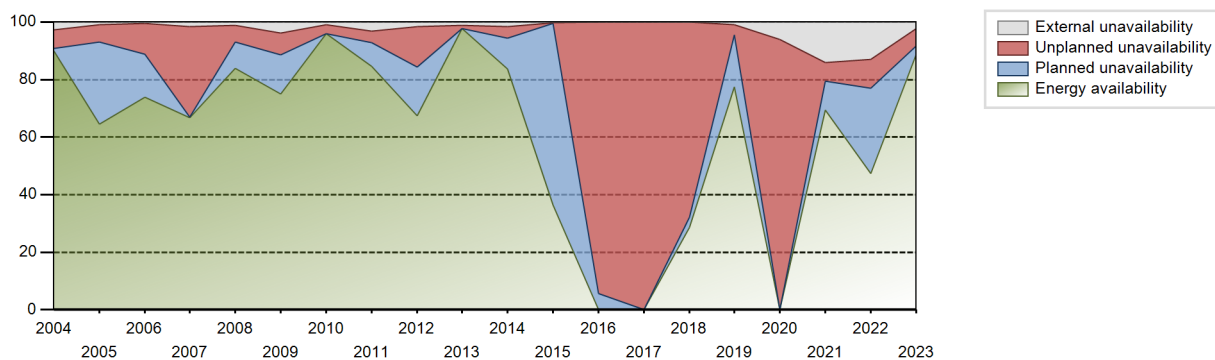


Performance for Years of Commercial Operation

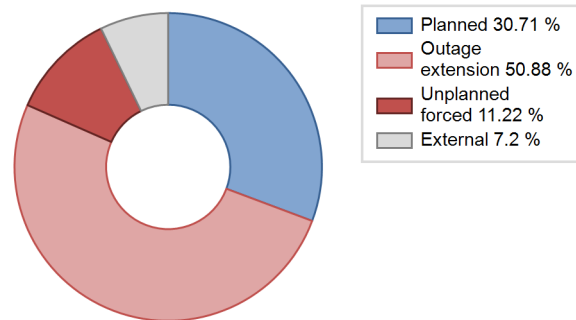
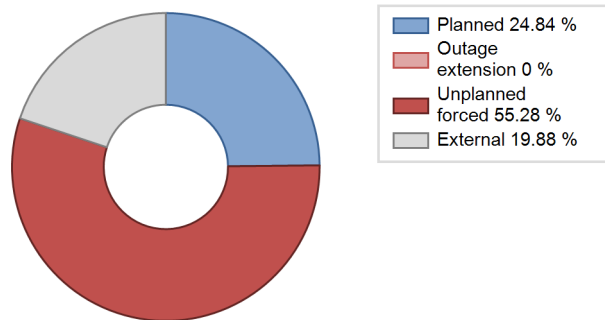
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 5997.80 | 5548 | 1290 | 99.64 | 99.64 | 103.20 | 100.00 | 0.36 | 0.36 | 0.00 | 0.00 |
| 1986 | 6040.90 | 4804 | 1290 | 52.22 | 52.33 | 53.46 | 54.84 | 19.74 | 12.87 | 34.80 | 0.12 |
| 1987 | 8859.60 | 6837 | 1290 | 76.84 | 77.30 | 78.40 | 78.05 | 8.19 | 6.90 | 15.80 | 0.46 |
| 1988 | 7725.00 | 6017 | 1330 | 73.49 | 75.49 | 66.12 | 68.50 | 6.03 | 4.84 | 19.66 | 2.00 |
| 1989 | 8956.44 | 7358 | 1330 | 80.09 | 83.35 | 76.87 | 84.00 | 12.29 | 11.68 | 4.96 | 3.26 |
| 1990 | 6496.27 | 5328 | 1330 | 59.05 | 59.09 | 55.76 | 60.82 | 20.84 | 15.56 | 25.35 | 0.04 |
| 1991 | 6140.31 | 4996 | 1330 | 54.92 | 55.13 | 52.70 | 57.03 | 28.23 | 21.68 | 23.19 | 0.21 |
| 1992 | 6906.92 | 5618 | 1330 | 61.74 | 63.63 | 59.12 | 63.96 | 20.80 | 16.71 | 19.67 | 1.89 |
| 1993 | 7954.42 | 7217 | 1330 | 76.90 | 87.91 | 68.27 | 82.39 | 10.19 | 9.98 | 2.11 | 11.01 |
| 1994 | 7115.24 | 6671 | 1330 | 74.52 | 77.62 | 61.07 | 76.15 | 4.06 | 3.28 | 19.10 | 3.10 |
| 1995 | 6934.50 | 6252 | 1330 | 65.76 | 70.46 | 59.52 | 71.37 | 2.39 | 1.72 | 27.82 | 4.69 |
| 1996 | 8407.42 | 7195 | 1330 | 78.51 | 83.80 | 71.96 | 81.91 | 6.22 | 5.56 | 10.64 | 5.29 |
| 1997 | 8139.80 | 7182 | 1330 | 83.47 | 83.90 | 69.86 | 81.99 | 15.12 | 14.94 | 1.16 | 0.43 |
| 1998 | 7300.40 | 6583 | 1330 | 69.09 | 73.11 | 62.66 | 75.15 | 11.87 | 9.84 | 17.05 | 4.02 |
| 1999 | 9243.77 | 7705 | 1330 | 84.11 | 85.59 | 79.34 | 87.96 | 1.64 | 1.42 | 12.98 | 1.49 |
| 2000 | 9849.89 | 8271 | 1330 | 94.43 | 96.04 | 84.31 | 94.16 | 3.55 | 3.54 | 0.42 | 1.61 |
| 2001 | 7843.13 | 6861 | 1330 | 76.04 | 76.68 | 67.32 | 78.32 | 8.36 | 6.99 | 16.33 | 0.64 |
| 2002 | 7984.37 | 6569 | 1330 | 72.01 | 73.19 | 68.53 | 74.99 | 11.67 | 9.67 | 17.14 | 1.18 |
| 2003 | 8814.93 | 7490 | 1330 | 81.14 | 82.10 | 75.66 | 85.50 | 6.51 | 5.72 | 12.18 | 0.95 |
| 2004 | 9562.68 | 8039 | 1330 | 89.87 | 92.58 | 81.85 | 91.52 | 6.49 | 6.42 | 1.00 | 2.71 |
| 2005 | 7246.43 | 5823 | 1330 | 64.47 | 65.28 | 62.19 | 66.47 | 3.68 | 6.15 | 28.56 | 0.81 |
| 2006 | 8143.51 | 6673 | 1330 | 73.89 | 74.40 | 69.90 | 76.18 | 11.60 | 10.70 | 14.90 | 0.51 |
| 2007 | 7558.05 | 6021 | 1330 | 66.80 | 68.30 | 64.87 | 68.73 | 31.67 | 31.65 | 0.06 | 1.49 |
| 2008 | 9315.58 | 7595 | 1330 | 83.97 | 85.07 | 79.74 | 86.46 | 3.03 | 5.92 | 9.01 | 1.09 |
| 2009 | 8393.37 | 6815 | 1330 | 74.97 | 78.79 | 72.04 | 77.80 | 2.23 | 7.58 | 13.63 | 3.82 |
| 2010 | 10209.97 | 8496 | 1330 | 95.98 | 96.93 | 87.63 | 96.99 | 3.04 | 3.04 | 0.03 | 0.96 |
| 2011 | 8868.96 | 7697 | 1330 | 84.55 | 87.68 | 76.12 | 87.87 | 1.01 | 4.10 | 8.22 | 3.13 |
| 2012 | 7298.37 | 6084 | 1330 | 67.34 | 68.96 | 62.47 | 69.26 | 1.66 | 14.03 | 17.01 | 1.61 |
| 2013 | 10778.91 | 8675 | 1330 | 97.70 | 98.86 | 92.52 | 99.03 | 1.11 | 1.11 | 0.03 | 1.16 |
| 2014 | 9113.01 | 7499 | 1330 | 83.67 | 85.18 | 78.22 | 85.61 | 1.93 | 4.13 | 10.69 | 1.51 |
| 2015 | 4064.60 | 3217 | 1330 | 36.33 | 36.48 | 34.89 | 36.72 | 0.79 | 0.29 | 63.23 | 0.15 |
| 2016 | 0.00 | 0 | 1330 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | 94.22 | 5.73 | 0.00 |
| 2017 | 0.00 | 0 | 1330 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 99.98 | 0.00 | 0.00 |
| 2018 | 3289.82 | 2950 | 1330 | 28.54 | 28.64 | 28.24 | 33.68 | 29.16 | 67.65 | 3.71 | 0.11 |
| 2019 | 8734.15 | 6924 | 1330 | 77.44 | 78.36 | 74.97 | 79.04 | 3.53 | 3.67 | 17.97 | 0.92 |
| 2020 | 0.00 | 0 | 1330 | 0.06 | 6.19 | 0.00 | 0.00 | 0.00 | 93.81 | 0.00 | 6.13 |
| 2021 | 8070.60 | 7004 | 1330 | 69.37 | 83.43 | 69.27 | 79.95 | 2.25 | 6.47 | 10.10 | 14.06 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|-------|-------|-------|
| 2022 | 5266.59 | 4525 | 1330 | 47.46 | 60.41 | 45.20 | 51.66 | 0.97 | 10.09 | 29.50 | 12.95 |
| 2023 | 9968.67 | 8132 | 1330 | 88.87 | 91.08 | 85.56 | 92.83 | 6.33 | 6.15 | 2.77 | 2.21 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 338 | | | 1319 | 2 |
| B. Refuelling without maintenance | 236 | | | 186 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 688 | 76 | |
| D. Inspection, maintenance or repair without refuelling | | | | 31 | 6 | |
| E. Testing of plant systems or components | | | | 13 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 158 | | |
| H. Nuclear regulatory requirements | | | | | 7 | |
| I. Grid capacity limitation | | | | | | 0 |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | 49 | | | 10 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 14 |
| P. Fire | | | | | 44 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 5 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 61 |
| Z. Other | | | | | 30 | 1 |
| Subtotal | 236 | 387 | 4 | 1076 | 1493 | 87 |
| Total | | 627 | | | 2656 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 14 |
| 12. Reactor I&C Systems | 27 | 72 |
| 13. Reactor Auxiliary Systems | | 9 |
| 14. Safety Systems | 266 | 26 |
| 15. Reactor Cooling Systems | | 52 |
| 16. Steam generation systems | | 537 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 5 |
| 31. Turbine and auxiliaries | 33 | 39 |
| 32. Feedwater and Main Steam System | | 28 |
| 33. Circulating Water System | | 41 |
| 34. Miscellaneous Systems | | 284 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 150 |
| 42. Electrical Power Supply Systems | 12 | 26 |
| Total | 338 | 1285 |

2023 Operating Experience

FR-38 **PALUEL-3** **FRANCE**

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PWR / P4 REP 1300 | Construction Date | : 1979-02-01 |
| Thermal power | : 3817 MWth | Grid Date | : 1985-09-30 |
| Gross electrical power | : 1382 MWe | Commercial Date | : 1986-02-01 |
| Reference unit power (net) | : 1330 MWe | Age at end of year | : 38 years |

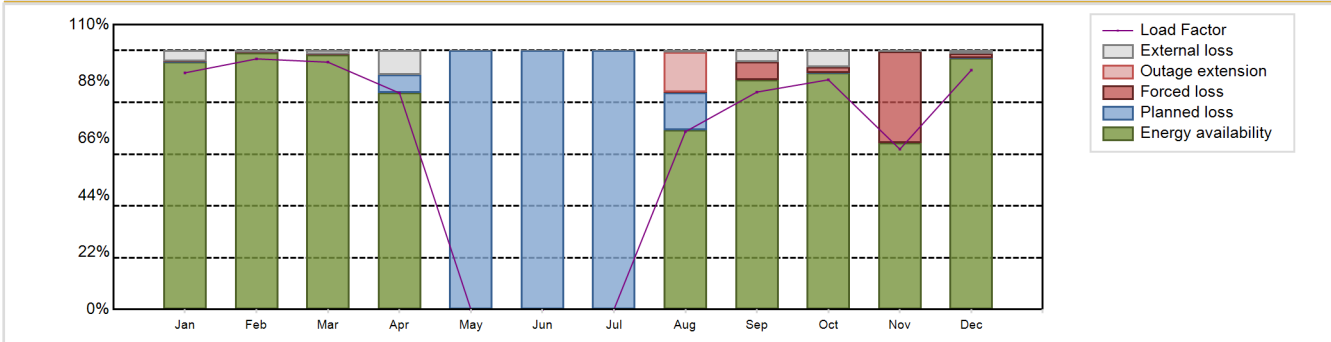
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.5 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 328.7 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 4.2 |
| Refuelling frequency [month] | : 16 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 33000 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.37 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 4.267 | HP cylinder inlet steam pressure [MPa] | : 6.95 |
| Number of fissile fuel assemblies/bundles | : 193 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.2 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 53 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 4 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 7384.88 GW(e).h | Forced Loss Rate (FLR) | : 5.45 % |
| Energy Availability Factor (EAF) | : 65.44 % | Unplanned Capability Loss Factor (UCL) | : 5.2 % |
| Unit Capability Factor (UCF) | : 67.79 % | Planned Unavailability Factor (PUF) | : 27.01 % |
| Load Factor (LF) | : 63.39 % | Externally cause unavailability (XUF) | : 2.35 % |
| Operating Factor (OF) | : 68.9 % | Total off-line time | : 2724 hours |

Annual Summary

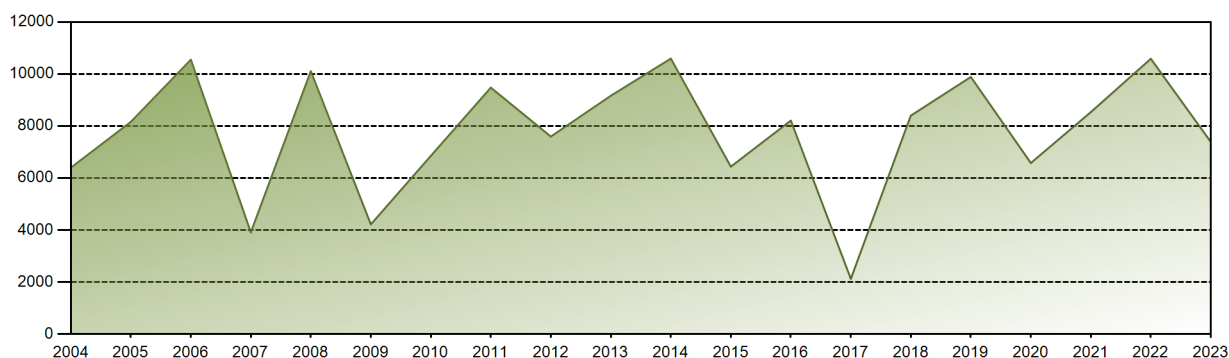


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 904.48 | 865.10 | 944.00 | 800.65 | 0.00 | 0.00 | 0.00 | 679.53 | 804.16 | 879.13 | 592.78 | 915.07 | 7384.88 |
| EAF [%] | 95.63 | 99.20 | 98.44 | 83.61 | 0.00 | 0.01 | 0.00 | 69.46 | 88.66 | 91.38 | 64.28 | 97.07 | 65.44 |
| UCF [%] | 99.77 | 99.82 | 99.87 | 92.87 | 0.00 | 0.01 | 0.00 | 70.15 | 93.08 | 97.65 | 64.54 | 98.11 | 67.79 |
| LF [%] | 91.41 | 96.79 | 95.53 | 83.61 | 0.00 | 0.00 | 0.00 | 68.67 | 83.98 | 88.72 | 61.90 | 92.48 | 63.39 |
| OF [%] | 97.85 | 100.00 | 100.00 | 93.19 | 0.00 | 0.00 | 0.00 | 77.96 | 95.42 | 99.87 | 64.86 | 100.00 | 68.90 |
| FLR [%] | 0.18 | 0.18 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.47 | 6.92 | 2.33 | 35.46 | 1.83 | 5.45 |
| UCL [%] | 0.18 | 0.18 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 15.62 | 6.92 | 2.32 | 35.46 | 1.83 | 5.20 |
| PUF [%] | 0.05 | 0.00 | 0.00 | 7.13 | 100.00 | 99.99 | 100.00 | 14.24 | 0.00 | 0.03 | 0.00 | 0.06 | 27.01 |
| XUF [%] | 4.14 | 0.62 | 1.43 | 9.26 | 0.00 | 0.00 | 0.00 | 0.69 | 4.42 | 6.26 | 0.27 | 1.04 | 2.35 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 301851.01 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 10.3 % |
| Cumulative Energy Availability Factor (EAF) | : 72.14 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 11.86 % |
| Cumulative Unit Capability Factor (UCF) | : 74.59 % | Cumulative Planned Unavailability Factor (PUF) | : 13.54 % |
| Cumulative Load Factor (LF) | : 67.78 % | Cumulative Externally cause unavailability (XUF) | : 2.46 % |
| Cumulative Operating Factor (OF) | : 74.05 % | | |

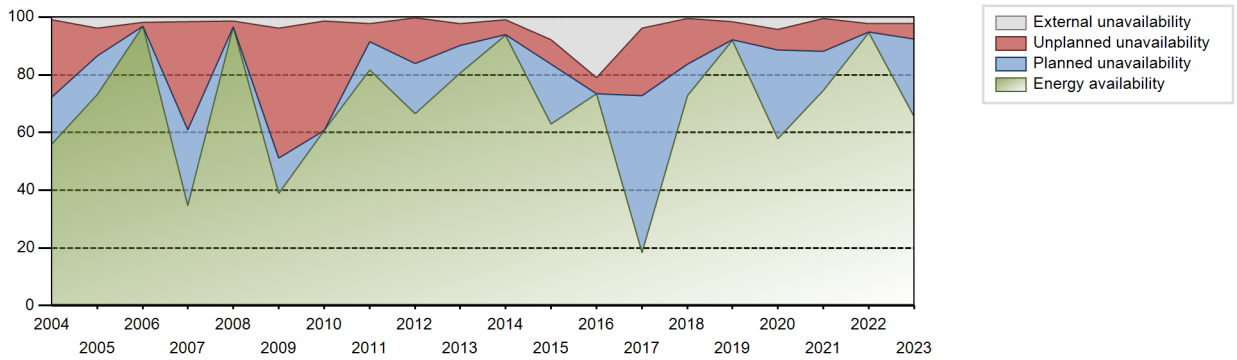
Electricity Production (net) [GWh]



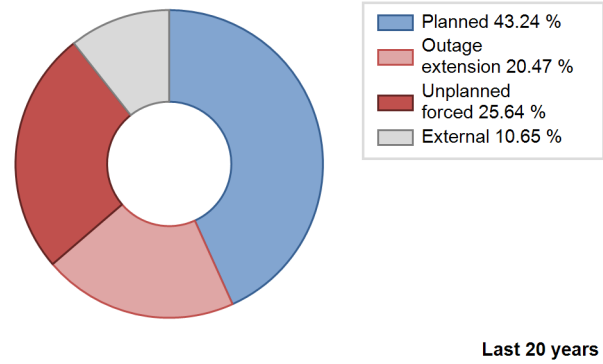
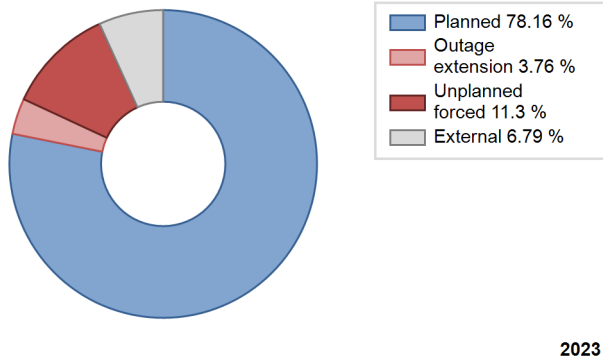
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 8321.70 | 6503 | 1290 | 72.10 | 72.10 | 71.52 | 71.84 | 7.84 | 6.13 | 21.77 | 0.00 |
| 1987 | 7716.60 | 6104 | 1290 | 78.31 | 78.35 | 68.29 | 69.68 | 15.09 | 13.93 | 7.72 | 0.04 |
| 1988 | 6763.00 | 5413 | 1330 | 59.22 | 68.73 | 57.89 | 61.62 | 16.92 | 14.00 | 17.27 | 9.51 |
| 1989 | 8124.44 | 6288 | 1330 | 70.16 | 70.70 | 69.73 | 71.78 | 14.82 | 12.30 | 17.00 | 0.54 |
| 1990 | 7321.98 | 6008 | 1330 | 66.25 | 67.22 | 62.85 | 68.58 | 2.17 | 1.49 | 31.29 | 0.97 |
| 1991 | 9587.15 | 7634 | 1330 | 86.25 | 86.48 | 82.29 | 87.15 | 10.69 | 10.36 | 3.16 | 0.23 |
| 1992 | 6886.61 | 5671 | 1330 | 62.95 | 63.20 | 58.95 | 64.56 | 24.89 | 20.94 | 15.86 | 0.24 |
| 1993 | 8459.03 | 6951 | 1330 | 73.36 | 77.52 | 72.60 | 79.35 | 2.29 | 1.81 | 20.67 | 4.16 |
| 1994 | 6703.62 | 5590 | 1330 | 61.83 | 63.39 | 57.54 | 63.81 | 23.27 | 19.22 | 17.39 | 1.56 |
| 1995 | 8733.26 | 7598 | 1330 | 84.09 | 85.55 | 74.96 | 86.74 | 1.21 | 1.05 | 13.40 | 1.47 |
| 1996 | 8027.69 | 7261 | 1330 | 84.55 | 84.90 | 68.71 | 82.66 | 15.07 | 15.07 | 0.03 | 0.35 |
| 1997 | 7618.80 | 6494 | 1330 | 72.79 | 73.18 | 65.39 | 74.13 | 1.57 | 1.17 | 25.65 | 0.39 |
| 1998 | 8327.02 | 6913 | 1330 | 76.12 | 77.61 | 71.47 | 78.92 | 6.54 | 5.43 | 16.96 | 1.49 |
| 1999 | 7636.71 | 6505 | 1330 | 73.75 | 76.13 | 65.55 | 74.26 | 12.58 | 10.95 | 12.92 | 2.38 |
| 2000 | 9819.79 | 8199 | 1330 | 94.42 | 94.73 | 84.05 | 93.34 | 4.34 | 4.30 | 0.97 | 0.31 |
| 2001 | 7815.94 | 6796 | 1330 | 79.62 | 81.62 | 67.09 | 77.58 | 1.48 | 1.23 | 17.15 | 2.00 |
| 2002 | 8900.48 | 7366 | 1330 | 80.37 | 82.28 | 76.39 | 84.09 | 6.38 | 5.61 | 12.11 | 1.92 |
| 2003 | 8181.73 | 6567 | 1330 | 74.26 | 74.87 | 70.22 | 74.97 | 24.57 | 24.39 | 0.74 | 0.61 |
| 2004 | 6395.50 | 5147 | 1330 | 56.04 | 57.01 | 54.74 | 58.60 | 31.91 | 26.71 | 16.28 | 0.97 |
| 2005 | 8157.60 | 6573 | 1330 | 73.15 | 76.92 | 70.02 | 75.03 | 10.52 | 9.74 | 13.33 | 3.78 |
| 2006 | 10549.56 | 8671 | 1330 | 96.79 | 98.63 | 90.55 | 98.98 | 1.32 | 1.32 | 0.05 | 1.84 |
| 2007 | 3908.79 | 3402 | 1330 | 34.75 | 36.28 | 33.55 | 38.84 | 14.66 | 37.58 | 26.14 | 1.52 |
| 2008 | 10106.55 | 8570 | 1330 | 96.59 | 98.00 | 86.51 | 97.56 | 1.92 | 1.92 | 0.08 | 1.41 |
| 2009 | 4214.55 | 3670 | 1330 | 38.84 | 42.69 | 36.17 | 41.89 | 39.64 | 44.94 | 12.38 | 3.84 |
| 2010 | 6850.05 | 5394 | 1330 | 60.64 | 61.91 | 58.79 | 61.58 | 38.08 | 38.07 | 0.02 | 1.27 |
| 2011 | 9475.26 | 7462 | 1330 | 81.69 | 84.03 | 81.33 | 85.18 | 2.90 | 6.26 | 9.70 | 2.34 |
| 2012 | 7592.85 | 5934 | 1330 | 66.60 | 66.86 | 64.99 | 67.55 | 1.33 | 15.83 | 17.31 | 0.26 |
| 2013 | 9162.71 | 7299 | 1330 | 80.52 | 82.69 | 78.64 | 83.32 | 1.31 | 7.61 | 9.70 | 2.17 |
| 2014 | 10592.86 | 8460 | 1330 | 93.80 | 94.80 | 90.92 | 96.58 | 5.05 | 5.04 | 0.17 | 0.99 |
| 2015 | 6436.51 | 5656 | 1330 | 62.88 | 70.74 | 55.25 | 64.57 | 0.57 | 8.37 | 20.89 | 7.86 |
| 2016 | 8209.45 | 7250 | 1330 | 73.38 | 94.35 | 70.27 | 82.54 | 5.61 | 5.61 | 0.04 | 20.98 |
| 2017 | 2121.65 | 1858 | 1330 | 18.27 | 22.19 | 18.21 | 21.21 | 3.59 | 23.29 | 54.52 | 3.92 |
| 2018 | 8399.29 | 6597 | 1330 | 72.81 | 73.40 | 72.09 | 75.31 | 1.48 | 15.69 | 10.91 | 0.59 |
| 2019 | 9886.14 | 8227 | 1330 | 91.83 | 93.43 | 84.85 | 93.92 | 6.27 | 6.25 | 0.32 | 1.60 |
| 2020 | 6577.17 | 5481 | 1330 | 57.82 | 62.09 | 56.30 | 62.40 | 4.53 | 7.18 | 30.73 | 4.26 |
| 2021 | 8534.76 | 6749 | 1330 | 74.52 | 75.06 | 73.25 | 77.04 | 13.13 | 11.34 | 13.60 | 0.54 |
| 2022 | 10585.79 | 8569 | 1330 | 94.61 | 96.93 | 90.86 | 97.82 | 2.87 | 2.87 | 0.21 | 2.31 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|-------------|-------------|-----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 396 | | | 888 | |
| B. Refuelling without maintenance | | | | 118 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2307 | | | 974 | 25 | |
| D. Inspection, maintenance or repair without refuelling | | | | 26 | | |
| E. Testing of plant systems or components | | | | 25 | 7 | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 4 |
| L. Human factor related | | | | | 11 | |
| M. Governmental requirements or court decisions | | | | | | 0 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 3 |
| O. Load dispatching, prioritization | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 1 | 29 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 16 | | | 63 |
| Z. Other | | 4 | | | 22 | |
| Subtotal | 2307 | 400 | 16 | 1143 | 957 | 101 |
| Total | | 2723 | | | 2201 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 35 |
| 12. Reactor I&C Systems | | 64 |
| 13. Reactor Auxiliary Systems | | 36 |
| 14. Safety Systems | 149 | 33 |
| 15. Reactor Cooling Systems | | 116 |
| 16. Steam generation systems | | 12 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 10 |
| 31. Turbine and auxiliaries | 33 | 38 |
| 32. Feedwater and Main Steam System | | 52 |
| 33. Circulating Water System | | 37 |
| 34. Miscellaneous Systems | 114 | 130 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 242 |
| 42. Electrical Power Supply Systems | 100 | 82 |
| Total | 396 | 888 |

2023 Operating Experience

FR-39

PALUEL-4

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1382 MWe
 Reference unit power (net) : 1330 MWe

Key Dates

Construction Date : 1980-02-01
 Grid Date : 1986-04-11
 Commercial Date : 1986-06-01
 Age at end of year : 37 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.2
 Number of control rod assemblies : 36
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.2

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

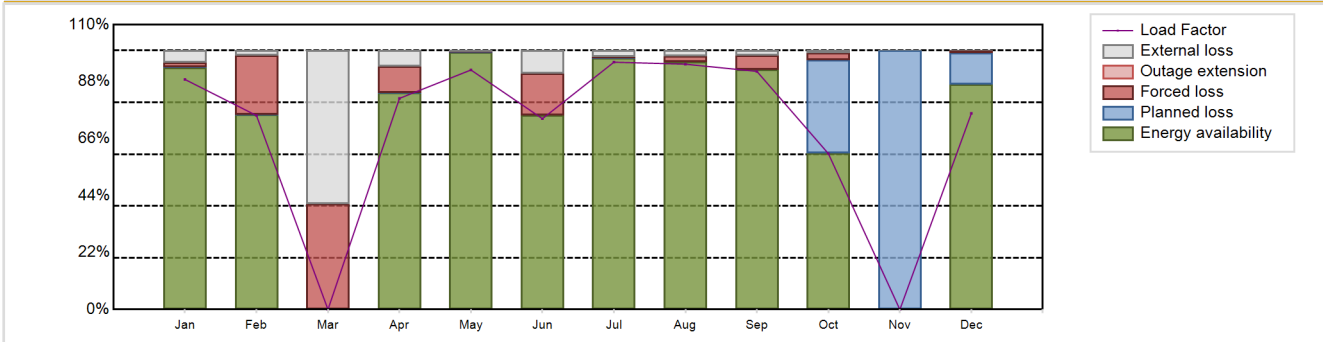
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8060.67 GW(e).h
 Energy Availability Factor (EAF) : 71.68 %
 Unit Capability Factor (UCF) : 79.08 %
 Load Factor (LF) : 69.19 %
 Operating Factor (OF) : 74.84 %
 Forced Loss Rate (FLR) : 9.78 %
 Unplanned Capability Loss Factor (UCL) : 8.57 %
 Planned Unavailability Factor (PUF) : 12.34 %
 Externally cause unavailability (XUF) : 7.41 %
 Total off-line time : 2204 hours

Annual Summary

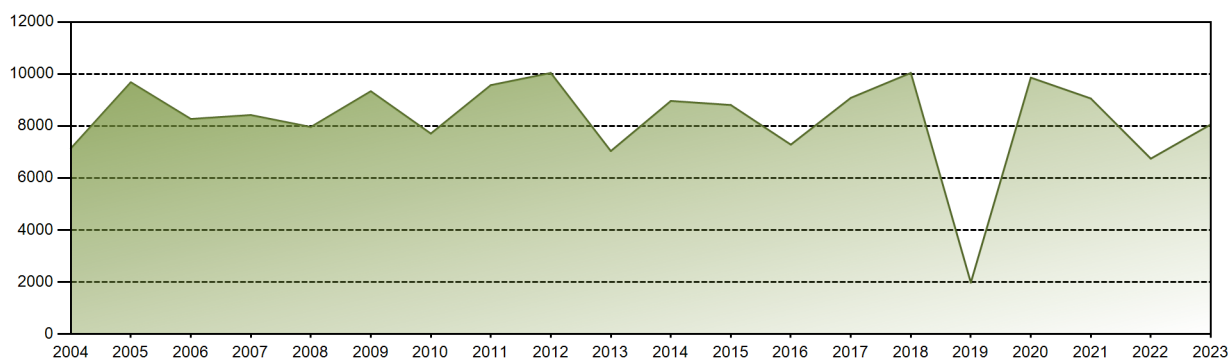


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 879.14 | 669.80 | 0.00 | 780.86 | 915.49 | 705.74 | 945.18 | 937.64 | 880.75 | 596.65 | 0.00 | 749.43 | 8060.67 |
| EAF [%] | 93.44 | 75.19 | 0.00 | 83.75 | 99.31 | 74.93 | 97.05 | 95.62 | 92.60 | 60.36 | 0.00 | 86.99 | 71.68 |
| UCF [%] | 98.01 | 76.95 | 59.09 | 89.81 | 99.63 | 83.71 | 99.40 | 97.69 | 94.60 | 61.35 | 0.00 | 86.99 | 79.08 |
| LF [%] | 88.85 | 74.94 | 0.00 | 81.54 | 92.52 | 73.70 | 95.52 | 94.76 | 91.98 | 60.22 | 0.00 | 75.74 | 69.19 |
| OF [%] | 100.00 | 77.38 | 0.00 | 90.83 | 100.00 | 77.08 | 100.00 | 100.00 | 96.11 | 62.42 | 0.00 | 93.28 | 74.84 |
| FLR [%] | 1.83 | 23.03 | 40.91 | 10.15 | 0.35 | 16.29 | 0.56 | 2.31 | 5.40 | 4.09 | 0.00 | 0.94 | 9.78 |
| UCL [%] | 1.82 | 23.02 | 40.91 | 10.15 | 0.35 | 16.29 | 0.56 | 2.31 | 5.40 | 2.62 | 0.00 | 0.83 | 8.57 |
| PUF [%] | 0.17 | 0.03 | 0.00 | 0.04 | 0.02 | 0.00 | 0.04 | 0.00 | 0.00 | 36.03 | 100.00 | 12.18 | 12.34 |
| XUF [%] | 4.57 | 1.76 | 59.09 | 6.06 | 0.33 | 8.79 | 2.34 | 2.08 | 1.99 | 1.00 | 0.00 | 0.00 | 7.41 |

Historical Summary

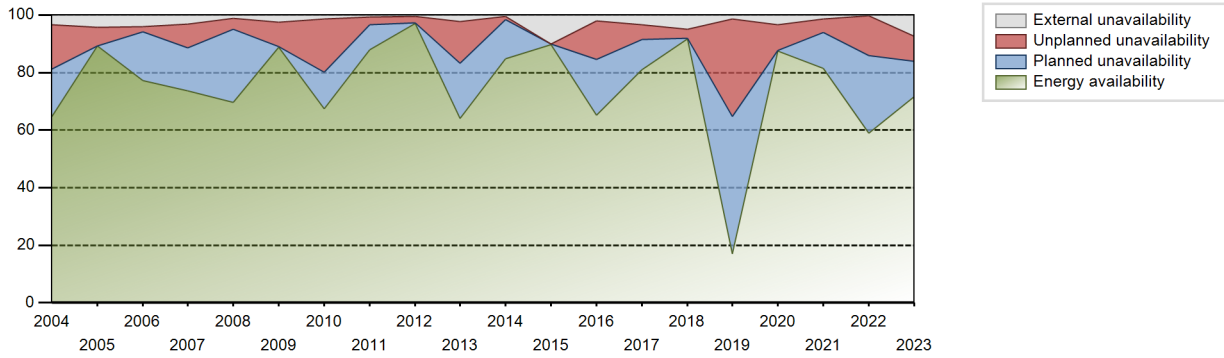
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 308994.74 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.5 % |
| Cumulative Energy Availability Factor (EAF) | : 75.8 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.68 % |
| Cumulative Unit Capability Factor (UCF) | : 78.02 % | Cumulative Planned Unavailability Factor (PUF) | : 13.3 % |
| Cumulative Load Factor (LF) | : 70.39 % | Cumulative Externally cause unavailability (XUF) | : 2.22 % |
| Cumulative Operating Factor (OF) | : 78.13 % | | |

Electricity Production (net) [GWh]

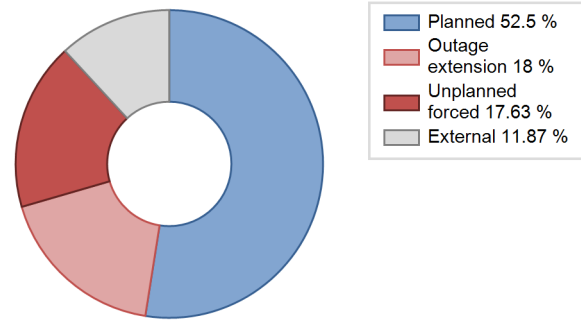
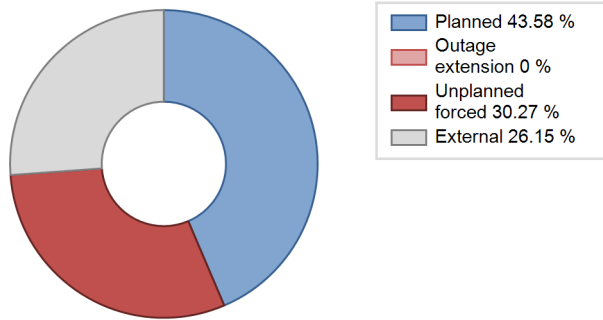


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 6118.60 | 5343 | 1300 | 85.21 | 85.69 | 78.04 | 83.67 | 14.30 | 14.30 | 0.02 | 0.48 |
| 1987 | 8014.60 | 6289 | 1290 | 69.74 | 69.84 | 70.92 | 71.79 | 15.59 | 12.90 | 17.25 | 0.11 |
| 1988 | 5909.00 | 4812 | 1330 | 53.58 | 54.01 | 50.58 | 54.78 | 26.16 | 19.13 | 26.86 | 0.43 |
| 1989 | 8268.30 | 6349 | 1330 | 70.98 | 72.12 | 70.97 | 72.48 | 14.06 | 11.80 | 16.07 | 1.14 |
| 1990 | 8067.69 | 6770 | 1330 | 78.49 | 78.70 | 69.25 | 77.28 | 11.57 | 10.30 | 11.00 | 0.21 |
| 1991 | 8325.58 | 6677 | 1330 | 74.20 | 74.52 | 71.46 | 76.22 | 8.12 | 6.58 | 18.89 | 0.32 |
| 1992 | 5553.31 | 4529 | 1330 | 48.65 | 48.93 | 47.53 | 51.56 | 35.83 | 27.32 | 23.75 | 0.28 |
| 1993 | 8683.78 | 6938 | 1330 | 75.35 | 77.78 | 74.53 | 79.20 | 3.29 | 2.65 | 19.57 | 2.43 |
| 1994 | 8329.73 | 6945 | 1330 | 76.49 | 77.31 | 71.49 | 79.28 | 7.70 | 6.45 | 16.24 | 0.82 |
| 1995 | 8346.82 | 7354 | 1330 | 88.12 | 88.46 | 71.64 | 83.95 | 11.52 | 11.52 | 0.03 | 0.34 |
| 1996 | 7848.12 | 6745 | 1330 | 72.36 | 75.21 | 67.18 | 76.79 | 13.07 | 11.31 | 13.48 | 2.85 |
| 1997 | 8633.65 | 7219 | 1330 | 78.22 | 81.91 | 74.10 | 82.41 | 6.09 | 5.31 | 12.78 | 3.70 |
| 1998 | 7776.71 | 6506 | 1330 | 68.32 | 71.17 | 66.75 | 74.27 | 4.80 | 3.59 | 25.24 | 2.85 |
| 1999 | 9879.73 | 8345 | 1330 | 94.56 | 96.10 | 84.80 | 95.26 | 3.08 | 3.05 | 0.85 | 1.53 |
| 2000 | 8358.80 | 7532 | 1330 | 84.44 | 86.05 | 71.55 | 85.75 | 1.37 | 1.19 | 12.76 | 1.60 |
| 2001 | 8581.02 | 7489 | 1330 | 82.14 | 84.54 | 73.65 | 85.49 | 1.24 | 1.06 | 14.40 | 2.40 |
| 2002 | 9303.30 | 8216 | 1330 | 92.67 | 95.66 | 79.85 | 93.79 | 0.70 | 0.67 | 3.67 | 2.99 |
| 2003 | 7960.72 | 7307 | 1330 | 81.93 | 82.79 | 68.33 | 83.41 | 8.86 | 8.05 | 9.17 | 0.86 |
| 2004 | 7138.56 | 6027 | 1330 | 64.63 | 67.89 | 61.10 | 68.61 | 18.67 | 15.58 | 16.52 | 3.26 |
| 2005 | 9682.12 | 7949 | 1330 | 89.18 | 93.34 | 83.09 | 90.73 | 6.61 | 6.60 | 0.05 | 4.16 |
| 2006 | 8270.83 | 7320 | 1330 | 77.23 | 81.37 | 70.99 | 83.56 | 1.70 | 1.70 | 16.93 | 4.14 |
| 2007 | 8421.51 | 6824 | 1330 | 73.68 | 76.85 | 72.28 | 77.90 | 1.26 | 8.29 | 14.86 | 3.16 |
| 2008 | 7962.59 | 6286 | 1330 | 69.59 | 70.82 | 68.16 | 71.56 | 0.21 | 3.72 | 25.46 | 1.23 |
| 2009 | 9337.13 | 7944 | 1330 | 88.89 | 91.39 | 80.14 | 90.68 | 8.56 | 8.55 | 0.06 | 2.50 |
| 2010 | 7709.46 | 6085 | 1330 | 67.44 | 68.90 | 66.17 | 69.46 | 2.78 | 18.44 | 12.66 | 1.46 |
| 2011 | 9571.58 | 7835 | 1330 | 87.90 | 88.66 | 82.15 | 89.44 | 0.57 | 2.65 | 8.69 | 0.76 |
| 2012 | 10040.06 | 8467 | 1330 | 97.16 | 97.73 | 85.94 | 96.39 | 2.25 | 2.25 | 0.03 | 0.57 |
| 2013 | 7036.36 | 5984 | 1330 | 64.01 | 66.26 | 60.39 | 68.31 | 6.36 | 14.57 | 19.18 | 2.25 |
| 2014 | 8962.84 | 7539 | 1330 | 84.83 | 85.39 | 76.93 | 86.06 | 1.21 | 1.04 | 13.56 | 0.56 |
| 2015 | 8807.53 | 7649 | 1330 | 89.81 | 99.80 | 75.60 | 87.32 | 0.13 | 0.13 | 0.06 | 9.99 |
| 2016 | 7284.06 | 6369 | 1330 | 65.14 | 67.12 | 62.35 | 72.51 | 12.58 | 13.54 | 19.35 | 1.98 |
| 2017 | 9082.31 | 7455 | 1330 | 80.97 | 84.31 | 77.95 | 85.10 | 4.09 | 5.11 | 10.58 | 3.35 |
| 2018 | 10041.61 | 8304 | 1330 | 91.73 | 96.68 | 86.19 | 94.79 | 3.21 | 3.21 | 0.12 | 4.95 |
| 2019 | 1977.33 | 1688 | 1330 | 17.03 | 18.47 | 16.97 | 19.27 | 6.39 | 33.73 | 47.80 | 1.44 |
| 2020 | 9859.60 | 8041 | 1330 | 87.50 | 90.89 | 84.39 | 91.54 | 8.91 | 8.89 | 0.23 | 3.39 |
| 2021 | 9058.04 | 7416 | 1330 | 81.50 | 82.93 | 77.75 | 84.66 | 5.21 | 4.56 | 12.51 | 1.42 |
| 2022 | 6745.15 | 5375 | 1330 | 58.97 | 59.31 | 57.89 | 61.36 | 5.04 | 13.85 | 26.84 | 0.34 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|-------------|-------------|------------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 666 | | | 587 | 1 |
| B. Refuelling without maintenance | 965 | | | 132 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 925 | 8 | |
| D. Inspection, maintenance or repair without refuelling | | | | 24 | | |
| E. Testing of plant systems or components | 69 | | | 15 | 0 | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 6 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 6 |
| L. Human factor related | | | | | 16 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| O. Load dispatching, prioritization | | | | | | 3 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 501 | | 10 | 25 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 30 |
| Z. Other | | | | | 54 | 2 |
| Subtotal | 1034 | 666 | 502 | 1096 | 678 | 77 |
| Total | | 2202 | | | 1851 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 92 |
| 12. Reactor I&C Systems | 46 | 31 |
| 13. Reactor Auxiliary Systems | 483 | 19 |
| 14. Safety Systems | | 13 |
| 15. Reactor Cooling Systems | | 25 |
| 16. Steam generation systems | | 46 |
| 21. Fuel Handling and Storage Facilities | | 10 |
| 31. Turbine and auxiliaries | 28 | 48 |
| 32. Feedwater and Main Steam System | | 25 |
| 33. Circulating Water System | 108 | 4 |
| 34. Miscellaneous Systems | | 156 |
| 41. Main Generator Systems | | 90 |
| 42. Electrical Power Supply Systems | | 30 |
| Total | 665 | 589 |

2023 Operating Experience

FR-63

PENLY-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1382 MWe
 Reference unit power (net) : 1330 MWe

Key Dates

Construction Date : 1982-09-01
 Grid Date : 1990-05-04
 Commercial Date : 1990-12-01
 Age at end of year : 33 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.2
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

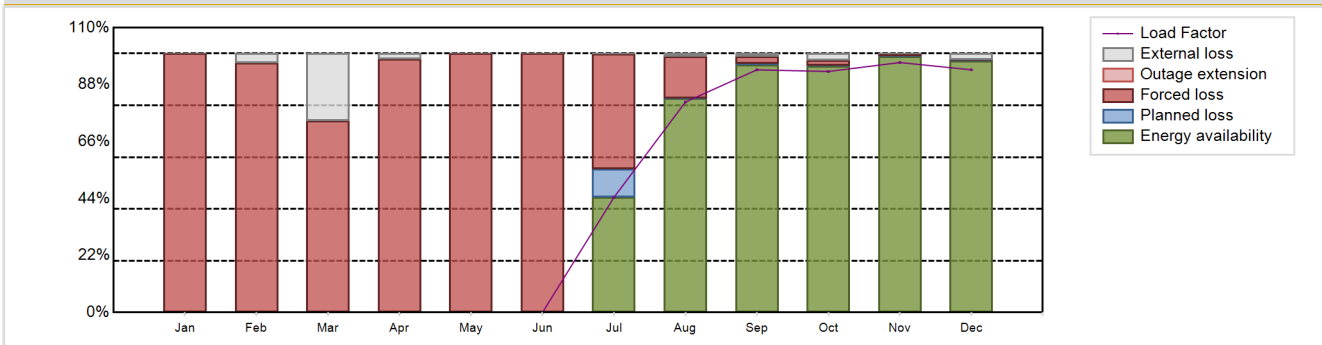
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 4916.24 GW(e).h
 Energy Availability Factor (EAF) : 43.15 %
 Unit Capability Factor (UCF) : 46.45 %
 Load Factor (LF) : 42.2 %
 Operating Factor (OF) : 45.41 %
 Forced Loss Rate (FLR) : 53.08 %
 Unplanned Capability Loss Factor (UCL) : 52.56 %
 Planned Unavailability Factor (PUF) : 1 %
 Externally cause unavailability (XUF) : 3.3 %
 Total off-line time : 4782 hours

Annual Summary

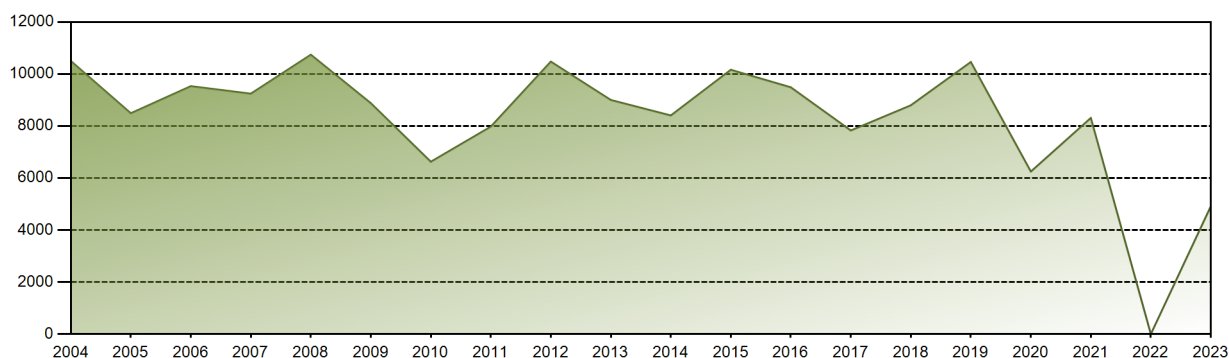


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 439.96 | 804.29 | 897.57 | 922.32 | 924.57 | 927.54 | 4916.24 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 44.60 | 82.65 | 95.64 | 95.25 | 98.79 | 97.24 | 43.15 |
| UCF [%] | 0.00 | 3.57 | 25.98 | 2.22 | 0.00 | 0.00 | 44.82 | 83.72 | 96.86 | 97.91 | 98.83 | 99.61 | 46.45 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 44.46 | 81.28 | 93.73 | 93.08 | 96.55 | 93.74 | 42.20 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 55.65 | 85.62 | 99.86 | 99.87 | 100.00 | 100.00 | 45.41 |
| FLR [%] | 100.00 | 96.43 | 74.02 | 97.78 | 100.00 | 100.00 | 49.80 | 16.25 | 2.74 | 1.99 | 0.80 | 0.28 | 53.08 |
| UCL [%] | 100.00 | 96.43 | 74.02 | 97.78 | 100.00 | 100.00 | 44.46 | 16.25 | 2.73 | 1.99 | 0.80 | 0.28 | 52.56 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.72 | 0.04 | 0.40 | 0.10 | 0.38 | 0.11 | 1.00 |
| XUF [%] | 0.00 | 3.57 | 25.98 | 2.22 | 0.00 | 0.00 | 0.22 | 1.07 | 1.23 | 2.66 | 0.03 | 2.38 | 3.30 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 280797.76 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.92 % |
| Cumulative Energy Availability Factor (EAF) | : 76.86 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.95 % |
| Cumulative Unit Capability Factor (UCF) | : 78.25 % | Cumulative Planned Unavailability Factor (PUF) | : 12.8 % |
| Cumulative Load Factor (LF) | : 72.29 % | Cumulative Externally cause unavailability (XUF) | : 1.39 % |
| Cumulative Operating Factor (OF) | : 78.41 % | | |

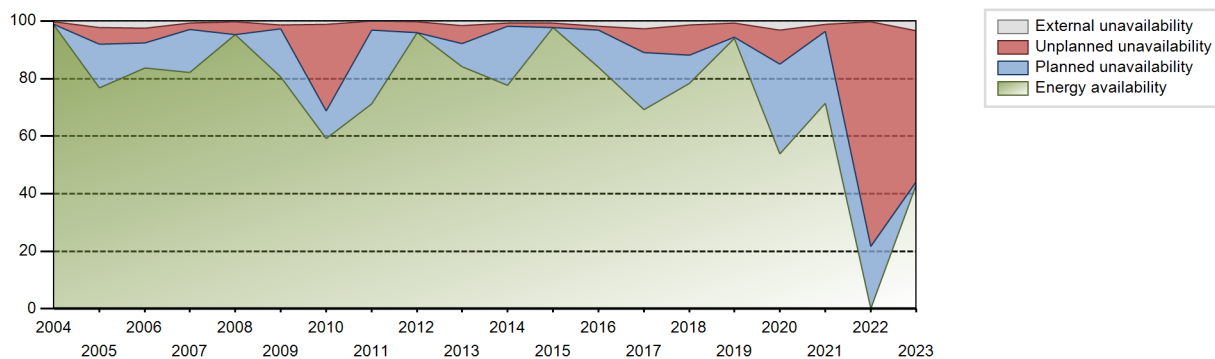
Electricity Production (net) [GWh]



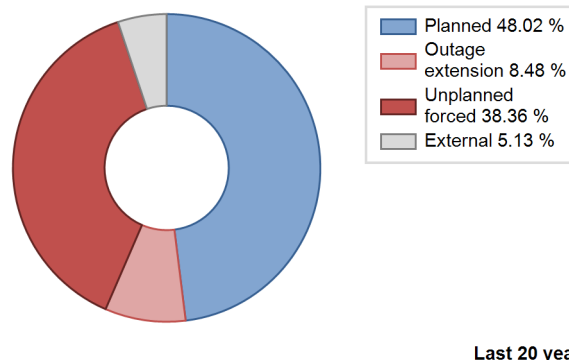
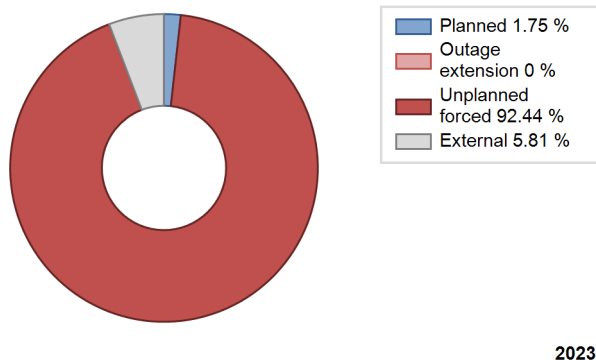
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1990 | 2887.12 | 3100 | 1330 | 98.94 | 98.94 | 98.15 | 99.19 | 0.96 | 0.96 | 0.10 | 0.00 |
| 1991 | 8436.71 | 6645 | 1330 | 74.23 | 74.27 | 72.41 | 75.86 | 10.99 | 9.17 | 16.56 | 0.04 |
| 1992 | 7922.21 | 6315 | 1330 | 70.91 | 71.23 | 67.81 | 71.89 | 3.72 | 2.75 | 26.02 | 0.32 |
| 1993 | 8023.87 | 7298 | 1330 | 71.90 | 84.61 | 68.87 | 83.31 | 0.95 | 0.81 | 14.58 | 12.70 |
| 1994 | 7969.13 | 6654 | 1330 | 85.04 | 86.07 | 68.40 | 75.96 | 0.20 | 0.18 | 13.75 | 1.03 |
| 1995 | 8879.06 | 7248 | 1330 | 80.78 | 81.87 | 76.21 | 82.74 | 3.62 | 3.08 | 15.05 | 1.09 |
| 1996 | 9530.76 | 7625 | 1330 | 85.23 | 85.71 | 81.58 | 86.81 | 2.07 | 1.81 | 12.48 | 0.48 |
| 1997 | 8503.41 | 6872 | 1330 | 76.69 | 77.50 | 72.99 | 78.45 | 11.41 | 9.98 | 12.52 | 0.80 |
| 1998 | 9965.66 | 8140 | 1330 | 97.87 | 97.97 | 85.54 | 92.92 | 1.07 | 1.06 | 0.98 | 0.10 |
| 1999 | 7998.46 | 6633 | 1330 | 71.52 | 74.38 | 68.65 | 75.72 | 12.99 | 11.11 | 14.51 | 2.87 |
| 2000 | 8271.73 | 6640 | 1330 | 73.67 | 73.85 | 70.80 | 75.59 | 13.80 | 11.82 | 14.34 | 0.17 |
| 2001 | 9825.84 | 8304 | 1330 | 98.40 | 98.69 | 84.34 | 94.79 | 0.55 | 0.55 | 0.76 | 0.29 |
| 2002 | 7146.66 | 5948 | 1330 | 66.91 | 67.24 | 61.34 | 67.90 | 6.95 | 5.02 | 27.74 | 0.34 |
| 2003 | 9290.83 | 7525 | 1330 | 84.64 | 84.64 | 79.74 | 85.90 | 3.49 | 3.06 | 12.30 | 0.00 |
| 2004 | 10500.23 | 8733 | 1330 | 98.57 | 98.93 | 89.88 | 99.42 | 0.74 | 0.74 | 0.33 | 0.37 |
| 2005 | 8491.26 | 7104 | 1330 | 76.88 | 79.06 | 72.88 | 81.10 | 4.78 | 5.86 | 15.08 | 2.18 |
| 2006 | 9533.15 | 7656 | 1330 | 83.60 | 86.07 | 81.82 | 87.40 | 4.87 | 5.09 | 8.84 | 2.46 |
| 2007 | 9243.57 | 7356 | 1330 | 82.07 | 82.73 | 79.34 | 83.97 | 1.85 | 2.32 | 14.95 | 0.66 |
| 2008 | 10743.35 | 8424 | 1330 | 95.24 | 95.53 | 91.96 | 95.90 | 4.45 | 4.45 | 0.03 | 0.29 |
| 2009 | 8878.54 | 7217 | 1330 | 80.49 | 81.76 | 76.21 | 82.39 | 1.22 | 1.36 | 16.87 | 1.28 |
| 2010 | 6627.27 | 5280 | 1330 | 59.23 | 60.38 | 56.88 | 60.27 | 32.32 | 30.00 | 9.62 | 1.15 |
| 2011 | 7976.85 | 6332 | 1330 | 71.30 | 71.41 | 68.47 | 72.28 | 0.85 | 3.00 | 25.59 | 0.11 |
| 2012 | 10476.99 | 8525 | 1330 | 95.85 | 96.05 | 89.68 | 97.05 | 3.88 | 3.88 | 0.07 | 0.19 |
| 2013 | 9001.96 | 7536 | 1330 | 84.12 | 85.74 | 77.26 | 86.03 | 0.67 | 6.26 | 7.99 | 1.63 |
| 2014 | 8406.70 | 6939 | 1330 | 77.63 | 78.26 | 72.16 | 79.21 | 0.78 | 1.15 | 20.59 | 0.63 |
| 2015 | 10162.55 | 8623 | 1330 | 97.69 | 98.37 | 87.23 | 98.44 | 1.54 | 1.54 | 0.09 | 0.68 |
| 2016 | 9489.07 | 7812 | 1330 | 83.87 | 85.65 | 81.22 | 88.93 | 1.56 | 1.36 | 12.99 | 1.78 |
| 2017 | 7829.20 | 6376 | 1330 | 69.30 | 71.90 | 67.20 | 72.79 | 1.56 | 8.37 | 19.73 | 2.60 |
| 2018 | 8796.74 | 7044 | 1330 | 78.37 | 79.72 | 75.50 | 80.41 | 2.90 | 10.61 | 9.67 | 1.35 |
| 2019 | 10462.26 | 8383 | 1330 | 93.91 | 94.57 | 89.80 | 95.70 | 1.07 | 4.91 | 0.53 | 0.66 |
| 2020 | 6249.27 | 5120 | 1330 | 53.91 | 56.99 | 53.49 | 58.29 | 3.42 | 11.92 | 31.09 | 3.08 |
| 2021 | 8310.67 | 6387 | 1330 | 71.39 | 72.54 | 71.33 | 72.91 | 3.21 | 2.41 | 25.05 | 1.15 |
| 2022 | 0.00 | 0 | 1330 | 0.00 | 0.27 | 0.00 | 0.00 | 99.65 | 78.09 | 21.63 | 0.27 |
| 2023 | 4916.24 | 3978 | 1330 | 43.15 | 46.45 | 42.20 | 45.41 | 53.08 | 52.56 | 1.00 | 3.30 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1990 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 4545 | | | 714 | 0 |
| B. Refuelling without maintenance | | | | 102 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 890 | 1 | |
| D. Inspection, maintenance or repair without refuelling | | | | 117 | | |
| E. Testing of plant systems or components | 5 | | | 13 | | 0 |
| H. Nuclear regulatory requirements | | | | | 1 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 3 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 3 |
| O. Load dispatching, prioritization | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 233 | | | 16 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 1 |
| Z. Other | | | | | 4 | 2 |
| Subtotal | 5 | 4545 | 233 | 1122 | 723 | 23 |
| Total | | 4783 | | | 1868 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1990 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 25 |
| 12. Reactor I&C Systems | | 21 |
| 13. Reactor Auxiliary Systems | | 24 |
| 14. Safety Systems | 4420 | 343 |
| 15. Reactor Cooling Systems | | 28 |
| 16. Steam generation systems | | 26 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 21. Fuel Handling and Storage Facilities | | 3 |
| 31. Turbine and auxiliaries | 26 | 33 |
| 32. Feedwater and Main Steam System | | 22 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 88 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | 99 | 83 |
| 42. Electrical Power Supply Systems | | 6 |
| Total | 4545 | 707 |

2023 Operating Experience

FR-64

PENLY-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1382 MWe
 Reference unit power (net) : 1330 MWe

Key Dates

Construction Date : 1984-08-01
 Grid Date : 1992-02-04
 Commercial Date : 1992-11-01
 Age at end of year : 31 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 804
 Fuel linear heat generation rate [kW/m] : 17.2
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 328.7
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

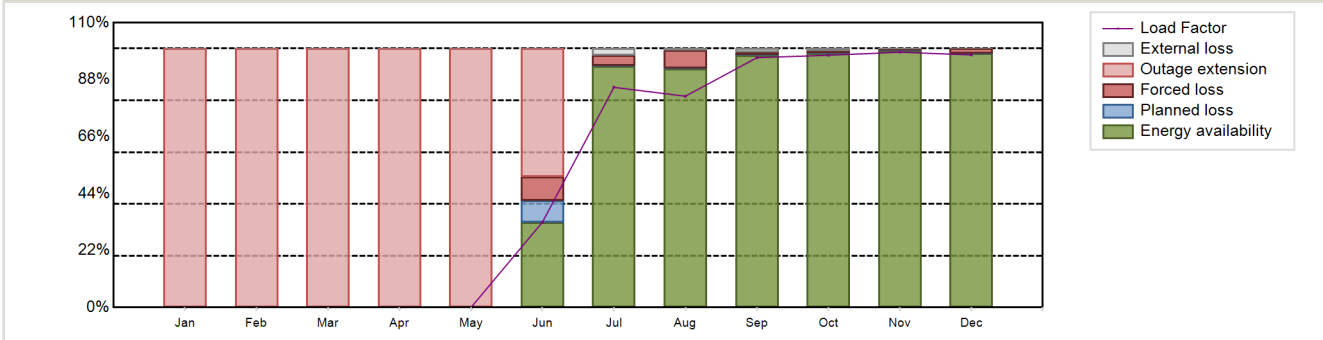
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5763.76 GW(e).h
 Energy Availability Factor (EAF) : 51.29 %
 Unit Capability Factor (UCF) : 51.74 %
 Load Factor (LF) : 49.47 %
 Operating Factor (OF) : 54.03 %
 Forced Loss Rate (FLR) : 3.89 %
 Unplanned Capability Loss Factor (UCL) : 47.52 %
 Planned Unavailability Factor (PUF) : 0.75 %
 Externally cause unavailability (XUF) : 0.44 %
 Total off-line time : 4027 hours

Annual Summary

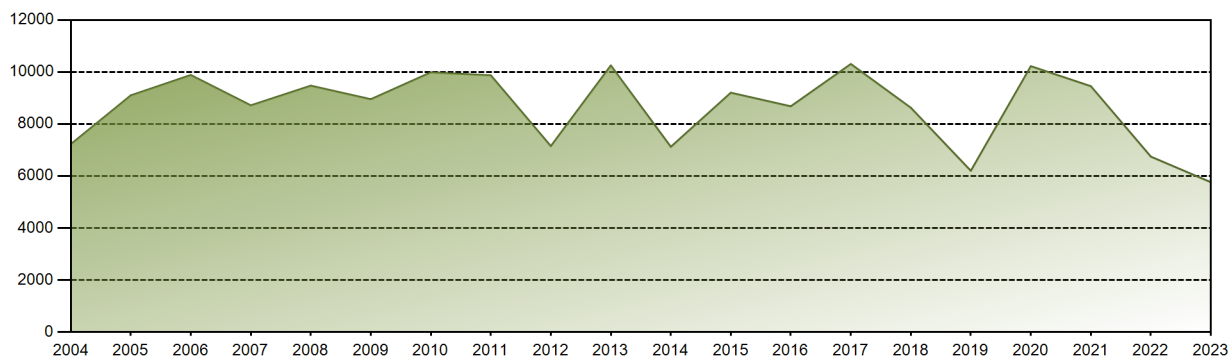


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 315.72 | 841.55 | 807.65 | 924.02 | 965.27 | 944.20 | 965.35 | 5763.76 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 32.96 | 93.12 | 92.28 | 97.36 | 98.21 | 99.22 | 98.04 | 51.29 |
| UCF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 32.96 | 95.62 | 92.98 | 98.65 | 98.97 | 99.24 | 98.04 | 51.74 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 32.97 | 85.05 | 81.62 | 96.49 | 97.42 | 98.60 | 97.56 | 49.47 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.56 | 100.00 | 93.68 | 100.00 | 99.87 | 100.00 | 100.00 | 54.03 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.02 | 4.13 | 6.93 | 1.08 | 0.98 | 0.68 | 1.92 | 3.89 |
| UCL [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 58.79 | 4.12 | 6.92 | 1.07 | 0.98 | 0.68 | 1.92 | 47.52 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.26 | 0.26 | 0.09 | 0.28 | 0.05 | 0.08 | 0.04 | 0.75 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.50 | 0.70 | 1.28 | 0.77 | 0.02 | 0.00 | 0.44 |

Historical Summary

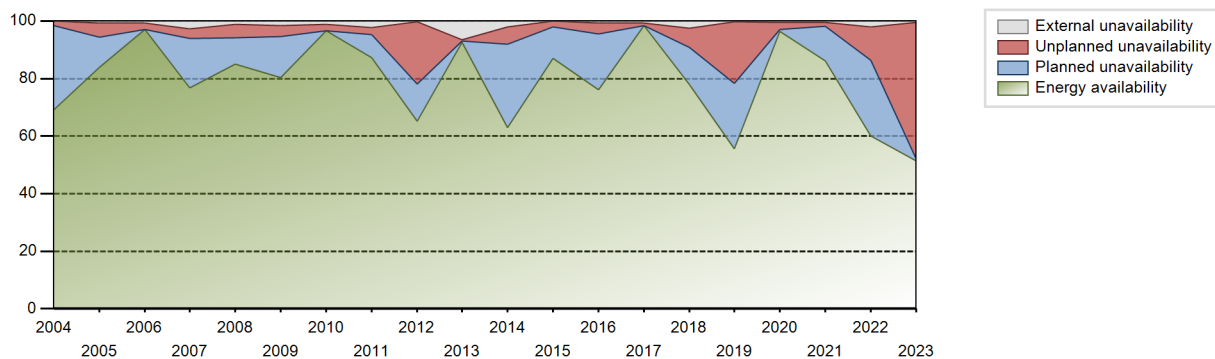
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 276229.45 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.75 % |
| Cumulative Energy Availability Factor (EAF) | : 80.68 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.6 % |
| Cumulative Unit Capability Factor (UCF) | : 82 % | Cumulative Planned Unavailability Factor (PUF) | : 11.4 % |
| Cumulative Load Factor (LF) | : 75.11 % | Cumulative Externally cause unavailability (XUF) | : 1.33 % |
| Cumulative Operating Factor (OF) | : 82.45 % | | |

Electricity Production (net) [GWh]

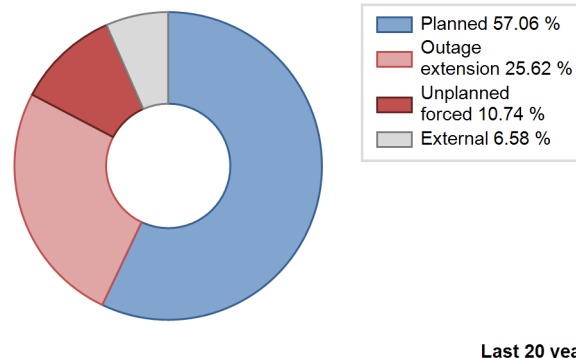
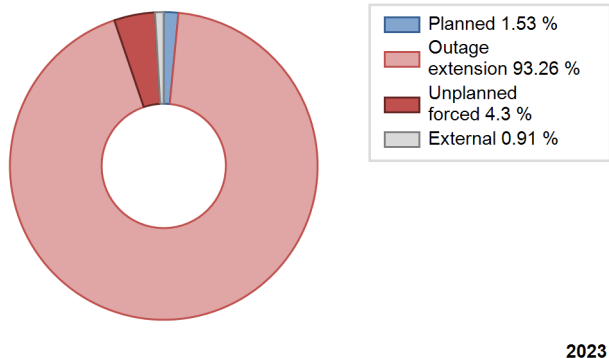


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1992 | 5149.77 | 4796 | 1330 | 99.98 | 99.98 | 101.22 | 100.00 | 0.00 | 0.00 | 0.02 | 0.00 |
| 1993 | 8611.76 | 6658 | 1330 | 74.40 | 75.16 | 73.92 | 76.00 | 0.54 | 0.41 | 24.43 | 0.76 |
| 1994 | 8759.66 | 7228 | 1330 | 77.57 | 81.28 | 75.19 | 82.51 | 3.58 | 3.01 | 15.71 | 3.70 |
| 1995 | 8169.73 | 6574 | 1330 | 73.77 | 73.98 | 70.12 | 75.05 | 16.06 | 14.16 | 11.86 | 0.21 |
| 1996 | 9757.97 | 8025 | 1330 | 89.29 | 91.33 | 83.52 | 91.36 | 8.62 | 8.61 | 0.06 | 2.04 |
| 1997 | 8068.94 | 7186 | 1330 | 82.95 | 84.26 | 69.26 | 82.03 | 4.09 | 3.60 | 12.14 | 1.32 |
| 1998 | 8877.52 | 7318 | 1330 | 81.07 | 82.94 | 76.20 | 83.54 | 4.74 | 4.12 | 12.93 | 1.87 |
| 1999 | 8636.97 | 7203 | 1330 | 79.35 | 81.27 | 74.13 | 82.23 | 5.19 | 4.45 | 14.28 | 1.92 |
| 2000 | 9584.47 | 8393 | 1330 | 96.84 | 97.11 | 82.04 | 95.55 | 2.85 | 2.85 | 0.04 | 0.27 |
| 2001 | 8816.23 | 7333 | 1330 | 80.24 | 82.09 | 75.67 | 83.71 | 4.63 | 3.98 | 13.93 | 1.85 |
| 2002 | 8464.26 | 6890 | 1330 | 78.98 | 79.07 | 72.65 | 78.65 | 9.06 | 7.88 | 13.06 | 0.09 |
| 2003 | 10207.81 | 8603 | 1330 | 97.65 | 97.65 | 87.61 | 98.21 | 1.90 | 1.89 | 0.47 | 0.00 |
| 2004 | 7225.85 | 6231 | 1330 | 69.09 | 69.21 | 61.85 | 70.94 | 2.04 | 1.44 | 29.35 | 0.12 |
| 2005 | 9102.59 | 7546 | 1330 | 84.01 | 84.78 | 78.13 | 86.14 | 2.96 | 4.86 | 10.36 | 0.78 |
| 2006 | 9885.16 | 8447 | 1330 | 96.99 | 97.73 | 84.85 | 96.43 | 2.24 | 2.23 | 0.03 | 0.74 |
| 2007 | 8718.65 | 7081 | 1330 | 76.70 | 79.44 | 74.83 | 80.83 | 4.06 | 3.36 | 17.20 | 2.73 |
| 2008 | 9474.85 | 7590 | 1330 | 85.00 | 86.11 | 81.10 | 86.41 | 1.39 | 4.70 | 9.18 | 1.11 |
| 2009 | 8954.23 | 7258 | 1330 | 80.32 | 81.97 | 76.86 | 82.85 | 1.70 | 3.81 | 14.22 | 1.64 |
| 2010 | 9986.96 | 8571 | 1330 | 96.52 | 97.72 | 85.72 | 97.84 | 2.25 | 2.25 | 0.03 | 1.20 |
| 2011 | 9873.06 | 7931 | 1330 | 87.16 | 89.53 | 84.74 | 90.54 | 1.03 | 2.42 | 8.05 | 2.37 |
| 2012 | 7151.26 | 5802 | 1330 | 65.28 | 65.59 | 61.21 | 66.05 | 19.48 | 21.64 | 12.76 | 0.31 |
| 2013 | 10253.29 | 8413 | 1330 | 92.59 | 99.11 | 88.00 | 96.04 | 0.46 | 0.45 | 0.43 | 6.52 |
| 2014 | 7123.77 | 5722 | 1330 | 62.89 | 64.90 | 61.14 | 65.32 | 2.68 | 5.99 | 29.11 | 2.01 |
| 2015 | 9204.63 | 7743 | 1330 | 87.14 | 87.26 | 79.00 | 88.39 | 0.94 | 1.91 | 10.83 | 0.12 |
| 2016 | 8682.34 | 6925 | 1330 | 76.22 | 77.01 | 74.32 | 78.84 | 1.05 | 3.70 | 19.30 | 0.78 |
| 2017 | 10308.82 | 8697 | 1330 | 98.33 | 99.03 | 88.48 | 99.28 | 0.91 | 0.91 | 0.05 | 0.70 |
| 2018 | 8627.09 | 7065 | 1330 | 77.84 | 80.27 | 74.05 | 80.65 | 1.78 | 6.64 | 13.09 | 2.43 |
| 2019 | 6201.08 | 4943 | 1330 | 55.63 | 55.93 | 53.22 | 56.43 | 1.31 | 21.30 | 22.78 | 0.30 |
| 2020 | 10224.76 | 8609 | 1330 | 96.37 | 96.76 | 87.52 | 98.01 | 1.17 | 2.65 | 0.59 | 0.39 |
| 2021 | 9455.83 | 7694 | 1330 | 86.14 | 86.61 | 81.16 | 87.83 | 1.42 | 1.25 | 12.14 | 0.47 |
| 2022 | 6747.56 | 5359 | 1330 | 60.12 | 62.23 | 57.92 | 61.18 | 2.63 | 11.63 | 26.14 | 2.11 |
| 2023 | 5763.76 | 4733 | 1330 | 51.29 | 51.74 | 49.47 | 54.03 | 3.89 | 47.52 | 0.75 | 0.44 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1992 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 4026 | | | 590 | |
| B. Refuelling without maintenance | | | | 143 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 793 | | |
| E. Testing of plant systems or components | 0 | | | 27 | | |
| H. Nuclear regulatory requirements | | | | | 11 | |
| I. Grid capacity limitation | | | | | | 1 |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 4 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 3 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 2 | 5 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 11 |
| Z. Other | | | | | 2 | 2 |
| Subtotal | 0 | 4026 | | 963 | 609 | 26 |
| Total | | 4026 | | | 1598 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1992 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 23 |
| 12. Reactor I&C Systems | | 16 |
| 13. Reactor Auxiliary Systems | | 16 |
| 14. Safety Systems | | 20 |
| 15. Reactor Cooling Systems | | 70 |
| 16. Steam generation systems | | 10 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | 47 | 34 |
| 32. Feedwater and Main Steam System | | 16 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | 3979 | 257 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 5 |
| 42. Electrical Power Supply Systems | | 99 |
| Total | 4026 | 577 |

2023 Operating Experience

FR-48

ST. ALBAN-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1381 MWe
 Reference unit power (net) : 1335 MWe

Key Dates

Construction Date : 1979-01-29
 Grid Date : 1985-08-30
 Commercial Date : 1986-05-01
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.2
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 328.3
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 4.1

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

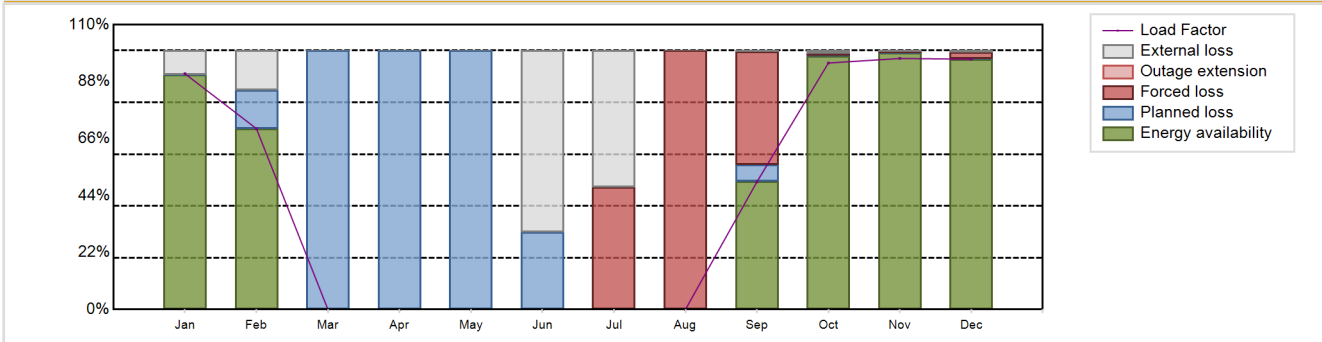
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 4843.46 GW(e).h
 Energy Availability Factor (EAF) : 41.8 %
 Unit Capability Factor (UCF) : 54.23 %
 Load Factor (LF) : 41.42 %
 Operating Factor (OF) : 44.97 %
 Forced Loss Rate (FLR) : 23.23 %
 Unplanned Capability Loss Factor (UCL) : 16.41 %
 Planned Unavailability Factor (PUF) : 29.36 %
 Externally cause unavailability (XUF) : 12.43 %
 Total off-line time : 4821 hours

Annual Summary

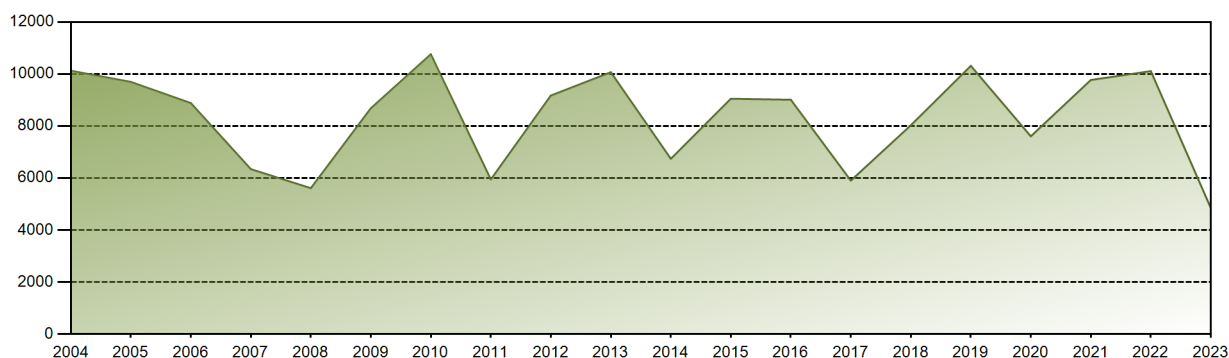


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|-------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 904.48 | 626.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 473.55 | 946.83 | 931.86 | 960.26 | 4843.46 |
| EAF [%] | 90.69 | 69.83 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 49.38 | 97.89 | 99.00 | 96.76 | 41.80 |
| UCF [%] | 100.00 | 85.19 | 0.00 | 0.00 | 0.00 | 70.14 | 52.82 | 0.00 | 49.79 | 99.01 | 99.42 | 97.30 | 54.23 |
| LF [%] | 91.06 | 69.83 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 49.27 | 95.20 | 96.95 | 96.68 | 41.42 |
| OF [%] | 100.00 | 85.57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 57.22 | 99.87 | 100.00 | 100.00 | 44.97 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 47.18 | 100.00 | 46.74 | 0.78 | 0.44 | 2.60 | 23.23 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 47.18 | 100.00 | 43.70 | 0.77 | 0.44 | 2.59 | 16.41 |
| PUF [%] | 0.00 | 14.81 | 100.00 | 100.00 | 100.00 | 29.86 | 0.00 | 0.00 | 6.51 | 0.22 | 0.14 | 0.10 | 29.36 |
| XUF [%] | 9.31 | 15.36 | 0.00 | 0.00 | 0.00 | 70.14 | 52.82 | 0.00 | 0.42 | 1.12 | 0.42 | 0.55 | 12.43 |

Historical Summary

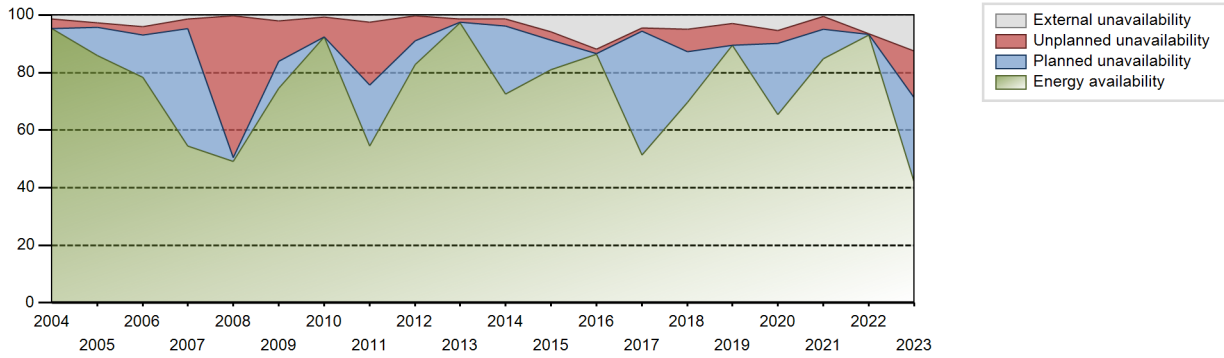
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 303716.16 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 9.08 % |
| Cumulative Energy Availability Factor (EAF) | : 74.61 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.93 % |
| Cumulative Unit Capability Factor (UCF) | : 77.27 % | Cumulative Planned Unavailability Factor (PUF) | : 13.8 % |
| Cumulative Load Factor (LF) | : 68.03 % | Cumulative Externally cause unavailability (XUF) | : 2.66 % |
| Cumulative Operating Factor (OF) | : 74.9 % | | |

Electricity Production (net) [GWh]

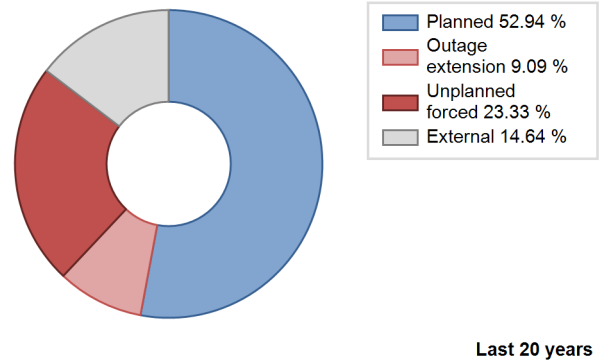
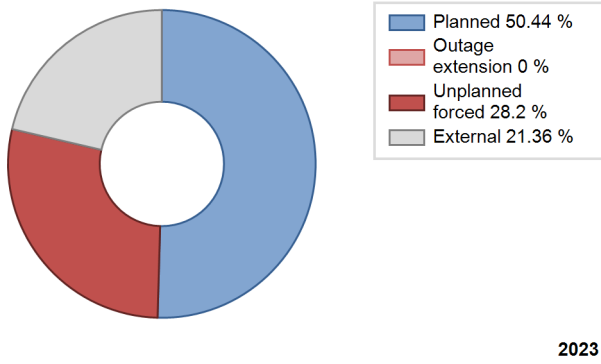


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 6722.90 | 5449 | 1300 | 66.38 | 67.62 | 51.14 | 54.11 | 17.05 | 13.90 | 18.48 | 1.24 |
| 1987 | 6101.60 | 4944 | 1300 | 56.16 | 56.61 | 53.58 | 56.44 | 20.02 | 14.17 | 29.21 | 0.45 |
| 1988 | 4562.00 | 3721 | 1335 | 82.37 | 83.39 | 38.90 | 42.36 | 11.01 | 10.32 | 6.29 | 1.01 |
| 1989 | 6781.29 | 5907 | 1335 | 63.54 | 70.68 | 57.99 | 67.43 | 10.17 | 8.00 | 21.32 | 7.14 |
| 1990 | 7799.06 | 6295 | 1335 | 68.64 | 70.38 | 66.69 | 71.86 | 15.39 | 12.81 | 16.81 | 1.74 |
| 1991 | 7935.34 | 6380 | 1335 | 73.32 | 74.44 | 67.85 | 72.83 | 12.62 | 10.75 | 14.82 | 1.11 |
| 1992 | 4812.15 | 3775 | 1335 | 42.11 | 42.12 | 41.04 | 42.98 | 45.73 | 35.50 | 22.38 | 0.01 |
| 1993 | 7376.03 | 6010 | 1335 | 65.75 | 68.18 | 63.07 | 68.61 | 17.44 | 14.40 | 17.42 | 2.43 |
| 1994 | 7575.62 | 6777 | 1335 | 93.82 | 94.52 | 64.78 | 77.36 | 5.46 | 5.45 | 0.02 | 0.70 |
| 1995 | 8535.72 | 7197 | 1335 | 78.17 | 81.11 | 72.99 | 82.16 | 2.27 | 1.88 | 17.00 | 2.95 |
| 1996 | 8126.62 | 6950 | 1335 | 83.10 | 83.67 | 69.30 | 79.12 | 3.91 | 3.40 | 12.92 | 0.57 |
| 1997 | 7112.76 | 5833 | 1335 | 63.62 | 65.48 | 60.82 | 66.59 | 12.82 | 9.63 | 24.89 | 1.86 |
| 1998 | 8255.92 | 6802 | 1335 | 89.95 | 90.64 | 70.60 | 77.65 | 8.95 | 8.91 | 0.45 | 0.69 |
| 1999 | 9240.59 | 7656 | 1335 | 85.68 | 86.27 | 79.02 | 87.40 | 2.52 | 2.23 | 11.50 | 0.59 |
| 2000 | 8027.83 | 6494 | 1335 | 71.39 | 72.16 | 68.46 | 73.93 | 12.97 | 10.76 | 17.08 | 0.77 |
| 2001 | 9298.49 | 7843 | 1335 | 89.61 | 89.84 | 79.51 | 89.53 | 9.55 | 9.49 | 0.68 | 0.23 |
| 2002 | 8768.82 | 7275 | 1335 | 79.60 | 81.04 | 74.98 | 83.05 | 6.57 | 5.70 | 13.26 | 1.44 |
| 2003 | 8691.94 | 7029 | 1335 | 78.00 | 80.58 | 74.32 | 80.24 | 2.24 | 1.85 | 17.58 | 2.57 |
| 2004 | 10127.42 | 8283 | 1335 | 95.28 | 96.62 | 86.36 | 94.30 | 3.37 | 3.37 | 0.02 | 1.33 |
| 2005 | 9697.02 | 7949 | 1335 | 85.96 | 88.64 | 82.91 | 90.73 | 1.71 | 1.54 | 9.81 | 2.69 |
| 2006 | 8882.10 | 7342 | 1335 | 78.35 | 82.46 | 75.95 | 83.81 | 3.41 | 2.91 | 14.63 | 4.11 |
| 2007 | 6342.04 | 4987 | 1335 | 54.55 | 55.89 | 54.23 | 56.93 | 5.08 | 3.40 | 40.71 | 1.34 |
| 2008 | 5610.15 | 4577 | 1335 | 49.16 | 49.33 | 47.84 | 52.11 | 46.41 | 49.43 | 1.25 | 0.17 |
| 2009 | 8681.78 | 6881 | 1335 | 74.60 | 76.69 | 74.24 | 78.55 | 7.66 | 13.97 | 9.34 | 2.09 |
| 2010 | 10759.91 | 8465 | 1335 | 92.33 | 93.10 | 92.01 | 96.63 | 6.86 | 6.86 | 0.03 | 0.77 |
| 2011 | 5946.79 | 5202 | 1335 | 54.57 | 57.07 | 50.85 | 59.38 | 7.51 | 21.77 | 21.15 | 2.50 |
| 2012 | 9171.05 | 7422 | 1335 | 82.81 | 83.11 | 78.21 | 84.49 | 2.45 | 8.60 | 8.29 | 0.30 |
| 2013 | 10069.65 | 8498 | 1335 | 97.38 | 98.71 | 86.11 | 97.01 | 1.26 | 1.26 | 0.03 | 1.34 |
| 2014 | 6739.26 | 5918 | 1335 | 72.44 | 73.89 | 57.63 | 67.56 | 2.82 | 2.42 | 23.69 | 1.45 |
| 2015 | 9047.80 | 7538 | 1335 | 81.10 | 86.97 | 77.37 | 86.05 | 3.07 | 2.76 | 10.27 | 5.88 |
| 2016 | 9010.70 | 8069 | 1335 | 86.46 | 98.38 | 76.84 | 91.86 | 1.55 | 1.55 | 0.07 | 11.93 |
| 2017 | 5900.57 | 5100 | 1335 | 51.39 | 55.80 | 50.46 | 58.22 | 1.92 | 1.09 | 43.11 | 4.41 |
| 2018 | 8028.05 | 6361 | 1335 | 69.66 | 74.70 | 68.65 | 72.61 | 6.39 | 7.74 | 17.56 | 5.04 |
| 2019 | 10312.99 | 8456 | 1335 | 89.47 | 92.44 | 88.19 | 96.53 | 7.47 | 7.46 | 0.10 | 2.97 |
| 2020 | 7603.38 | 6035 | 1335 | 65.52 | 70.88 | 64.84 | 68.70 | 0.63 | 4.51 | 24.61 | 5.36 |
| 2021 | 9770.53 | 7586 | 1335 | 84.88 | 85.43 | 83.55 | 86.60 | 4.84 | 4.34 | 10.23 | 0.55 |
| 2022 | 10111.34 | 8662 | 1335 | 93.12 | 99.53 | 86.46 | 98.88 | 0.38 | 0.37 | 0.09 | 6.41 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1403 | | | 648 | |
| B. Refuelling without maintenance | | | | 137 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2519 | | | 975 | 6 | |
| D. Inspection, maintenance or repair without refuelling | | | | 43 | 0 | |
| E. Testing of plant systems or components | | | | 23 | | |
| H. Nuclear regulatory requirements | | | | | 37 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 17 |
| L. Human factor related | | | | | 5 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 20 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 898 | | 8 | 31 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 0 | 38 |
| Z. Other | | | | | 13 | 0 |
| Subtotal | 2519 | 1403 | 898 | 1178 | 717 | 107 |
| Total | | 4820 | | | 2002 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 38 |
| 12. Reactor I&C Systems | | 25 |
| 13. Reactor Auxiliary Systems | | 17 |
| 14. Safety Systems | | 11 |
| 15. Reactor Cooling Systems | | 74 |
| 16. Steam generation systems | | 4 |
| 21. Fuel Handling and Storage Facilities | | 9 |
| 31. Turbine and auxiliaries | | 106 |
| 32. Feedwater and Main Steam System | 1403 | 89 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 65 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 150 |
| 42. Electrical Power Supply Systems | | 46 |
| Total | 1403 | 641 |

2023 Operating Experience

FR-49

ST. ALBAN-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

Reactor Unit Details

Reactor type and model : PWR / P4 REP 1300
 Thermal power : 3817 MWth
 Gross electrical power : 1381 MWe
 Reference unit power (net) : 1335 MWe

Key Dates

Construction Date : 1979-07-31
 Grid Date : 1986-07-03
 Commercial Date : 1987-03-01
 Age at end of year : 37 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 16
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.267
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.2
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 328.3
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 4.1

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.95
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

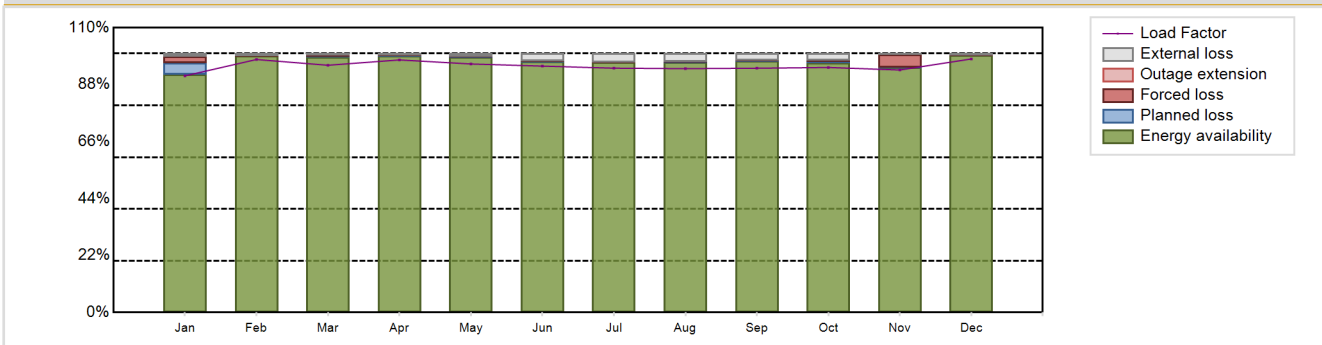
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 11131.59 GW(e).h
 Energy Availability Factor (EAF) : 97.05 %
 Unit Capability Factor (UCF) : 98.74 %
 Load Factor (LF) : 95.19 %
 Operating Factor (OF) : 99.99 %
 Forced Loss Rate (FLR) : 0.76 %
 Unplanned Capability Loss Factor (UCL) : 0.76 %
 Planned Unavailability Factor (PUF) : 0.5 %
 Externally cause unavailability (XUF) : 1.69 %
 Total off-line time : 1 hours

Annual Summary

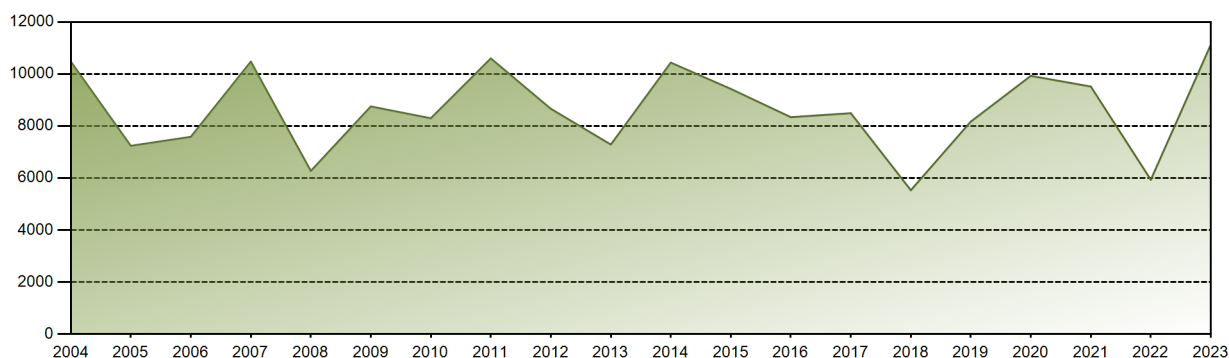


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 907.85 | 876.66 | 947.19 | 937.75 | 953.47 | 914.77 | 937.32 | 935.35 | 906.85 | 941.34 | 900.33 | 972.71 | 11131.59 |
| EAF [%] | 91.96 | 99.04 | 98.67 | 99.02 | 98.65 | 96.83 | 96.58 | 96.63 | 97.07 | 96.44 | 94.67 | 99.24 | 97.05 |
| UCF [%] | 93.08 | 99.94 | 99.30 | 99.60 | 99.88 | 99.80 | 99.83 | 99.83 | 99.78 | 99.03 | 95.14 | 99.80 | 98.74 |
| LF [%] | 91.40 | 97.72 | 95.49 | 97.56 | 96.00 | 95.17 | 94.37 | 94.17 | 94.35 | 94.65 | 93.67 | 97.93 | 95.19 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.87 | 100.00 | 100.00 | 99.99 |
| FLR [%] | 2.68 | 0.01 | 0.52 | 0.26 | 0.06 | 0.06 | 0.11 | 0.04 | 0.15 | 0.47 | 4.83 | 0.06 | 0.76 |
| UCL [%] | 2.56 | 0.01 | 0.52 | 0.26 | 0.06 | 0.06 | 0.11 | 0.04 | 0.15 | 0.47 | 4.82 | 0.06 | 0.76 |
| PUF [%] | 4.36 | 0.06 | 0.18 | 0.15 | 0.05 | 0.14 | 0.06 | 0.12 | 0.07 | 0.50 | 0.03 | 0.14 | 0.50 |
| XUF [%] | 1.12 | 0.90 | 0.64 | 0.58 | 1.24 | 2.97 | 3.25 | 3.20 | 2.71 | 2.60 | 0.47 | 0.56 | 1.69 |

Historical Summary

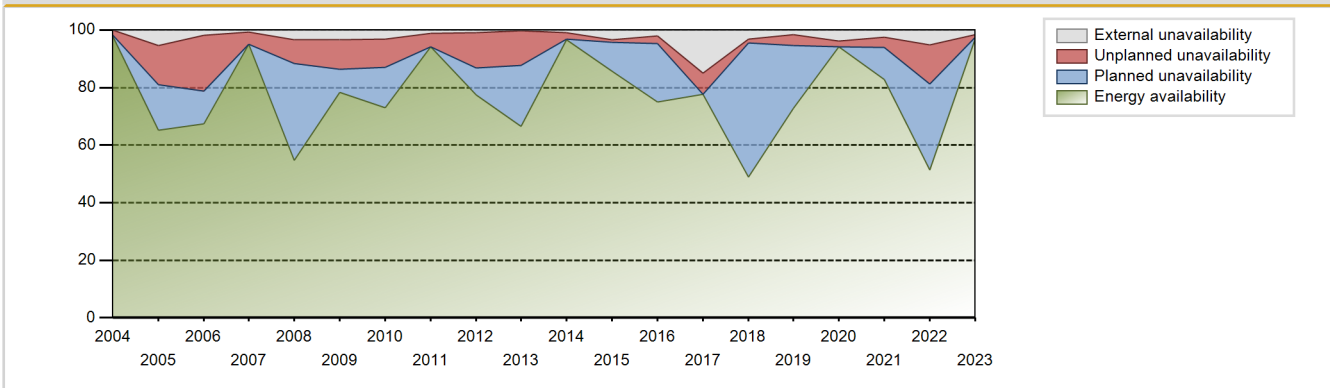
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 300108.92 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.61 % |
| Cumulative Energy Availability Factor (EAF) | : 75.51 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.25 % |
| Cumulative Unit Capability Factor (UCF) | : 78.33 % | Cumulative Planned Unavailability Factor (PUF) | : 13.42 % |
| Cumulative Load Factor (LF) | : 69.1 % | Cumulative Externally cause unavailability (XUF) | : 2.82 % |
| Cumulative Operating Factor (OF) | : 77.17 % | | |

Electricity Production (net) [GWh]

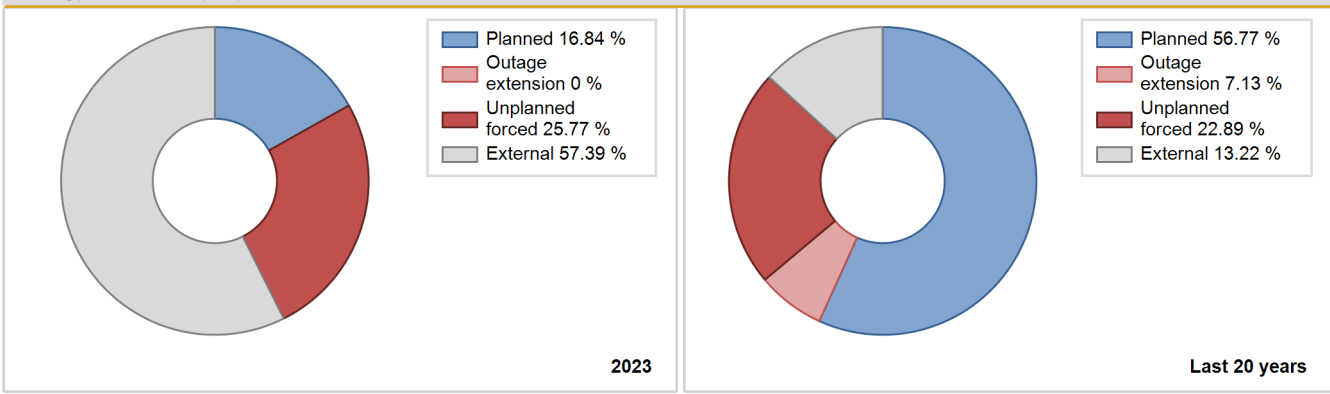


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 6952.20 | 6094 | 1300 | 79.01 | 79.06 | 59.07 | 68.27 | 20.94 | 20.94 | 0.00 | 0.05 |
| 1988 | 5185.00 | 4308 | 1335 | 46.48 | 47.29 | 44.22 | 49.04 | 31.63 | 21.88 | 30.83 | 0.81 |
| 1989 | 6126.50 | 4806 | 1335 | 56.23 | 57.46 | 52.39 | 54.86 | 33.18 | 28.53 | 14.01 | 1.23 |
| 1990 | 6070.64 | 5146 | 1335 | 56.52 | 60.26 | 51.91 | 58.74 | 23.59 | 18.60 | 21.14 | 3.74 |
| 1991 | 7962.55 | 6484 | 1335 | 71.13 | 73.29 | 68.09 | 74.02 | 8.73 | 7.01 | 19.70 | 2.16 |
| 1992 | 6375.15 | 5405 | 1335 | 62.34 | 64.33 | 54.36 | 61.53 | 20.15 | 16.23 | 19.44 | 1.99 |
| 1993 | 6433.10 | 6121 | 1335 | 83.07 | 90.86 | 55.01 | 69.87 | 8.11 | 8.02 | 1.12 | 7.78 |
| 1994 | 7125.76 | 6074 | 1335 | 73.00 | 74.87 | 60.93 | 69.34 | 6.29 | 5.02 | 20.11 | 1.86 |
| 1995 | 7751.41 | 6763 | 1335 | 72.69 | 76.09 | 66.28 | 77.20 | 10.39 | 8.82 | 15.09 | 3.40 |
| 1996 | 8344.63 | 7247 | 1335 | 79.67 | 81.54 | 71.16 | 82.50 | 3.68 | 3.11 | 15.34 | 1.88 |
| 1997 | 8049.72 | 7072 | 1335 | 91.80 | 92.33 | 68.83 | 80.73 | 7.25 | 7.21 | 0.46 | 0.53 |
| 1998 | 6555.74 | 5654 | 1335 | 63.23 | 66.72 | 56.06 | 64.54 | 11.90 | 9.02 | 24.26 | 3.49 |
| 1999 | 8606.97 | 7188 | 1335 | 79.30 | 80.33 | 73.60 | 82.05 | 8.76 | 7.71 | 11.96 | 1.03 |
| 2000 | 8729.60 | 7202 | 1335 | 79.03 | 86.47 | 74.44 | 81.99 | 3.56 | 3.19 | 10.34 | 7.45 |
| 2001 | 8654.77 | 7657 | 1335 | 91.30 | 91.41 | 74.01 | 87.41 | 2.03 | 1.89 | 6.69 | 0.11 |
| 2002 | 8290.64 | 6950 | 1335 | 75.20 | 77.33 | 70.89 | 79.34 | 6.52 | 5.39 | 17.28 | 2.13 |
| 2003 | 9254.77 | 7558 | 1335 | 83.01 | 87.77 | 79.14 | 86.28 | 0.52 | 0.45 | 11.77 | 4.76 |
| 2004 | 10476.49 | 8709 | 1335 | 97.73 | 97.77 | 89.34 | 99.15 | 1.74 | 1.73 | 0.49 | 0.04 |
| 2005 | 7237.98 | 6361 | 1335 | 65.22 | 70.61 | 61.88 | 72.61 | 16.03 | 13.68 | 15.71 | 5.38 |
| 2006 | 7584.24 | 6292 | 1335 | 67.40 | 69.14 | 64.85 | 71.83 | 21.25 | 19.57 | 11.28 | 1.74 |
| 2007 | 10476.05 | 8660 | 1335 | 95.02 | 95.65 | 89.58 | 98.86 | 4.33 | 4.33 | 0.02 | 0.62 |
| 2008 | 6270.91 | 5320 | 1335 | 54.70 | 58.09 | 53.48 | 60.56 | 5.25 | 8.33 | 33.58 | 3.39 |
| 2009 | 8753.18 | 7052 | 1335 | 78.37 | 81.82 | 74.85 | 80.50 | 9.69 | 10.26 | 7.92 | 3.45 |
| 2010 | 8297.53 | 6659 | 1335 | 73.03 | 76.19 | 70.95 | 76.02 | 2.30 | 9.78 | 14.03 | 3.16 |
| 2011 | 10599.69 | 8474 | 1335 | 94.13 | 95.33 | 90.64 | 96.74 | 4.55 | 4.55 | 0.12 | 1.20 |
| 2012 | 8662.28 | 7044 | 1335 | 77.41 | 78.39 | 73.87 | 80.19 | 1.24 | 12.13 | 9.47 | 0.98 |
| 2013 | 7287.87 | 6032 | 1335 | 66.54 | 66.80 | 62.32 | 68.86 | 9.50 | 11.95 | 21.25 | 0.26 |
| 2014 | 10438.17 | 8684 | 1335 | 96.57 | 97.45 | 89.26 | 99.13 | 2.36 | 2.35 | 0.19 | 0.89 |
| 2015 | 9426.74 | 7930 | 1335 | 85.74 | 89.08 | 80.61 | 90.53 | 1.02 | 0.92 | 10.00 | 3.34 |
| 2016 | 8339.93 | 7056 | 1335 | 75.04 | 77.18 | 71.12 | 80.33 | 3.19 | 2.56 | 20.26 | 2.14 |
| 2017 | 8493.06 | 7023 | 1335 | 77.61 | 92.52 | 72.62 | 80.17 | 7.37 | 7.36 | 0.13 | 14.91 |
| 2018 | 5530.66 | 4805 | 1335 | 48.84 | 51.97 | 47.29 | 54.85 | 2.44 | 1.42 | 46.61 | 3.13 |
| 2019 | 8171.02 | 6622 | 1335 | 72.77 | 74.32 | 69.87 | 75.59 | 4.87 | 3.81 | 21.87 | 1.55 |
| 2020 | 9928.37 | 8649 | 1335 | 94.16 | 97.94 | 84.67 | 98.46 | 2.00 | 2.00 | 0.06 | 3.78 |
| 2021 | 9517.07 | 7697 | 1335 | 82.78 | 85.22 | 81.38 | 87.87 | 3.99 | 3.55 | 11.24 | 2.44 |
| 2022 | 5931.74 | 4727 | 1335 | 51.44 | 56.62 | 50.72 | 53.96 | 19.30 | 13.54 | 29.84 | 5.19 |
| 2023 | 11131.59 | 8759 | 1335 | 97.05 | 98.74 | 95.19 | 99.99 | 0.76 | 0.76 | 0.50 | 1.69 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 618 | |
| B. Refuelling without maintenance | | | | 87 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 962 | 18 | |
| D. Inspection, maintenance or repair without refuelling | | | | 53 | | |
| E. Testing of plant systems or components | | | | 39 | 1 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 4 |
| L. Human factor related | | | | | 18 | 0 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 22 |
| O. Load dispatching, prioritization | | | | | | 1 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 1 | 25 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 31 |
| Z. Other | | | | | 9 | 0 |
| Subtotal | | | | 1141 | 665 | 83 |
| Total | | 0 | | | 1889 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 37 |
| 12. Reactor I&C Systems | | 58 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 14 |
| 15. Reactor Cooling Systems | | 34 |
| 16. Steam generation systems | | 75 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 21. Fuel Handling and Storage Facilities | | 18 |
| 31. Turbine and auxiliaries | | 94 |
| 32. Feedwater and Main Steam System | | 79 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 50 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 105 |
| 42. Electrical Power Supply Systems | | 28 |
| Total | | 610 |

2023 Operating Experience

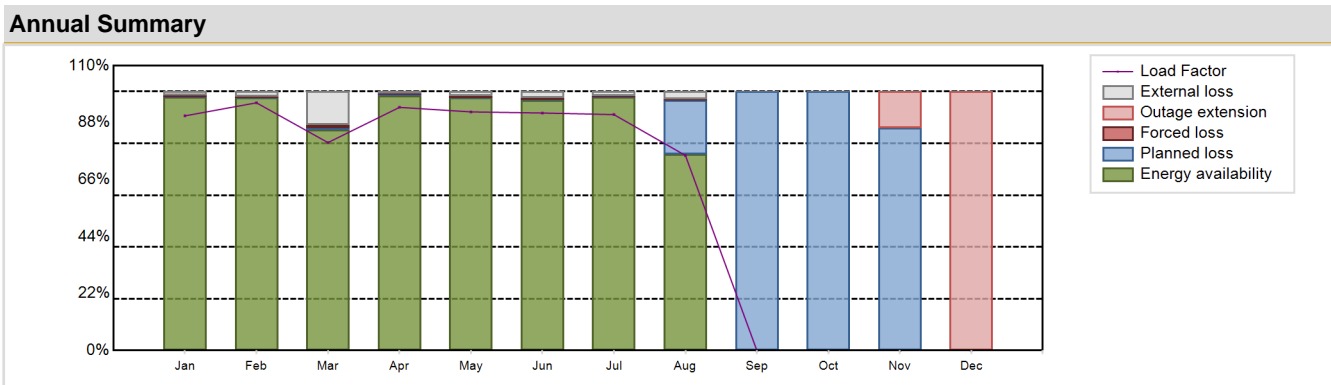
FR-17 **ST. LAURENT B-1** **FRANCE**

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP2 | Construction Date | : 1976-05-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1981-01-21 |
| Gross electrical power | : 956 MWe | Commercial Date | : 1983-08-01 |
| Reference unit power (net) | : 915 MWe | Age at end of year | : 42 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 321 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33735 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Cooling towers |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 41 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4734.88 GW(e).h | Forced Loss Rate (FLR) | : 0.73 % |
| Energy Availability Factor (EAF) | : 62.1 % | Unplanned Capability Loss Factor (UCL) | : 10.12 % |
| Unit Capability Factor (UCF) | : 64.18 % | Planned Unavailability Factor (PUF) | : 25.7 % |
| Load Factor (LF) | : 59.07 % | Externally cause unavailability (XUF) | : 2.09 % |
| Operating Factor (OF) | : 64.71 % | Total off-line time | : 3091 hours |

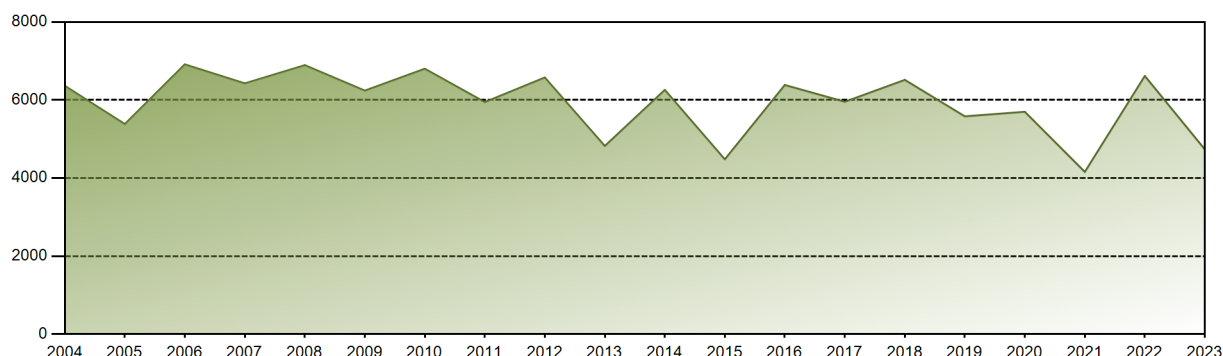


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|---------|
| GW(e)-h | 616.97 | 588.26 | 546.01 | 618.69 | 627.43 | 604.29 | 620.30 | 512.94 | 0.00 | 0.00 | 0.00 | 0.00 | 4734.88 |
| EAF [%] | 97.78 | 97.56 | 85.28 | 98.47 | 97.66 | 96.62 | 97.76 | 75.86 | 0.00 | 0.00 | 0.00 | 0.00 | 62.10 |
| UCF [%] | 99.15 | 99.36 | 97.99 | 99.05 | 99.22 | 99.06 | 99.38 | 78.63 | 0.00 | 0.00 | 0.00 | 0.00 | 64.18 |
| LF [%] | 90.63 | 95.67 | 80.31 | 93.91 | 92.17 | 91.73 | 91.12 | 75.35 | 0.00 | 0.00 | 0.00 | 0.00 | 59.07 |
| OF [%] | 97.58 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 80.65 | 0.00 | 0.00 | 0.00 | 0.00 | 64.71 |
| FLR [%] | 0.74 | 0.55 | 1.42 | 0.54 | 0.72 | 0.56 | 0.44 | 0.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.73 |
| UCL [%] | 0.74 | 0.55 | 1.41 | 0.54 | 0.72 | 0.56 | 0.44 | 0.70 | 0.00 | 0.00 | 14.03 | 100.00 | 10.12 |
| PUF [%] | 0.11 | 0.09 | 0.60 | 0.40 | 0.06 | 0.38 | 0.18 | 20.68 | 100.00 | 100.00 | 85.97 | 0.00 | 25.70 |
| XUF [%] | 1.37 | 1.80 | 12.71 | 0.59 | 1.56 | 2.45 | 1.62 | 2.77 | 0.00 | 0.00 | 0.00 | 0.00 | 2.09 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 235791.82 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.35 % |
| Cumulative Energy Availability Factor (EAF) | : 75.19 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.42 % |
| Cumulative Unit Capability Factor (UCF) | : 77.35 % | Cumulative Planned Unavailability Factor (PUF) | : 14.23 % |
| Cumulative Load Factor (LF) | : 72.36 % | Cumulative Externally cause unavailability (XUF) | : 2.15 % |
| Cumulative Operating Factor (OF) | : 77.69 % | | |

Electricity Production (net) [GWh]

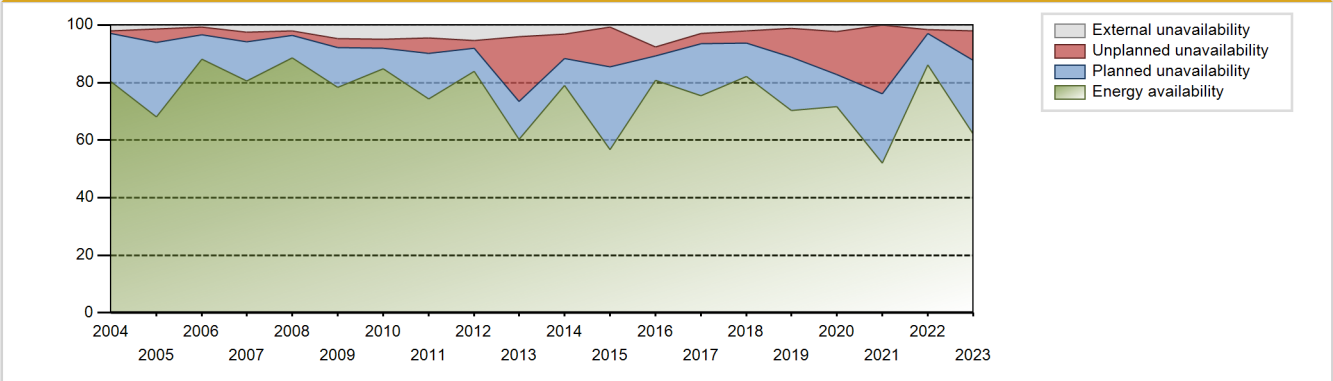


Performance for Years of Commercial Operation

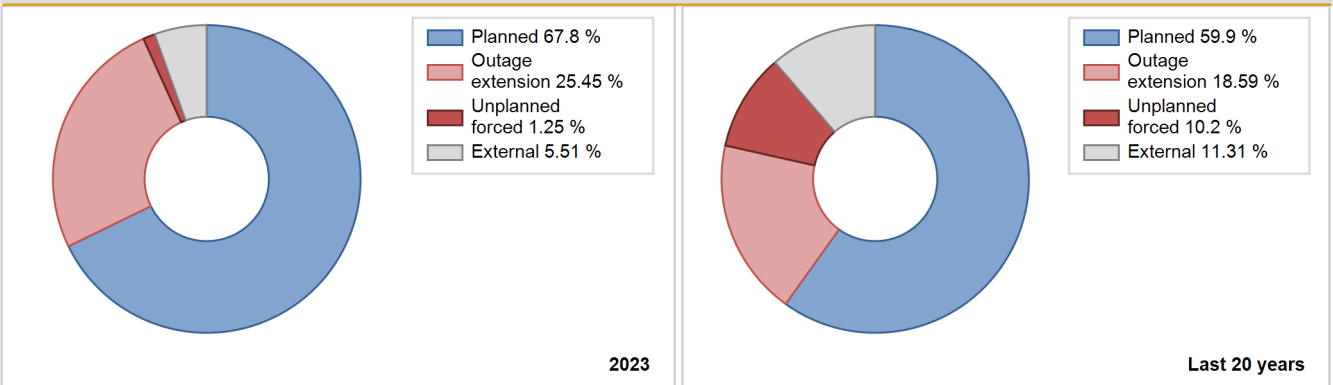
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 3670.00 | 4382 | 880 | 91.99 | 91.99 | 91.89 | 93.85 | 8.01 | 8.01 | 0.00 | 0.00 |
| 1984 | 4401.00 | 5042 | 880 | 55.95 | 55.95 | 56.93 | 57.40 | 22.37 | 16.12 | 27.92 | 0.00 |
| 1985 | 5630.40 | 6827 | 880 | 75.00 | 76.09 | 73.04 | 77.93 | 10.66 | 9.08 | 14.83 | 1.09 |
| 1986 | 5476.40 | 7144 | 880 | 79.72 | 79.78 | 71.04 | 81.55 | 10.61 | 9.47 | 10.75 | 0.06 |
| 1987 | 5171.30 | 6667 | 880 | 76.14 | 76.83 | 67.08 | 76.11 | 9.98 | 8.51 | 14.66 | 0.69 |
| 1988 | 5721.00 | 6464 | 915 | 75.95 | 76.30 | 71.18 | 73.59 | 15.48 | 13.97 | 9.73 | 0.35 |
| 1989 | 6609.76 | 7699 | 915 | 82.69 | 85.43 | 82.46 | 87.89 | 9.30 | 8.76 | 5.81 | 2.73 |
| 1990 | 6113.67 | 7089 | 915 | 84.12 | 86.26 | 76.27 | 80.92 | 7.98 | 7.48 | 6.26 | 2.15 |
| 1991 | 4005.40 | 4736 | 915 | 52.29 | 53.65 | 49.97 | 54.06 | 32.18 | 25.46 | 20.89 | 1.36 |
| 1992 | 5621.12 | 6690 | 915 | 74.05 | 75.42 | 69.94 | 76.16 | 9.59 | 8.00 | 16.58 | 1.37 |
| 1993 | 5668.51 | 6821 | 915 | 72.38 | 75.27 | 70.72 | 77.87 | 11.93 | 10.20 | 14.54 | 2.89 |
| 1994 | 6095.73 | 7252 | 915 | 85.11 | 87.05 | 76.05 | 82.79 | 1.53 | 1.35 | 11.60 | 1.93 |
| 1995 | 4442.99 | 5211 | 915 | 60.27 | 64.30 | 55.43 | 59.49 | 0.89 | 0.58 | 35.13 | 4.03 |
| 1996 | 5541.09 | 6888 | 915 | 78.78 | 79.06 | 68.94 | 78.42 | 17.99 | 17.34 | 3.60 | 0.27 |
| 1997 | 5132.60 | 6404 | 915 | 75.43 | 76.15 | 64.03 | 73.11 | 14.88 | 13.31 | 10.54 | 0.72 |
| 1998 | 6030.71 | 7366 | 915 | 82.11 | 84.57 | 75.24 | 84.09 | 0.83 | 0.71 | 14.72 | 2.45 |
| 1999 | 5062.64 | 6207 | 915 | 67.92 | 69.71 | 63.16 | 70.86 | 21.66 | 19.28 | 11.02 | 1.78 |
| 2000 | 5086.74 | 5957 | 915 | 65.97 | 66.43 | 63.29 | 67.82 | 22.62 | 19.42 | 14.15 | 0.46 |
| 2001 | 6814.76 | 7735 | 915 | 86.40 | 86.84 | 85.02 | 88.30 | 2.69 | 2.40 | 10.76 | 0.44 |
| 2002 | 6637.03 | 7592 | 915 | 83.36 | 85.56 | 82.80 | 86.67 | 1.31 | 1.13 | 13.31 | 2.20 |
| 2003 | 6630.44 | 7658 | 915 | 82.81 | 86.53 | 82.72 | 87.42 | 2.33 | 2.06 | 11.40 | 3.73 |
| 2004 | 6364.19 | 7356 | 915 | 80.41 | 82.41 | 79.18 | 83.74 | 1.06 | 0.88 | 16.71 | 2.00 |
| 2005 | 5384.07 | 6186 | 915 | 68.11 | 69.53 | 67.16 | 70.61 | 0.86 | 4.54 | 25.93 | 1.43 |
| 2006 | 6914.14 | 7973 | 915 | 88.21 | 88.91 | 86.26 | 91.02 | 2.53 | 2.75 | 8.34 | 0.70 |
| 2007 | 6426.68 | 7380 | 915 | 80.55 | 83.06 | 80.18 | 84.25 | 2.74 | 3.35 | 13.58 | 2.52 |
| 2008 | 6894.13 | 8034 | 915 | 88.62 | 90.77 | 85.78 | 91.46 | 0.51 | 1.36 | 7.87 | 2.15 |
| 2009 | 6241.46 | 7298 | 915 | 78.42 | 83.22 | 77.87 | 83.31 | 2.19 | 3.01 | 13.77 | 4.79 |
| 2010 | 6802.10 | 7967 | 915 | 84.89 | 89.81 | 84.86 | 90.95 | 1.61 | 3.07 | 7.13 | 4.91 |
| 2011 | 5947.96 | 7000 | 915 | 74.24 | 78.71 | 74.21 | 79.91 | 3.25 | 5.47 | 15.82 | 4.47 |
| 2012 | 6577.57 | 7708 | 915 | 83.89 | 89.34 | 81.84 | 87.75 | 0.48 | 2.61 | 8.06 | 5.45 |
| 2013 | 4822.46 | 5662 | 915 | 60.34 | 64.38 | 60.16 | 64.63 | 0.07 | 22.44 | 13.18 | 4.05 |
| 2014 | 6259.24 | 7417 | 915 | 79.08 | 82.18 | 78.09 | 84.67 | 8.07 | 8.52 | 9.30 | 3.10 |
| 2015 | 4480.02 | 5185 | 915 | 56.68 | 57.45 | 55.89 | 59.19 | 4.48 | 13.81 | 28.74 | 0.77 |
| 2016 | 6385.17 | 7366 | 915 | 80.74 | 88.45 | 79.44 | 83.86 | 1.44 | 3.03 | 8.52 | 7.71 |
| 2017 | 5955.70 | 6794 | 915 | 75.48 | 78.39 | 74.30 | 77.56 | 1.75 | 3.53 | 18.07 | 2.92 |
| 2018 | 6516.26 | 7535 | 915 | 82.17 | 84.33 | 81.30 | 86.02 | 4.55 | 4.02 | 11.66 | 2.16 |
| 2019 | 5581.31 | 6561 | 915 | 70.25 | 71.36 | 69.63 | 74.90 | 8.72 | 10.03 | 18.61 | 1.11 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|-------|-------|------|
| 2020 | 5698.35 | 6792 | 915 | 71.59 | 73.83 | 70.90 | 77.32 | 9.56 | 15.06 | 11.12 | 2.24 |
| 2021 | 4157.53 | 4788 | 915 | 52.02 | 52.02 | 51.87 | 54.66 | 7.87 | 23.85 | 24.13 | 0.00 |
| 2022 | 6616.63 | 7711 | 915 | 86.12 | 87.65 | 82.55 | 88.03 | 1.56 | 1.39 | 10.96 | 1.53 |
| 2023 | 4734.88 | 5669 | 915 | 62.10 | 64.18 | 59.07 | 64.71 | 0.73 | 10.12 | 25.70 | 2.09 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|--|-------------|-------------|-----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 845 | | | 564 | |
| B. Refuelling without maintenance | | | | 148 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2227 | | | 1139 | 14 | |
| E. Testing of plant systems or components | | | | 7 | 2 | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 6 |
| L. Human factor related | | | | | 16 | |
| O. Load dispatching, prioritization | | | 18 | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant , spare part delivery problems etc.) | | | | | 22 | 37 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 221 | 1 |
| Z. Other | | | | | 6 | 1 |
| Subtotal | 2227 | 845 | 18 | 1294 | 846 | 47 |
| Total | | 3090 | | | 2187 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 10 |
| 12. Reactor I&C Systems | | 27 |
| 13. Reactor Auxiliary Systems | | 15 |
| 14. Safety Systems | | 28 |
| 15. Reactor Cooling Systems | | 9 |
| 16. Steam generation systems | | 72 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | | 52 |
| 32. Feedwater and Main Steam System | | 14 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | 845 | 207 |
| 35. All other I&C Systems | | 3 |
| 41. Main Generator Systems | | 109 |
| 42. Electrical Power Supply Systems | | 8 |
| Total | 845 | 564 |

2023 Operating Experience

FR-23 **ST. LAURENT B-2** **FRANCE**

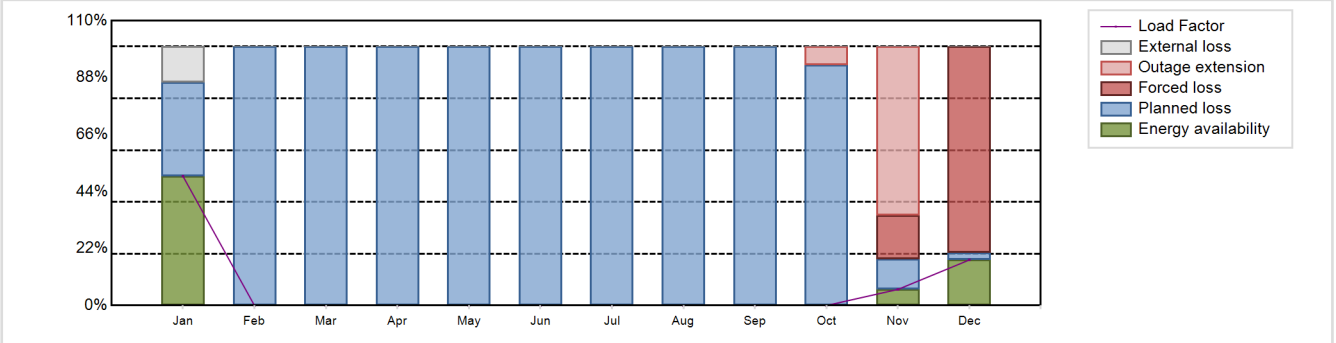
Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : PWR / CP2 | Construction Date | : 1976-07-01 |
| Thermal power | : 2785 MWth | Grid Date | : 1981-06-01 |
| Gross electrical power | : 956 MWe | Commercial Date | : 1983-08-01 |
| Reference unit power (net) | : 915 MWe | Age at end of year | : 42 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 321 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 33735 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.45 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Cooling towers |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 41 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|------------------|--|--------------|
| Net Energy Production | : 500.78 GW(e).h | Forced Loss Rate (FLR) | : 52.33 % |
| Energy Availability Factor (EAF) | : 6.25 % | Unplanned Capability Loss Factor (UCL) | : 14.1 % |
| Unit Capability Factor (UCF) | : 7.42 % | Planned Unavailability Factor (PUF) | : 78.47 % |
| Load Factor (LF) | : 6.25 % | Externally cause unavailability (XUF) | : 1.17 % |
| Operating Factor (OF) | : 11.63 % | Total off-line time | : 7741 hours |

Annual Summary

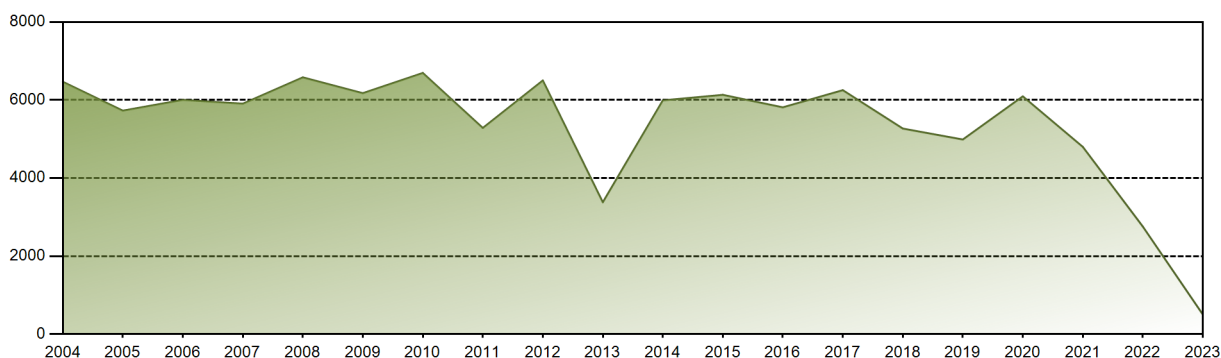


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|--------|--------|
| GW(e)-h | 339.95 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 40.97 | 119.86 | 500.78 |
| EAF [%] | 49.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.23 | 17.62 | 6.25 |
| UCF [%] | 63.77 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.23 | 17.62 | 7.42 |
| LF [%] | 49.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.22 | 17.61 | 6.25 |
| OF [%] | 64.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.75 | 54.57 | 11.63 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 73.16 | 81.87 | 52.33 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.11 | 82.02 | 79.54 | 14.10 |
| PUF [%] | 36.23 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.89 | 11.75 | 2.84 | 78.47 |
| XUF [%] | 13.83 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.17 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 225243.98 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.24 % |
| Cumulative Energy Availability Factor (EAF) | : 72.24 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.42 % |
| Cumulative Unit Capability Factor (UCF) | : 75.96 % | Cumulative Planned Unavailability Factor (PUF) | : 15.62 % |
| Cumulative Load Factor (LF) | : 68.11 % | Cumulative Externally cause unavailability (XUF) | : 3.72 % |
| Cumulative Operating Factor (OF) | : 75.13 % | | |

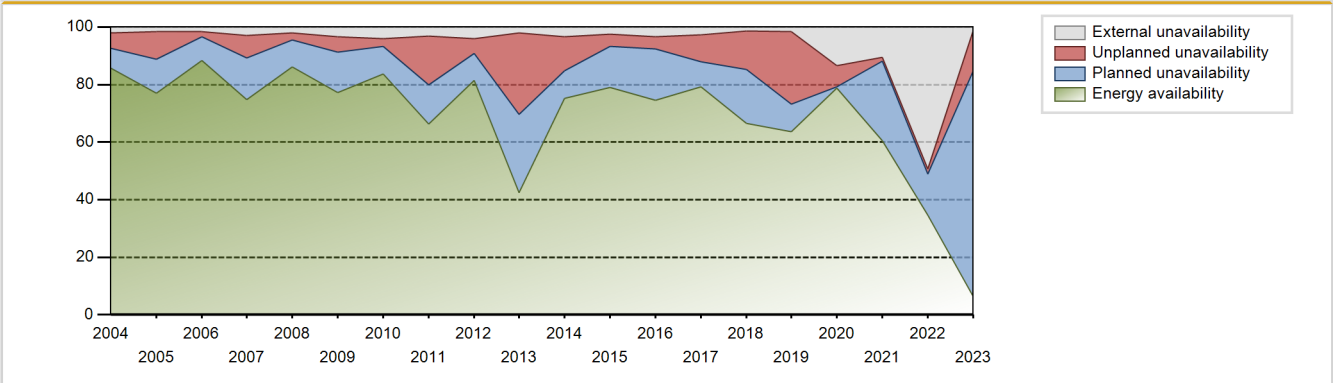
Electricity Production (net) [GWh]



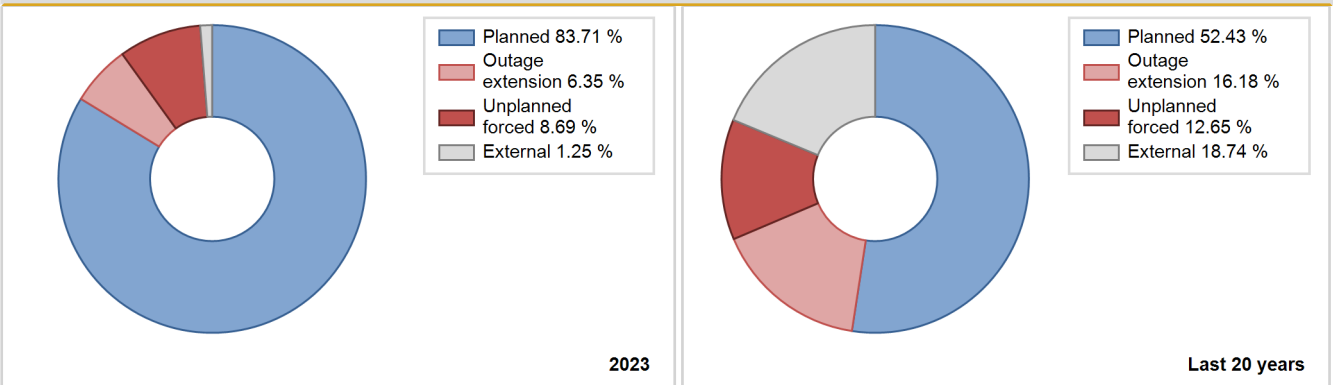
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 4123.00 | 4839 | 880 | 16.06 | 16.06 | 15.84 | 16.74 | 34.68 | 8.53 | 75.41 | 0.00 |
| 1984 | 5724.00 | 7237 | 880 | 88.88 | 88.88 | 74.05 | 82.39 | 11.08 | 11.07 | 0.05 | 0.00 |
| 1985 | 5295.60 | 6806 | 880 | 75.70 | 77.55 | 68.70 | 77.69 | 9.43 | 8.08 | 14.37 | 1.86 |
| 1986 | 5662.80 | 7337 | 880 | 79.78 | 81.74 | 73.46 | 83.76 | 9.65 | 8.73 | 9.53 | 1.96 |
| 1987 | 5060.20 | 6798 | 880 | 79.41 | 79.86 | 65.64 | 77.60 | 10.75 | 9.62 | 10.52 | 0.45 |
| 1988 | 5108.00 | 6262 | 880 | 69.57 | 69.61 | 66.08 | 71.29 | 12.35 | 9.81 | 20.58 | 0.04 |
| 1989 | 5034.03 | 6490 | 880 | 75.92 | 81.39 | 65.30 | 74.09 | 8.36 | 7.42 | 11.19 | 5.47 |
| 1990 | 5165.86 | 6212 | 915 | 71.29 | 73.78 | 64.45 | 70.91 | 15.77 | 13.81 | 12.41 | 2.49 |
| 1991 | 6043.04 | 7374 | 915 | 84.25 | 86.09 | 75.39 | 84.18 | 4.84 | 4.38 | 9.53 | 1.84 |
| 1992 | 5490.13 | 6982 | 915 | 79.41 | 80.61 | 68.31 | 79.49 | 10.42 | 9.38 | 10.01 | 1.20 |
| 1993 | 5042.24 | 6149 | 915 | 64.11 | 68.73 | 62.91 | 70.19 | 9.30 | 7.04 | 24.23 | 4.61 |
| 1994 | 6322.70 | 7406 | 915 | 81.17 | 83.73 | 78.88 | 84.54 | 5.20 | 4.60 | 11.67 | 2.56 |
| 1995 | 5311.31 | 6720 | 915 | 72.12 | 72.87 | 66.26 | 76.71 | 17.25 | 15.19 | 11.94 | 0.75 |
| 1996 | 6057.67 | 7303 | 915 | 80.85 | 82.22 | 75.37 | 83.14 | 5.77 | 5.04 | 12.74 | 1.37 |
| 1997 | 5960.69 | 7147 | 915 | 78.13 | 80.78 | 74.37 | 81.59 | 1.01 | 0.82 | 18.39 | 2.66 |
| 1998 | 6415.27 | 7585 | 915 | 83.15 | 85.68 | 80.04 | 86.59 | 4.51 | 4.05 | 10.27 | 2.52 |
| 1999 | 5845.85 | 7013 | 915 | 77.25 | 79.00 | 72.93 | 80.06 | 7.64 | 6.54 | 14.47 | 1.74 |
| 2000 | 5134.00 | 6069 | 915 | 66.99 | 67.63 | 63.88 | 69.09 | 21.60 | 18.64 | 13.74 | 0.64 |
| 2001 | 6046.65 | 7226 | 915 | 80.11 | 81.74 | 75.44 | 82.49 | 3.42 | 2.89 | 15.37 | 1.63 |
| 2002 | 6215.02 | 7434 | 915 | 82.66 | 82.67 | 77.54 | 84.86 | 5.88 | 5.17 | 12.16 | 0.01 |
| 2003 | 4702.44 | 5580 | 915 | 61.64 | 61.64 | 58.67 | 63.70 | 9.15 | 6.21 | 32.14 | 0.00 |
| 2004 | 6468.60 | 7838 | 915 | 85.64 | 87.62 | 80.48 | 89.23 | 5.79 | 5.38 | 7.00 | 1.99 |
| 2005 | 5728.05 | 7038 | 915 | 76.98 | 78.63 | 71.45 | 80.33 | 8.53 | 9.59 | 11.77 | 1.66 |
| 2006 | 6004.32 | 7580 | 915 | 88.27 | 89.77 | 74.91 | 86.53 | 1.61 | 1.96 | 8.27 | 1.51 |
| 2007 | 5906.81 | 6949 | 915 | 74.73 | 77.72 | 73.69 | 79.33 | 4.74 | 7.85 | 14.43 | 2.99 |
| 2008 | 6581.43 | 7784 | 915 | 86.07 | 88.03 | 81.89 | 88.62 | 0.97 | 2.59 | 9.37 | 1.97 |
| 2009 | 6175.76 | 7086 | 915 | 77.33 | 80.73 | 77.05 | 80.89 | 1.94 | 5.29 | 13.98 | 3.40 |
| 2010 | 6694.83 | 7737 | 915 | 83.59 | 87.63 | 83.52 | 88.32 | 1.99 | 2.77 | 9.60 | 4.03 |
| 2011 | 5285.01 | 6171 | 915 | 66.20 | 69.40 | 65.94 | 70.45 | 13.86 | 16.81 | 13.78 | 3.20 |
| 2012 | 6501.97 | 7591 | 915 | 81.35 | 85.32 | 80.90 | 86.42 | 0.76 | 5.18 | 9.50 | 3.98 |
| 2013 | 3380.08 | 3990 | 915 | 42.44 | 44.40 | 42.17 | 45.55 | 3.05 | 28.42 | 27.18 | 1.97 |
| 2014 | 5991.68 | 7035 | 915 | 75.25 | 78.52 | 74.75 | 80.31 | 5.04 | 11.92 | 9.56 | 3.26 |
| 2015 | 6132.94 | 7188 | 915 | 79.00 | 81.43 | 76.51 | 82.05 | 0.84 | 4.22 | 14.35 | 2.42 |
| 2016 | 5812.80 | 6867 | 915 | 74.58 | 77.94 | 72.32 | 78.18 | 1.21 | 4.26 | 17.79 | 3.37 |
| 2017 | 6252.54 | 7246 | 915 | 79.24 | 82.02 | 78.01 | 82.72 | 1.47 | 9.23 | 8.74 | 2.78 |
| 2018 | 5268.72 | 6257 | 915 | 66.58 | 67.98 | 65.73 | 71.43 | 6.91 | 13.35 | 18.67 | 1.40 |
| 2019 | 4987.68 | 6030 | 915 | 63.60 | 65.28 | 62.23 | 68.84 | 15.74 | 25.18 | 9.54 | 1.68 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2020 | 6094.77 | 7807 | 915 | 78.83 | 92.29 | 75.83 | 88.88 | 7.26 | 7.23 | 0.48 | 13.46 |
| 2021 | 4799.08 | 5972 | 915 | 60.50 | 70.99 | 59.87 | 68.17 | 1.90 | 1.37 | 27.64 | 10.49 |
| 2022 | 2756.21 | 3256 | 915 | 34.55 | 83.82 | 34.39 | 37.17 | 2.03 | 1.74 | 14.44 | 49.27 |
| 2023 | 500.78 | 1019 | 915 | 6.25 | 7.42 | 6.25 | 11.63 | 52.33 | 14.10 | 78.47 | 1.17 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 975 | | | 673 | |
| B. Refuelling without maintenance | | | | 88 | | |
| C. Inspection, maintenance or repair combined with refuelling | 6765 | | | 1203 | 11 | |
| D. Inspection, maintenance or repair without refuelling | | | | 5 | | |
| E. Testing of plant systems or components | | | | 11 | 1 | |
| H. Nuclear regulatory requirements | | | | | 10 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 13 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 14 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 79 | 139 |
| Z. Other | | | | | 29 | |
| Subtotal | 6765 | 975 | | 1307 | 816 | 157 |
| Total | | 7740 | | | 2280 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 12 |
| 12. Reactor I&C Systems | | 15 |
| 13. Reactor Auxiliary Systems | | 15 |
| 14. Safety Systems | | 43 |
| 15. Reactor Cooling Systems | | 33 |
| 16. Steam generation systems | 213 | 37 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 18 |
| 31. Turbine and auxiliaries | | 200 |
| 32. Feedwater and Main Steam System | 126 | 26 |
| 33. Circulating Water System | | 5 |
| 34. Miscellaneous Systems | 520 | 187 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | 116 | 53 |
| 42. Electrical Power Supply Systems | | 15 |
| Total | 975 | 662 |

2023 Operating Experience

FR-18

TRICASTIN-1

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)



Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2785 MWth
 Gross electrical power : 955 MWe
 Reference unit power (net) : 915 MWe

Key Dates

Construction Date : 1974-11-01
 Grid Date : 1980-05-31
 Commercial Date : 1980-12-01
 Age at end of year : 43 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2/MOX
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 42000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 45
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

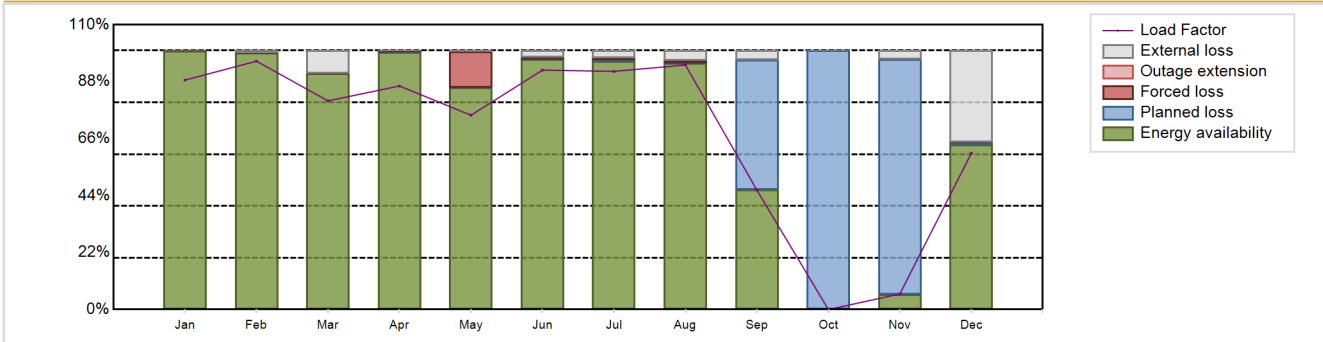
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5453.03 GW(e).h
 Energy Availability Factor (EAF) : 73.09 %
 Unit Capability Factor (UCF) : 78.29 %
 Load Factor (LF) : 68.03 %
 Operating Factor (OF) : 75.72 %
 Forced Loss Rate (FLR) : 1.85 %
 Unplanned Capability Loss Factor (UCL) : 1.47 %
 Planned Unavailability Factor (PUF) : 20.23 %
 Externally cause unavailability (XUF) : 5.2 %
 Total off-line time : 2127 hours

Annual Summary

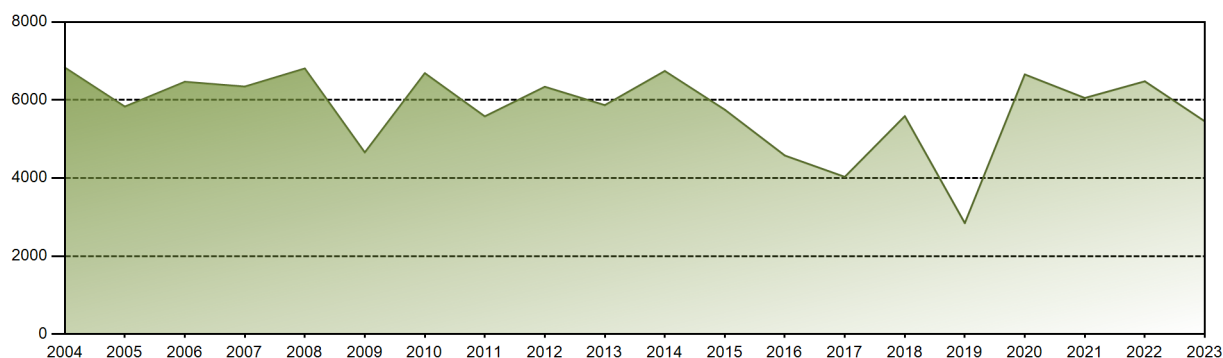


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|---------|
| GW(e)-h | 603.28 | 589.74 | 547.80 | 568.76 | 510.89 | 609.19 | 626.10 | 642.76 | 303.88 | 0.00 | 39.57 | 411.08 | 5453.03 |
| EAF [%] | 99.95 | 99.00 | 91.13 | 99.33 | 85.72 | 96.57 | 95.78 | 95.13 | 46.15 | 0.00 | 5.87 | 63.64 | 73.09 |
| UCF [%] | 99.95 | 99.76 | 99.91 | 99.40 | 86.01 | 99.29 | 98.53 | 98.95 | 49.83 | 0.00 | 9.20 | 99.11 | 78.29 |
| LF [%] | 88.62 | 95.91 | 80.58 | 86.33 | 75.05 | 92.47 | 91.97 | 94.42 | 46.13 | 0.00 | 6.01 | 60.39 | 68.03 |
| OF [%] | 96.24 | 100.00 | 100.00 | 100.00 | 88.04 | 100.00 | 100.00 | 100.00 | 50.00 | 0.00 | 10.83 | 64.65 | 75.72 |
| FLR [%] | 0.01 | 0.23 | 0.03 | 0.58 | 13.99 | 0.60 | 0.90 | 1.00 | 0.00 | 0.00 | 0.00 | 0.06 | 1.85 |
| UCL [%] | 0.01 | 0.23 | 0.03 | 0.58 | 13.99 | 0.60 | 0.89 | 1.00 | 0.00 | 0.00 | 0.00 | 0.06 | 1.47 |
| PUF [%] | 0.04 | 0.02 | 0.06 | 0.02 | 0.00 | 0.11 | 0.58 | 0.04 | 50.17 | 100.00 | 90.80 | 0.83 | 20.23 |
| XUF [%] | 0.00 | 0.76 | 8.78 | 0.07 | 0.29 | 2.72 | 2.75 | 3.83 | 3.68 | 0.00 | 3.33 | 35.47 | 5.20 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 249821.31 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.75 % |
| Cumulative Energy Availability Factor (EAF) | : 75.29 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.8 % |
| Cumulative Unit Capability Factor (UCF) | : 78.24 % | Cumulative Planned Unavailability Factor (PUF) | : 13.96 % |
| Cumulative Load Factor (LF) | : 71.64 % | Cumulative Externally cause unavailability (XUF) | : 2.95 % |
| Cumulative Operating Factor (OF) | : 78.94 % | | |

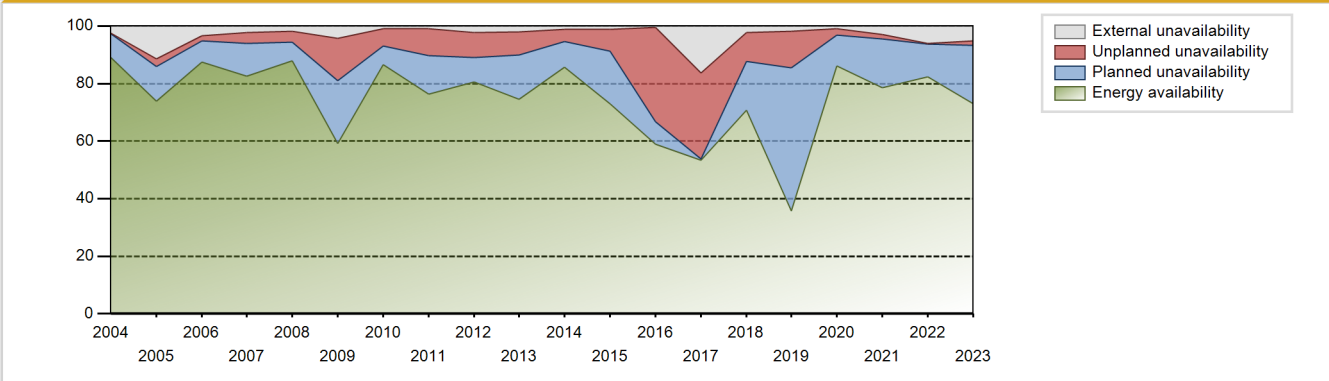
Electricity Production (net) [GWh]



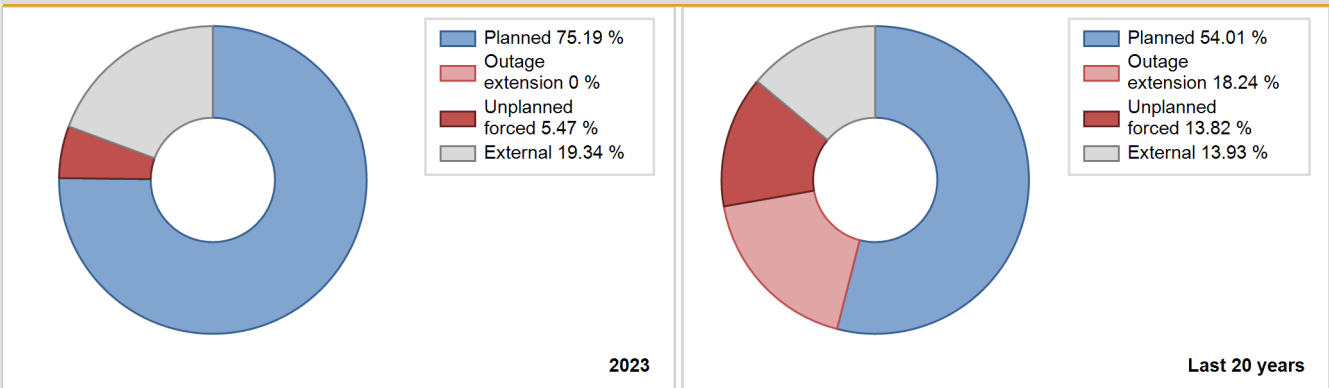
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | 2468.00 | 3412 | 918 | 56.60 | 56.60 | 95.84 | 97.04 | 43.40 | 43.40 | 0.00 | 0.00 |
| 1981 | 4416.00 | 5176 | 920 | 56.33 | 56.33 | 54.79 | 59.09 | 20.34 | 14.39 | 29.28 | 0.00 |
| 1982 | 5909.80 | 8151 | 915 | 81.86 | 82.78 | 73.73 | 93.05 | 17.22 | 17.22 | 0.00 | 0.92 |
| 1983 | 5111.00 | 6097 | 915 | 67.24 | 67.24 | 63.76 | 69.60 | 12.27 | 9.41 | 23.35 | 0.00 |
| 1984 | 6468.00 | 7662 | 915 | 86.67 | 86.67 | 80.47 | 87.23 | 2.06 | 1.82 | 11.51 | 0.00 |
| 1985 | 6217.90 | 7560 | 915 | 81.64 | 85.97 | 77.57 | 86.30 | 2.01 | 1.77 | 12.27 | 4.33 |
| 1986 | 5880.30 | 7188 | 915 | 77.05 | 79.44 | 73.36 | 82.05 | 7.60 | 6.54 | 14.02 | 2.39 |
| 1987 | 5978.10 | 7360 | 915 | 78.15 | 83.46 | 74.58 | 84.02 | 6.66 | 5.96 | 10.58 | 5.31 |
| 1988 | 5836.00 | 7200 | 915 | 76.70 | 79.77 | 72.61 | 81.97 | 5.40 | 4.55 | 15.68 | 3.07 |
| 1989 | 5830.15 | 7550 | 915 | 83.17 | 83.31 | 72.74 | 86.19 | 4.50 | 3.92 | 12.76 | 0.14 |
| 1990 | 5099.69 | 6377 | 915 | 65.08 | 68.77 | 63.62 | 72.80 | 6.40 | 4.70 | 26.53 | 3.69 |
| 1991 | 5909.12 | 7262 | 915 | 77.01 | 83.18 | 73.72 | 82.90 | 4.86 | 4.25 | 12.57 | 6.17 |
| 1992 | 5659.31 | 7573 | 915 | 82.99 | 85.27 | 70.41 | 86.21 | 2.21 | 1.92 | 12.81 | 2.27 |
| 1993 | 6134.82 | 7393 | 915 | 77.71 | 83.93 | 76.54 | 84.39 | 4.55 | 4.00 | 12.07 | 6.22 |
| 1994 | 5008.42 | 6458 | 915 | 70.27 | 75.44 | 62.48 | 73.72 | 13.11 | 11.39 | 13.17 | 5.17 |
| 1995 | 5372.68 | 6374 | 915 | 70.60 | 71.28 | 67.03 | 72.76 | 17.56 | 15.19 | 13.53 | 0.68 |
| 1996 | 7302.13 | 8448 | 915 | 93.78 | 94.47 | 90.85 | 96.17 | 4.85 | 4.82 | 0.71 | 0.69 |
| 1997 | 5548.30 | 6711 | 915 | 72.49 | 73.13 | 69.22 | 76.61 | 9.22 | 7.42 | 19.45 | 0.64 |
| 1998 | 5503.66 | 7075 | 915 | 71.03 | 71.03 | 68.66 | 80.76 | 16.38 | 13.92 | 15.05 | 0.00 |
| 1999 | 3426.65 | 4016 | 915 | 44.51 | 44.90 | 42.75 | 45.84 | 41.81 | 32.27 | 22.83 | 0.40 |
| 2000 | 6644.86 | 7842 | 915 | 87.15 | 87.68 | 82.67 | 89.28 | 2.36 | 2.12 | 10.21 | 0.53 |
| 2001 | 6053.29 | 7261 | 915 | 82.03 | 83.19 | 75.52 | 82.89 | 0.83 | 0.69 | 16.12 | 1.15 |
| 2002 | 6384.56 | 7778 | 915 | 86.67 | 87.67 | 79.65 | 88.79 | 1.48 | 1.32 | 11.01 | 1.01 |
| 2003 | 5670.06 | 7029 | 915 | 73.02 | 85.15 | 70.74 | 80.24 | 1.26 | 1.08 | 13.76 | 12.13 |
| 2004 | 6832.46 | 8049 | 915 | 89.00 | 91.54 | 85.01 | 91.63 | 0.18 | 0.16 | 8.30 | 2.54 |
| 2005 | 5830.97 | 7007 | 915 | 73.98 | 85.33 | 72.74 | 79.98 | 2.29 | 2.64 | 12.02 | 11.35 |
| 2006 | 6466.79 | 7989 | 915 | 87.40 | 90.66 | 80.68 | 91.20 | 0.04 | 1.97 | 7.36 | 3.26 |
| 2007 | 6344.72 | 7496 | 915 | 82.55 | 84.84 | 79.16 | 85.57 | 1.43 | 3.66 | 11.49 | 2.29 |
| 2008 | 6808.19 | 7950 | 915 | 87.86 | 89.74 | 84.71 | 90.51 | 0.20 | 3.68 | 6.58 | 1.88 |
| 2009 | 4655.39 | 5435 | 915 | 59.21 | 63.45 | 58.08 | 62.04 | 8.56 | 14.84 | 21.71 | 4.24 |
| 2010 | 6688.43 | 7755 | 915 | 86.65 | 87.51 | 83.44 | 88.53 | 2.34 | 6.00 | 6.49 | 0.86 |
| 2011 | 5580.09 | 6483 | 915 | 76.43 | 77.39 | 69.62 | 74.01 | 0.25 | 9.31 | 13.30 | 0.96 |
| 2012 | 6339.05 | 7345 | 915 | 80.56 | 82.92 | 78.87 | 83.62 | 4.22 | 8.55 | 8.54 | 2.36 |
| 2013 | 5868.42 | 6741 | 915 | 74.66 | 76.70 | 73.21 | 76.95 | 1.82 | 7.97 | 15.33 | 2.04 |
| 2014 | 6743.76 | 7683 | 915 | 85.74 | 86.92 | 84.14 | 87.71 | 3.18 | 4.24 | 8.84 | 1.18 |
| 2015 | 5751.37 | 6557 | 915 | 73.07 | 74.21 | 71.75 | 74.85 | 2.79 | 7.58 | 18.20 | 1.14 |
| 2016 | 4576.92 | 5400 | 915 | 58.84 | 59.37 | 56.95 | 61.48 | 3.78 | 32.71 | 7.91 | 0.53 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2017 | 4029.83 | 4975 | 915 | 53.33 | 69.61 | 50.28 | 56.79 | 29.14 | 29.98 | 0.40 | 16.28 |
| 2018 | 5586.73 | 6477 | 915 | 70.79 | 73.09 | 69.70 | 73.94 | 4.87 | 9.93 | 16.98 | 2.30 |
| 2019 | 2843.84 | 3231 | 915 | 35.70 | 37.49 | 35.48 | 36.88 | 16.76 | 12.76 | 49.75 | 1.79 |
| 2020 | 6655.75 | 7846 | 915 | 86.13 | 87.16 | 82.81 | 89.32 | 2.43 | 2.17 | 10.67 | 1.03 |
| 2021 | 6052.10 | 7270 | 915 | 78.53 | 81.44 | 75.51 | 82.99 | 1.92 | 1.59 | 16.96 | 2.91 |
| 2022 | 6479.64 | 7555 | 915 | 82.40 | 88.49 | 80.84 | 86.24 | 0.32 | 0.28 | 11.23 | 6.09 |
| 2023 | 5453.03 | 6633 | 915 | 73.09 | 78.29 | 68.03 | 75.72 | 1.85 | 1.47 | 20.23 | 5.20 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|---|-------------|-------------|------------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 26 | | | 378 | 1 |
| B. Refuelling without maintenance | | | | 115 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1722 | | | 1050 | 7 | |
| D. Inspection, maintenance or repair without refuelling | | | | 14 | 2 | |
| E. Testing of plant systems or components | | | | 4 | 1 | |
| H. Nuclear regulatory requirements | | | | | 116 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 11 |
| L. Human factor related | | 63 | | | 10 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| O. Load dispatching, prioritization | | | 28 | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 15 | 14 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 263 | | | 38 |
| Z. Other | | | 24 | | 25 | 1 |
| Subtotal | 1722 | 89 | 315 | 1183 | 554 | 69 |
| Total | | 2126 | | | 1806 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1980 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 67 |
| 12. Reactor I&C Systems | 26 | 10 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 60 |
| 15. Reactor Cooling Systems | | 18 |
| 16. Steam generation systems | | 86 |
| 21. Fuel Handling and Storage Facilities | | 7 |
| 31. Turbine and auxiliaries | | 43 |
| 32. Feedwater and Main Steam System | | 7 |
| 33. Circulating Water System | | 4 |
| 34. Miscellaneous Systems | | 85 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 63 |
| 42. Electrical Power Supply Systems | | 36 |
| Total | 26 | 489 |

2023 Operating Experience

FR-19

TRICASTIN-2

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)



Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2785 MWth
 Gross electrical power : 955 MWe
 Reference unit power (net) : 915 MWe

Key Dates

Construction Date : 1974-12-01
 Grid Date : 1980-08-07
 Commercial Date : 1980-12-01
 Age at end of year : 43 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2/MOX
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 45
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

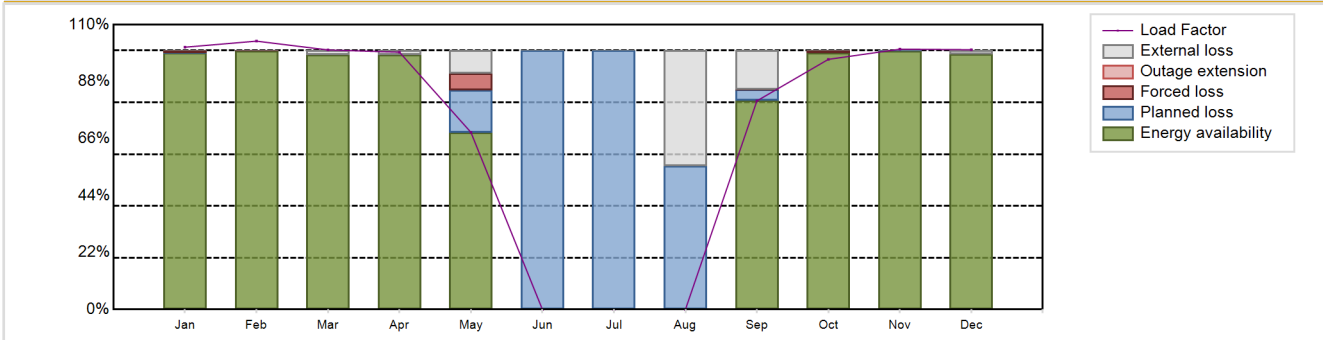
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5664.11 GW(e).h
 Energy Availability Factor (EAF) : 69.98 %
 Unit Capability Factor (UCF) : 76.13 %
 Load Factor (LF) : 70.67 %
 Operating Factor (OF) : 71.6 %
 Forced Loss Rate (FLR) : 0.9 %
 Unplanned Capability Loss Factor (UCL) : 0.69 %
 Planned Unavailability Factor (PUF) : 23.17 %
 Externally cause unavailability (XUF) : 6.15 %
 Total off-line time : 2488 hours

Annual Summary

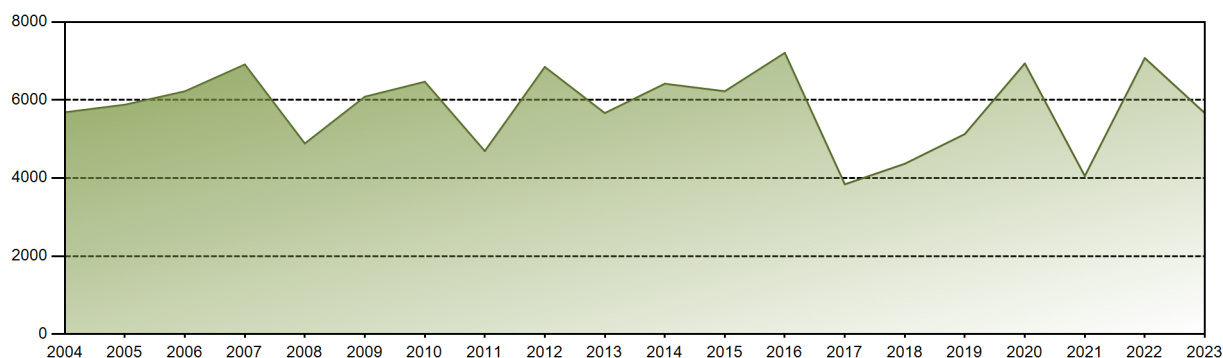


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|---------|
| GW(e)-h | 689.66 | 637.37 | 681.63 | 654.75 | 465.78 | 0.00 | 0.00 | 0.00 | 530.80 | 658.65 | 662.39 | 683.09 | 5664.11 |
| EAF [%] | 99.22 | 99.95 | 98.40 | 98.43 | 68.45 | 0.00 | 0.00 | 0.01 | 80.66 | 99.08 | 99.96 | 98.51 | 69.98 |
| UCF [%] | 99.22 | 99.95 | 100.00 | 100.00 | 77.34 | 0.00 | 0.00 | 44.49 | 95.58 | 99.08 | 99.96 | 100.00 | 76.13 |
| LF [%] | 101.31 | 103.66 | 100.26 | 99.39 | 68.42 | 0.00 | 0.00 | 0.00 | 80.57 | 96.62 | 100.55 | 100.34 | 70.67 |
| OF [%] | 99.46 | 100.00 | 100.00 | 100.00 | 77.42 | 0.00 | 0.00 | 0.00 | 85.14 | 99.87 | 100.00 | 100.00 | 71.60 |
| FLR [%] | 0.76 | 0.01 | 0.00 | 0.00 | 7.70 | 0.00 | 0.00 | 0.00 | 0.01 | 0.92 | 0.00 | 0.00 | 0.90 |
| UCL [%] | 0.76 | 0.01 | 0.00 | 0.00 | 6.45 | 0.00 | 0.00 | 0.00 | 0.01 | 0.92 | 0.00 | 0.00 | 0.69 |
| PUF [%] | 0.02 | 0.04 | 0.00 | 0.00 | 16.21 | 100.00 | 100.00 | 55.51 | 4.41 | 0.00 | 0.04 | 0.00 | 23.17 |
| XUF [%] | 0.00 | 0.00 | 1.60 | 1.57 | 8.89 | 0.00 | 0.00 | 44.48 | 14.92 | 0.00 | 0.00 | 1.49 | 6.15 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 250293.1 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.17 % |
| Cumulative Energy Availability Factor (EAF) | : 75.12 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7 % |
| Cumulative Unit Capability Factor (UCF) | : 78.57 % | Cumulative Planned Unavailability Factor (PUF) | : 14.42 % |
| Cumulative Load Factor (LF) | : 72.02 % | Cumulative Externally cause unavailability (XUF) | : 3.46 % |
| Cumulative Operating Factor (OF) | : 78.15 % | | |

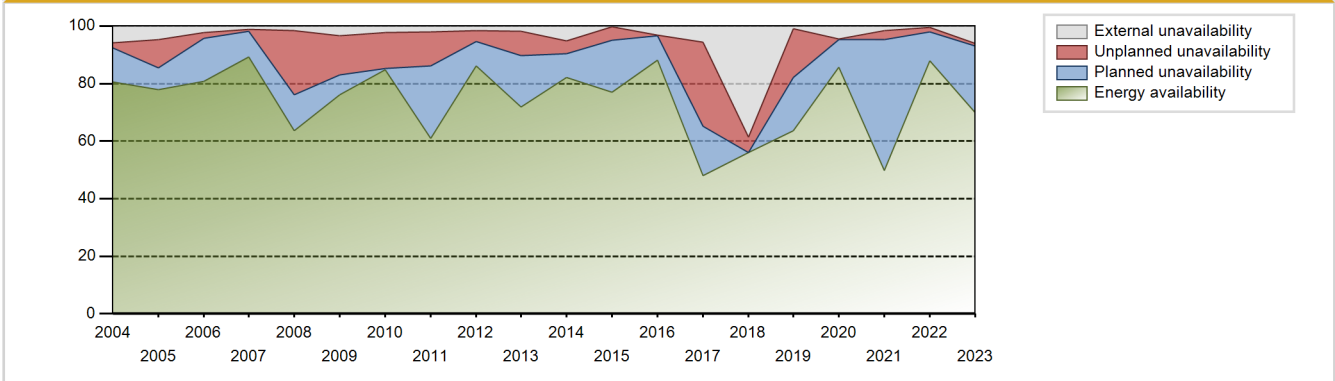
Electricity Production (net) [GWh]



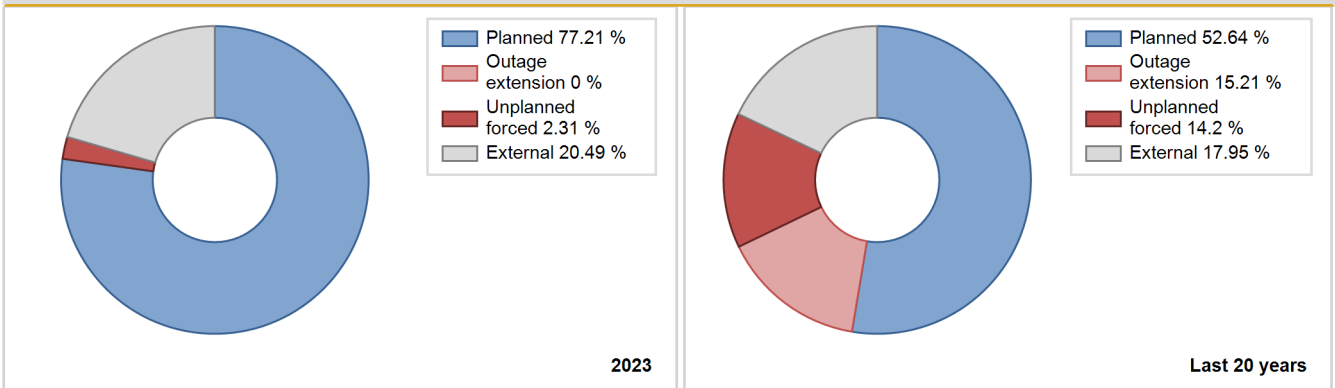
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | 1614.00 | 2559 | 917 | 68.70 | 68.70 | 68.08 | 76.34 | 9.91 | 7.56 | 23.74 | 0.00 |
| 1981 | 6155.10 | 7819 | 920 | 82.33 | 82.33 | 76.37 | 89.26 | 4.42 | 3.81 | 13.87 | 0.00 |
| 1982 | 4056.20 | 5932 | 915 | 63.03 | 63.03 | 50.61 | 67.72 | 11.83 | 8.46 | 28.51 | 0.00 |
| 1983 | 5624.00 | 7245 | 915 | 81.92 | 81.92 | 70.16 | 82.71 | 1.75 | 1.46 | 16.62 | 0.00 |
| 1984 | 6603.00 | 7684 | 915 | 87.18 | 87.18 | 82.15 | 87.48 | 4.50 | 4.11 | 8.72 | 0.00 |
| 1985 | 6261.70 | 7375 | 915 | 79.37 | 86.02 | 78.12 | 84.19 | 4.24 | 3.81 | 10.17 | 6.64 |
| 1986 | 6286.60 | 7631 | 915 | 82.60 | 85.78 | 78.43 | 87.11 | 4.14 | 3.71 | 10.51 | 3.18 |
| 1987 | 5302.30 | 6500 | 915 | 69.61 | 73.17 | 66.15 | 74.20 | 10.08 | 8.20 | 18.63 | 3.56 |
| 1988 | 4896.00 | 6628 | 915 | 73.08 | 76.03 | 60.92 | 75.46 | 13.58 | 11.95 | 12.02 | 2.95 |
| 1989 | 5164.73 | 6650 | 915 | 71.40 | 74.33 | 64.44 | 75.91 | 25.15 | 24.97 | 0.70 | 2.93 |
| 1990 | 5614.37 | 7177 | 915 | 72.54 | 80.90 | 70.04 | 81.93 | 2.87 | 2.39 | 16.70 | 8.36 |
| 1991 | 4459.14 | 5429 | 915 | 58.16 | 60.81 | 55.63 | 61.97 | 15.63 | 11.26 | 27.93 | 2.65 |
| 1992 | 6099.10 | 7118 | 915 | 78.72 | 79.95 | 75.88 | 81.03 | 8.45 | 7.38 | 12.67 | 1.24 |
| 1993 | 5777.08 | 6876 | 915 | 72.92 | 77.31 | 72.07 | 78.49 | 12.48 | 11.03 | 11.66 | 4.39 |
| 1994 | 6216.70 | 7222 | 915 | 79.09 | 81.66 | 77.56 | 82.44 | 6.02 | 5.24 | 13.10 | 2.57 |
| 1995 | 6312.32 | 7504 | 915 | 81.63 | 84.62 | 78.75 | 85.66 | 3.01 | 2.63 | 12.75 | 2.99 |
| 1996 | 6391.27 | 7615 | 915 | 82.08 | 84.90 | 79.52 | 86.69 | 1.18 | 1.02 | 14.08 | 2.83 |
| 1997 | 5218.84 | 6107 | 915 | 66.82 | 68.49 | 65.11 | 69.71 | 1.07 | 0.74 | 30.77 | 1.67 |
| 1998 | 6293.90 | 7354 | 915 | 81.20 | 83.02 | 78.52 | 83.95 | 7.01 | 6.26 | 10.72 | 1.82 |
| 1999 | 5661.49 | 6674 | 915 | 73.01 | 74.99 | 70.63 | 76.19 | 11.30 | 9.55 | 15.45 | 1.98 |
| 2000 | 4293.76 | 5092 | 915 | 55.29 | 56.70 | 53.42 | 57.97 | 23.28 | 17.20 | 26.10 | 1.41 |
| 2001 | 6710.46 | 7779 | 915 | 87.14 | 87.24 | 83.72 | 88.80 | 2.49 | 2.23 | 10.54 | 0.10 |
| 2002 | 6593.92 | 7714 | 915 | 86.87 | 87.14 | 82.27 | 88.06 | 0.23 | 0.20 | 12.66 | 0.28 |
| 2003 | 6195.95 | 7521 | 915 | 84.36 | 88.44 | 77.30 | 85.86 | 0.76 | 0.68 | 10.88 | 4.07 |
| 2004 | 5684.23 | 7271 | 915 | 80.68 | 86.42 | 70.72 | 82.78 | 2.15 | 1.90 | 11.67 | 5.74 |
| 2005 | 5878.67 | 7128 | 915 | 77.85 | 82.60 | 73.33 | 81.36 | 9.85 | 9.87 | 7.53 | 4.75 |
| 2006 | 6221.30 | 7366 | 915 | 80.69 | 83.01 | 77.62 | 84.09 | 1.78 | 1.91 | 15.09 | 2.31 |
| 2007 | 6910.13 | 7989 | 915 | 89.26 | 90.37 | 86.20 | 91.19 | 0.27 | 0.82 | 8.81 | 1.10 |
| 2008 | 4884.40 | 5768 | 915 | 63.59 | 65.13 | 60.77 | 65.66 | 1.42 | 22.37 | 12.50 | 1.54 |
| 2009 | 6083.60 | 7028 | 915 | 76.12 | 79.58 | 75.90 | 80.23 | 1.98 | 13.57 | 6.85 | 3.46 |
| 2010 | 6467.47 | 7629 | 915 | 84.84 | 87.15 | 80.69 | 87.09 | 12.52 | 12.47 | 0.38 | 2.31 |
| 2011 | 4690.91 | 5560 | 915 | 60.94 | 62.96 | 58.52 | 63.47 | 1.11 | 11.80 | 25.23 | 2.03 |
| 2012 | 6847.18 | 7806 | 915 | 86.09 | 87.67 | 85.19 | 88.87 | 0.98 | 3.71 | 8.63 | 1.58 |
| 2013 | 5664.14 | 6607 | 915 | 71.85 | 73.76 | 70.67 | 75.42 | 6.53 | 8.27 | 17.96 | 1.91 |
| 2014 | 6417.13 | 7593 | 915 | 82.09 | 87.19 | 80.06 | 86.68 | 0.54 | 4.44 | 8.38 | 5.10 |
| 2015 | 6224.43 | 6828 | 915 | 77.05 | 77.38 | 77.66 | 77.95 | 0.21 | 4.59 | 18.02 | 0.33 |
| 2016 | 7208.49 | 7948 | 915 | 88.24 | 91.29 | 89.69 | 90.48 | 0.43 | 0.39 | 8.32 | 3.05 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2017 | 3839.11 | 4529 | 915 | 47.96 | 53.48 | 47.90 | 51.70 | 32.46 | 29.21 | 17.30 | 5.52 |
| 2018 | 4365.93 | 5046 | 915 | 56.03 | 94.64 | 54.47 | 57.60 | 5.35 | 5.35 | 0.01 | 38.61 |
| 2019 | 5126.60 | 5725 | 915 | 63.55 | 64.50 | 63.96 | 65.35 | 3.01 | 16.84 | 18.66 | 0.95 |
| 2020 | 6937.00 | 7615 | 915 | 85.66 | 90.26 | 86.31 | 86.69 | 0.12 | 0.11 | 9.63 | 4.61 |
| 2021 | 4051.53 | 4413 | 915 | 49.71 | 51.40 | 50.55 | 50.38 | 5.68 | 3.09 | 45.51 | 1.69 |
| 2022 | 7074.48 | 7808 | 915 | 87.99 | 88.55 | 88.26 | 89.13 | 1.61 | 1.45 | 10.00 | 0.56 |
| 2023 | 5664.11 | 6272 | 915 | 69.98 | 76.13 | 70.67 | 71.60 | 0.90 | 0.69 | 23.17 | 6.15 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|---|-------------|-------------|------------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 52 | | | 429 | |
| B. Refuelling without maintenance | | | | 99 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1997 | | | 1079 | 24 | |
| D. Inspection, maintenance or repair without refuelling | | | | 24 | | |
| E. Testing of plant systems or components | 0 | | | 3 | 1 | |
| H. Nuclear regulatory requirements | | | | | 36 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 21 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 27 | | | 19 |
| O. Load dispatching, prioritization | | | | | | 0 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | 411 | | | 52 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 77 |
| Z. Other | | | | | 27 | 2 |
| Subtotal | 1997 | 52 | 438 | 1205 | 538 | 150 |
| Total | | 2487 | | | 1893 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1980 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 62 |
| 12. Reactor I&C Systems | | 28 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | | 54 |
| 15. Reactor Cooling Systems | 48 | 34 |
| 16. Steam generation systems | | 26 |
| 21. Fuel Handling and Storage Facilities | | 3 |
| 31. Turbine and auxiliaries | 4 | 62 |
| 32. Feedwater and Main Steam System | | 12 |
| 33. Circulating Water System | | 8 |
| 34. Miscellaneous Systems | | 118 |
| 41. Main Generator Systems | | 29 |
| 42. Electrical Power Supply Systems | | 30 |
| Total | 52 | 472 |

2023 Operating Experience

FR-25

TRICASTIN-3

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)



Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2785 MWth
 Gross electrical power : 955 MWe
 Reference unit power (net) : 915 MWe

Key Dates

Construction Date : 1975-04-01
 Grid Date : 1981-02-10
 Commercial Date : 1981-05-11
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2/MOX
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 45
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

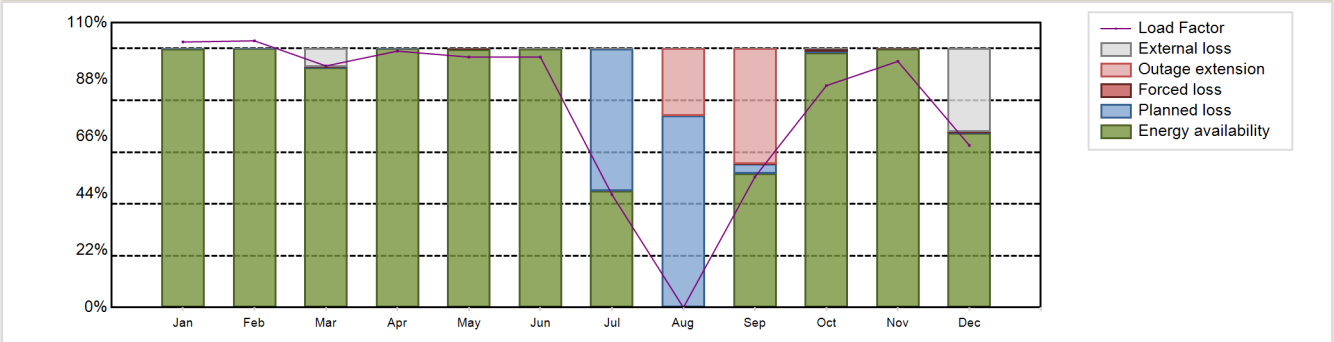
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 6179.71 GW(e).h
 Energy Availability Factor (EAF) : 79.26 %
 Unit Capability Factor (UCF) : 82.61 %
 Load Factor (LF) : 77.1 %
 Operating Factor (OF) : 80.37 %
 Forced Loss Rate (FLR) : 0.22 %
 Unplanned Capability Loss Factor (UCL) : 6.06 %
 Planned Unavailability Factor (PUF) : 11.33 %
 Externally cause unavailability (XUF) : 3.35 %
 Total off-line time : 1720 hours

Annual Summary

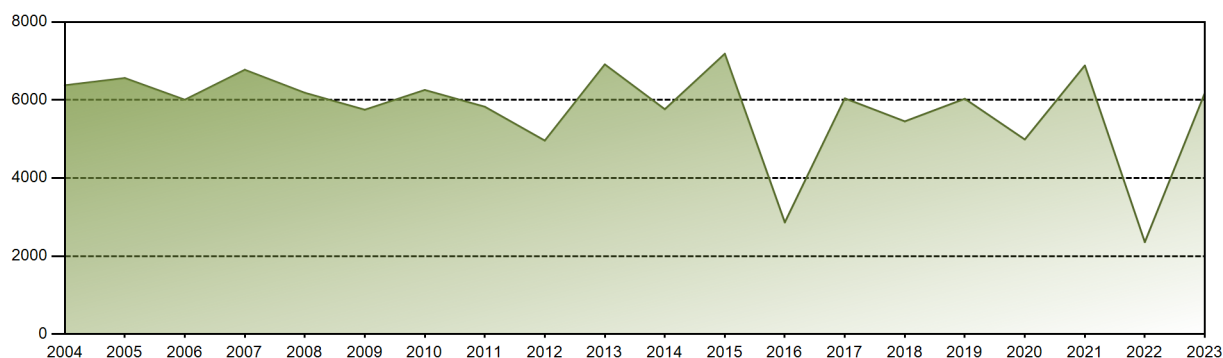


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|---------|
| GW(e)-h | 698.06 | 633.36 | 634.30 | 652.44 | 658.32 | 637.25 | 297.06 | 0.00 | 332.18 | 584.06 | 626.30 | 426.38 | 6179.71 |
| EAF [%] | 99.93 | 99.99 | 92.66 | 99.99 | 99.99 | 99.93 | 44.93 | 0.00 | 51.63 | 98.34 | 99.84 | 67.38 | 79.26 |
| UCF [%] | 99.93 | 99.99 | 99.86 | 99.99 | 99.59 | 99.93 | 44.95 | 0.00 | 51.63 | 98.34 | 99.84 | 99.60 | 82.61 |
| LF [%] | 102.54 | 103.01 | 93.30 | 99.03 | 96.70 | 96.73 | 43.64 | 0.00 | 50.42 | 85.68 | 95.07 | 62.63 | 77.10 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 45.16 | 0.00 | 55.42 | 98.79 | 100.00 | 68.01 | 80.37 |
| FLR [%] | 0.00 | 0.00 | 0.07 | 0.00 | 0.41 | 0.00 | 0.00 | 0.00 | 0.01 | 1.22 | 0.16 | 0.32 | 0.22 |
| UCL [%] | 0.00 | 0.00 | 0.07 | 0.00 | 0.41 | 0.00 | 0.00 | 25.99 | 44.62 | 1.21 | 0.16 | 0.32 | 6.06 |
| PUF [%] | 0.07 | 0.01 | 0.07 | 0.01 | 0.00 | 0.07 | 55.05 | 74.01 | 3.75 | 0.44 | 0.00 | 0.08 | 11.33 |
| XUF [%] | 0.00 | 0.00 | 7.20 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 32.22 | 3.35 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 251366.73 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.38 % |
| Cumulative Energy Availability Factor (EAF) | : 75.81 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.62 % |
| Cumulative Unit Capability Factor (UCF) | : 79.37 % | Cumulative Planned Unavailability Factor (PUF) | : 14.01 % |
| Cumulative Load Factor (LF) | : 73.33 % | Cumulative Externally cause unavailability (XUF) | : 3.57 % |
| Cumulative Operating Factor (OF) | : 78.48 % | | |

Electricity Production (net) [GWh]

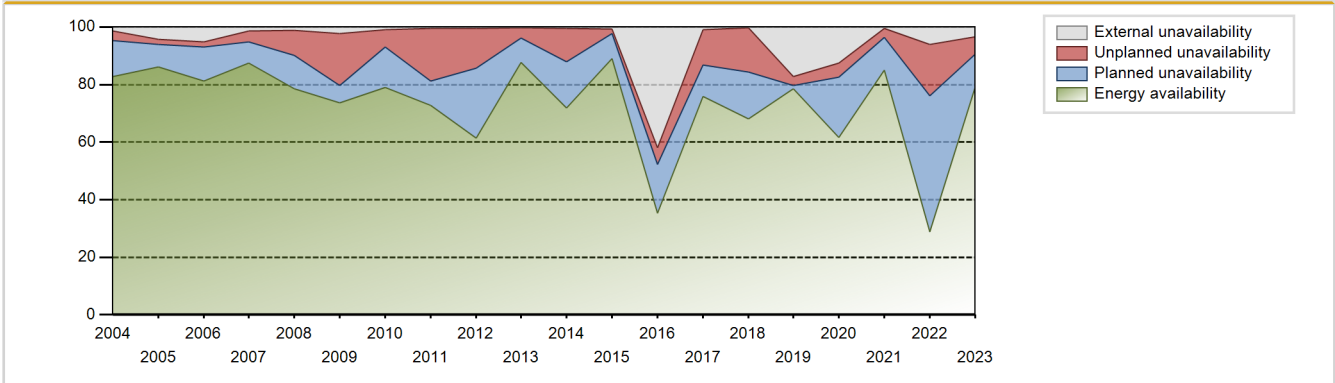


Performance for Years of Commercial Operation

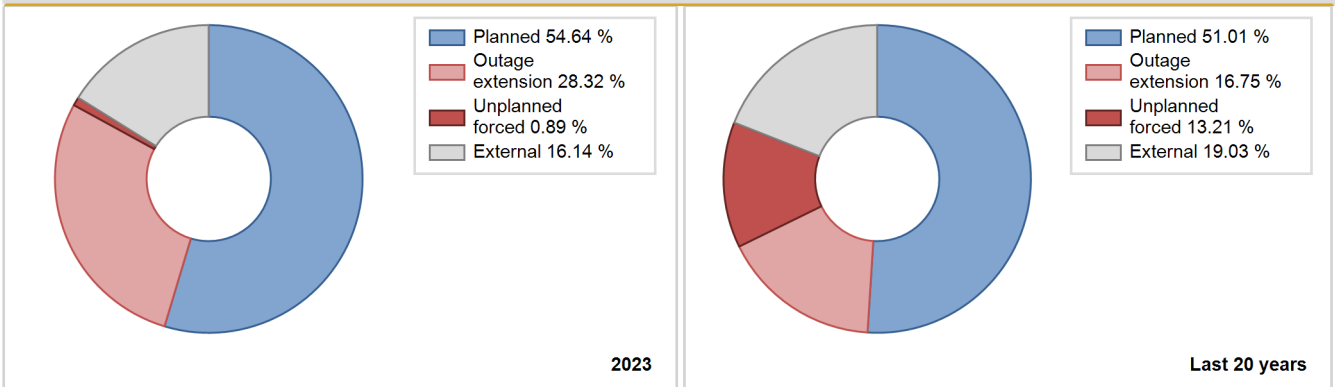
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 4917.60 | 6463 | 919 | 78.00 | 78.00 | 73.91 | 81.89 | 0.00 | 0.00 | 22.00 | 0.00 |
| 1982 | 5067.30 | 5966 | 915 | 65.83 | 65.83 | 63.22 | 68.11 | 7.17 | 5.08 | 29.09 | 0.00 |
| 1983 | 6342.00 | 7544 | 915 | 82.77 | 82.77 | 79.12 | 86.12 | 4.29 | 3.71 | 13.52 | 0.00 |
| 1984 | 6682.00 | 7668 | 915 | 85.11 | 85.11 | 83.14 | 87.30 | 2.01 | 1.74 | 13.14 | 0.00 |
| 1985 | 7166.00 | 8518 | 915 | 94.29 | 97.06 | 89.40 | 97.24 | 0.89 | 0.87 | 2.06 | 2.77 |
| 1986 | 6230.40 | 7704 | 915 | 83.48 | 86.83 | 77.73 | 87.95 | 3.18 | 2.85 | 10.32 | 3.34 |
| 1987 | 5654.30 | 6810 | 915 | 75.37 | 76.85 | 70.54 | 77.74 | 8.05 | 6.73 | 16.42 | 1.48 |
| 1988 | 5722.00 | 7106 | 915 | 77.98 | 80.29 | 71.19 | 80.90 | 8.35 | 7.32 | 12.39 | 2.31 |
| 1989 | 5834.63 | 7188 | 915 | 75.88 | 80.92 | 72.79 | 82.05 | 2.34 | 1.94 | 17.14 | 5.04 |
| 1990 | 6457.21 | 7671 | 915 | 84.62 | 85.77 | 80.56 | 87.57 | 2.00 | 1.75 | 12.48 | 1.15 |
| 1991 | 4746.80 | 5941 | 915 | 62.06 | 66.50 | 59.22 | 67.82 | 23.92 | 20.91 | 12.59 | 4.43 |
| 1992 | 5198.98 | 6010 | 915 | 66.63 | 67.55 | 64.69 | 68.42 | 6.11 | 4.39 | 28.06 | 0.92 |
| 1993 | 6423.91 | 7373 | 915 | 81.39 | 83.29 | 80.14 | 84.17 | 5.63 | 4.97 | 11.74 | 1.89 |
| 1994 | 6496.49 | 7641 | 915 | 83.59 | 86.27 | 81.05 | 87.23 | 2.85 | 2.53 | 11.20 | 2.68 |
| 1995 | 6494.69 | 7675 | 915 | 85.14 | 86.97 | 81.03 | 87.61 | 2.11 | 1.88 | 11.15 | 1.83 |
| 1996 | 5806.69 | 7172 | 915 | 76.16 | 79.30 | 72.25 | 81.65 | 7.59 | 6.51 | 14.19 | 3.13 |
| 1997 | 6192.76 | 7331 | 915 | 79.06 | 82.57 | 77.26 | 83.69 | 8.25 | 7.42 | 10.01 | 3.51 |
| 1998 | 6359.54 | 7375 | 915 | 80.49 | 82.28 | 79.34 | 84.19 | 6.55 | 5.77 | 11.96 | 1.79 |
| 1999 | 5731.67 | 6828 | 915 | 74.01 | 76.65 | 71.51 | 77.95 | 11.85 | 10.31 | 13.04 | 2.64 |
| 2000 | 5985.21 | 7325 | 915 | 78.99 | 82.30 | 74.47 | 83.39 | 8.50 | 7.65 | 10.05 | 3.32 |
| 2001 | 4929.48 | 5777 | 915 | 65.18 | 65.77 | 61.50 | 65.95 | 15.73 | 12.27 | 21.96 | 0.59 |
| 2002 | 5976.06 | 7140 | 915 | 80.19 | 80.44 | 74.56 | 81.51 | 1.24 | 1.01 | 18.55 | 0.25 |
| 2003 | 6144.89 | 7607 | 915 | 79.71 | 86.93 | 76.66 | 86.84 | 4.69 | 4.28 | 8.79 | 7.23 |
| 2004 | 6377.15 | 7455 | 915 | 82.86 | 84.34 | 79.34 | 84.87 | 3.69 | 3.23 | 12.43 | 1.47 |
| 2005 | 6563.04 | 7981 | 915 | 86.14 | 90.44 | 81.87 | 91.10 | 0.74 | 1.69 | 7.87 | 4.30 |
| 2006 | 6006.89 | 7488 | 915 | 81.28 | 86.47 | 74.94 | 85.48 | 1.44 | 1.78 | 11.75 | 5.18 |
| 2007 | 6775.03 | 7862 | 915 | 87.57 | 88.96 | 84.53 | 89.75 | 2.62 | 3.78 | 7.26 | 1.39 |
| 2008 | 6185.23 | 7030 | 915 | 78.59 | 79.66 | 76.96 | 80.03 | 0.32 | 8.87 | 11.48 | 1.06 |
| 2009 | 5750.65 | 6608 | 915 | 73.61 | 75.88 | 71.74 | 75.43 | 16.37 | 18.01 | 6.11 | 2.27 |
| 2010 | 6257.49 | 7089 | 915 | 79.10 | 80.07 | 78.07 | 80.92 | 1.30 | 5.87 | 14.05 | 0.98 |
| 2011 | 5827.60 | 6507 | 915 | 72.83 | 73.42 | 72.71 | 74.28 | 17.38 | 18.27 | 8.31 | 0.59 |
| 2012 | 4959.82 | 5534 | 915 | 61.47 | 61.93 | 61.71 | 63.00 | 1.39 | 13.77 | 24.31 | 0.45 |
| 2013 | 6912.58 | 7765 | 915 | 87.60 | 87.87 | 86.24 | 88.64 | 0.83 | 3.52 | 8.61 | 0.28 |
| 2014 | 5763.72 | 6369 | 915 | 71.84 | 72.39 | 71.91 | 72.71 | 7.95 | 11.53 | 16.08 | 0.55 |
| 2015 | 7186.07 | 7928 | 915 | 89.05 | 89.64 | 89.65 | 90.50 | 0.48 | 1.58 | 8.77 | 0.59 |
| 2016 | 2863.03 | 3168 | 915 | 35.34 | 77.34 | 35.62 | 36.07 | 0.00 | 5.73 | 16.94 | 42.00 |
| 2017 | 6042.82 | 6785 | 915 | 75.80 | 76.75 | 75.39 | 77.45 | 2.57 | 12.33 | 10.91 | 0.95 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2018 | 5453.10 | 6019 | 915 | 68.17 | 68.32 | 68.03 | 68.71 | 18.45 | 15.46 | 16.21 | 0.16 |
| 2019 | 6032.36 | 7059 | 915 | 78.63 | 95.75 | 75.26 | 80.58 | 1.18 | 3.13 | 1.12 | 17.13 |
| 2020 | 4987.94 | 5578 | 915 | 61.67 | 74.21 | 62.06 | 63.50 | 2.40 | 4.82 | 20.97 | 12.54 |
| 2021 | 6884.54 | 7514 | 915 | 85.10 | 85.49 | 85.89 | 85.78 | 1.68 | 3.21 | 11.30 | 0.39 |
| 2022 | 2357.63 | 2566 | 915 | 28.75 | 34.91 | 29.41 | 29.29 | 3.33 | 17.80 | 47.29 | 6.16 |
| 2023 | 6179.71 | 7040 | 915 | 79.26 | 82.61 | 77.10 | 80.37 | 0.22 | 6.06 | 11.33 | 3.35 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|-------------|------------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 523 | | | 444 | |
| B. Refuelling without maintenance | 959 | | | 127 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1017 | 6 | |
| D. Inspection, maintenance or repair without refuelling | | | | 22 | | |
| E. Testing of plant systems or components | | | | 4 | 1 | |
| H. Nuclear regulatory requirements | | | | | 23 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 23 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 238 | | | 32 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 15 | 104 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 32 |
| Z. Other | | | | | 23 | |
| Subtotal | 959 | 523 | 238 | 1170 | 535 | 168 |
| Total | | 1720 | | | 1873 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 13 |
| 12. Reactor I&C Systems | | 31 |
| 13. Reactor Auxiliary Systems | | 18 |
| 14. Safety Systems | | 44 |
| 15. Reactor Cooling Systems | | 36 |
| 16. Steam generation systems | | 87 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 21. Fuel Handling and Storage Facilities | | 5 |
| 31. Turbine and auxiliaries | 8 | 93 |
| 32. Feedwater and Main Steam System | | 6 |
| 34. Miscellaneous Systems | 515 | 121 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 83 |
| 42. Electrical Power Supply Systems | | 8 |
| Total | 523 | 550 |

2023 Operating Experience

FR-26

TRICASTIN-4

FRANCE

Status at end of year : **Operational**
 Operator : EDF (ÉLECTRICITÉ DE FRANCE)
 Owner : EDF (ÉLECTRICITÉ DE FRANCE)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)



Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2785 MWth
 Gross electrical power : 955 MWe
 Reference unit power (net) : 915 MWe

Key Dates

Construction Date : 1975-05-01
 Grid Date : 1981-06-12
 Commercial Date : 1981-11-01
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2/MOX
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 33735
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 45
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.45
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

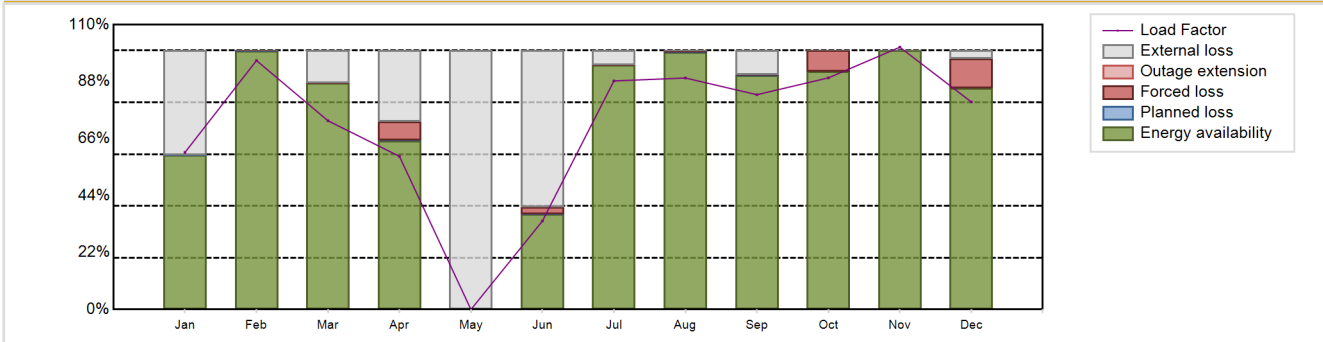
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5694.38 GW(e).h
 Energy Availability Factor (EAF) : 75.69 %
 Unit Capability Factor (UCF) : 97.4 %
 Load Factor (LF) : 71.04 %
 Operating Factor (OF) : 78.3 %

Forced Loss Rate (FLR) : 2.55 %
 Unplanned Capability Loss Factor (UCL) : 2.55 %
 Planned Unavailability Factor (PUF) : 0.05 %
 Externally cause unavailability (XUF) : 21.71 %
 Total off-line time : 1901 hours

Annual Summary

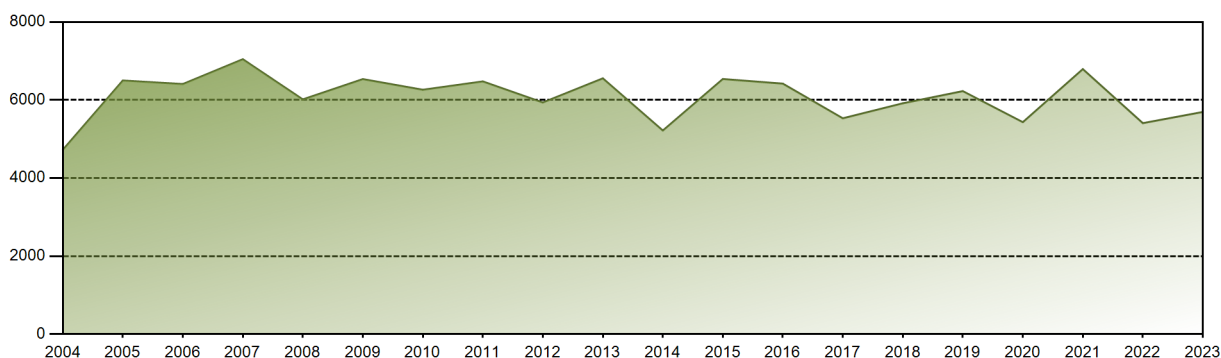


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 413.10 | 591.29 | 495.68 | 389.76 | 0.00 | 225.25 | 600.99 | 608.72 | 546.60 | 609.93 | 667.37 | 545.66 | 5694.38 |
| EAF [%] | 59.65 | 99.85 | 87.43 | 65.00 | 0.00 | 36.85 | 94.44 | 99.25 | 90.31 | 91.90 | 100.00 | 85.57 | 75.69 |
| UCF [%] | 99.99 | 99.85 | 100.00 | 92.40 | 100.00 | 97.20 | 99.94 | 99.40 | 99.59 | 91.90 | 100.00 | 88.74 | 97.40 |
| LF [%] | 60.68 | 96.16 | 72.91 | 59.16 | 0.00 | 34.19 | 88.28 | 89.42 | 82.97 | 89.48 | 101.30 | 80.15 | 71.04 |
| OF [%] | 60.35 | 100.00 | 100.00 | 72.64 | 0.00 | 37.22 | 94.89 | 100.00 | 90.83 | 99.87 | 100.00 | 85.48 | 78.30 |
| FLR [%] | 0.00 | 0.09 | 0.00 | 7.24 | 0.00 | 2.75 | 0.01 | 0.59 | 0.38 | 8.10 | 0.00 | 11.26 | 2.55 |
| UCL [%] | 0.00 | 0.09 | 0.00 | 7.21 | 0.00 | 2.75 | 0.01 | 0.59 | 0.38 | 8.10 | 0.00 | 11.26 | 2.55 |
| PUF [%] | 0.01 | 0.06 | 0.00 | 0.39 | 0.00 | 0.04 | 0.05 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.05 |
| XUF [%] | 40.34 | 0.00 | 12.57 | 27.40 | 100.00 | 60.35 | 5.50 | 0.15 | 9.27 | 0.00 | 0.00 | 3.17 | 21.71 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 252372.58 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.6 % |
| Cumulative Energy Availability Factor (EAF) | : 78.5 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.4 % |
| Cumulative Unit Capability Factor (UCF) | : 81.77 % | Cumulative Planned Unavailability Factor (PUF) | : 12.83 % |
| Cumulative Load Factor (LF) | : 74.39 % | Cumulative Externally cause unavailability (XUF) | : 3.27 % |
| Cumulative Operating Factor (OF) | : 80.89 % | | |

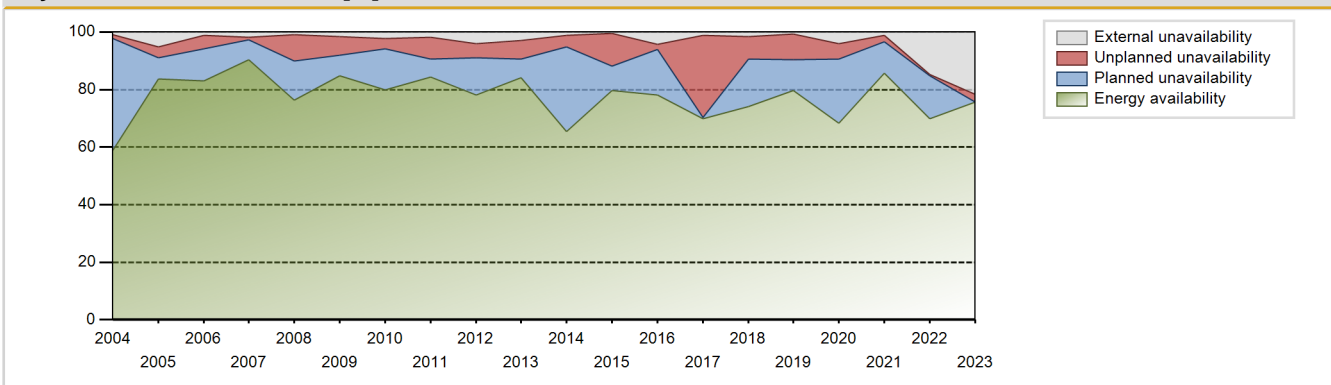
Electricity Production (net) [GWh]



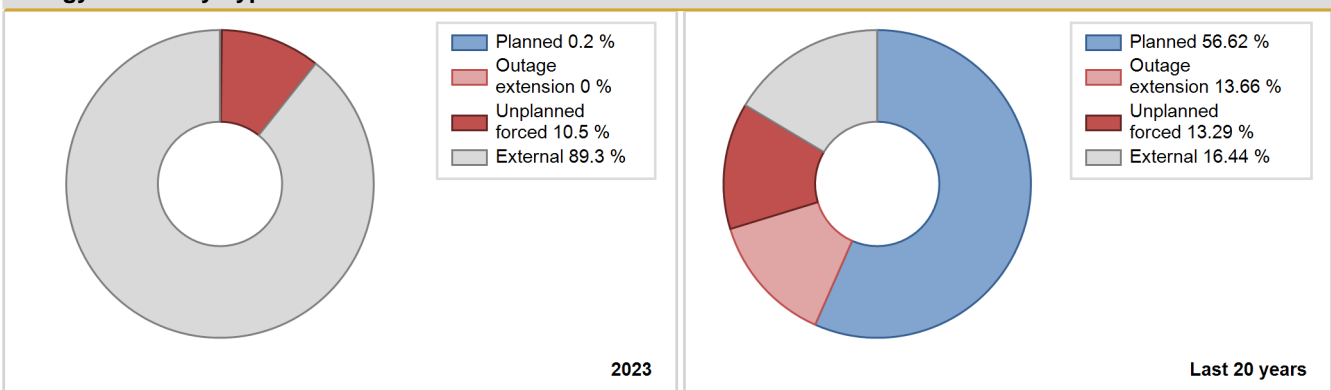
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 2480.00 | 3883 | 917 | 97.21 | 97.21 | 95.30 | 99.86 | 0.00 | 0.00 | 2.79 | 0.00 |
| 1982 | 5470.50 | 6311 | 915 | 69.85 | 69.85 | 68.25 | 72.04 | 5.62 | 4.16 | 25.99 | 0.00 |
| 1983 | 6170.00 | 7386 | 915 | 80.67 | 80.67 | 76.98 | 84.32 | 3.68 | 3.08 | 16.25 | 0.00 |
| 1984 | 5446.00 | 7587 | 915 | 87.08 | 87.08 | 67.76 | 86.37 | 4.70 | 4.30 | 8.62 | 0.00 |
| 1985 | 6161.70 | 7816 | 915 | 84.80 | 91.35 | 76.87 | 89.22 | 0.51 | 0.47 | 8.19 | 6.54 |
| 1986 | 5873.90 | 7568 | 915 | 81.78 | 85.70 | 73.28 | 86.39 | 0.52 | 0.45 | 13.85 | 3.92 |
| 1987 | 5725.70 | 7257 | 915 | 80.12 | 84.16 | 71.43 | 82.84 | 5.52 | 4.92 | 10.93 | 4.04 |
| 1988 | 3770.00 | 4772 | 915 | 66.25 | 67.65 | 46.91 | 54.33 | 19.52 | 16.41 | 15.94 | 1.41 |
| 1989 | 5729.11 | 7335 | 915 | 79.80 | 82.94 | 71.48 | 83.73 | 3.98 | 3.44 | 13.62 | 3.14 |
| 1990 | 5201.58 | 7329 | 915 | 77.42 | 82.72 | 64.89 | 83.66 | 5.39 | 4.71 | 12.57 | 5.30 |
| 1991 | 5742.81 | 6838 | 915 | 74.55 | 77.09 | 71.65 | 78.06 | 11.76 | 10.27 | 12.64 | 2.54 |
| 1992 | 6459.26 | 7968 | 915 | 86.69 | 90.20 | 80.37 | 90.71 | 0.54 | 0.49 | 9.31 | 3.51 |
| 1993 | 5302.81 | 6842 | 915 | 70.89 | 80.08 | 66.16 | 78.11 | 2.01 | 1.64 | 18.27 | 9.19 |
| 1994 | 5952.97 | 7049 | 915 | 77.80 | 80.87 | 74.27 | 80.47 | 7.76 | 6.81 | 12.33 | 3.06 |
| 1995 | 6208.92 | 7562 | 915 | 81.99 | 85.67 | 77.46 | 86.32 | 4.77 | 4.29 | 10.04 | 3.69 |
| 1996 | 6700.35 | 7774 | 915 | 86.55 | 87.59 | 83.37 | 88.50 | 1.75 | 1.56 | 10.85 | 1.04 |
| 1997 | 6488.77 | 7595 | 915 | 84.84 | 86.00 | 80.95 | 86.70 | 1.26 | 1.09 | 12.90 | 1.17 |
| 1998 | 5912.98 | 7138 | 915 | 76.19 | 80.45 | 73.77 | 81.48 | 9.79 | 8.73 | 10.82 | 4.25 |
| 1999 | 5887.87 | 7158 | 915 | 77.95 | 80.49 | 73.46 | 81.71 | 11.36 | 10.31 | 9.20 | 2.53 |
| 2000 | 5780.25 | 6873 | 915 | 75.76 | 77.41 | 71.92 | 78.24 | 5.60 | 4.59 | 18.00 | 1.65 |
| 2001 | 6036.95 | 7138 | 915 | 81.25 | 83.00 | 75.32 | 81.48 | 6.39 | 5.67 | 11.34 | 1.75 |
| 2002 | 6260.60 | 7168 | 915 | 81.89 | 83.97 | 78.11 | 81.83 | 4.25 | 3.73 | 12.31 | 2.08 |
| 2003 | 6387.89 | 7399 | 915 | 79.89 | 82.88 | 79.70 | 84.46 | 5.91 | 5.20 | 11.92 | 2.99 |
| 2004 | 4724.06 | 5359 | 915 | 58.84 | 59.83 | 58.78 | 61.01 | 2.24 | 1.37 | 38.80 | 0.99 |
| 2005 | 6501.37 | 7728 | 915 | 83.63 | 88.80 | 81.10 | 88.21 | 4.04 | 3.74 | 7.46 | 5.16 |
| 2006 | 6410.44 | 7412 | 915 | 82.98 | 84.10 | 79.98 | 84.61 | 2.81 | 4.73 | 11.17 | 1.12 |
| 2007 | 7046.97 | 8096 | 915 | 90.42 | 92.18 | 87.91 | 92.41 | 0.13 | 0.96 | 6.86 | 1.75 |
| 2008 | 6016.61 | 6867 | 915 | 76.42 | 77.35 | 74.86 | 78.18 | 2.16 | 9.14 | 13.51 | 0.93 |
| 2009 | 6536.71 | 7630 | 915 | 84.80 | 86.48 | 81.55 | 87.10 | 0.89 | 6.30 | 7.23 | 1.67 |
| 2010 | 6263.83 | 7275 | 915 | 79.97 | 82.28 | 78.15 | 83.05 | 0.31 | 3.51 | 14.21 | 2.31 |
| 2011 | 6477.78 | 7589 | 915 | 84.30 | 86.18 | 80.82 | 86.63 | 4.34 | 7.46 | 6.36 | 1.87 |
| 2012 | 5937.33 | 7062 | 915 | 78.04 | 82.15 | 73.87 | 80.40 | 0.43 | 4.83 | 13.02 | 4.10 |
| 2013 | 6556.13 | 7607 | 915 | 84.21 | 87.24 | 81.79 | 86.84 | 1.34 | 6.41 | 6.35 | 3.03 |
| 2014 | 5218.80 | 5828 | 915 | 65.48 | 66.62 | 65.11 | 66.53 | 0.01 | 3.98 | 29.40 | 1.14 |
| 2015 | 6538.75 | 7080 | 915 | 79.60 | 80.15 | 81.58 | 80.82 | 2.51 | 11.24 | 8.61 | 0.55 |
| 2016 | 6420.53 | 6914 | 915 | 78.13 | 82.46 | 79.88 | 78.71 | 1.98 | 1.67 | 15.88 | 4.33 |
| 2017 | 5531.81 | 6267 | 915 | 69.86 | 70.95 | 69.01 | 71.54 | 25.20 | 28.63 | 0.42 | 1.09 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|-------|
| 2018 | 5916.77 | 6699 | 915 | 74.10 | 75.71 | 73.82 | 76.47 | 3.43 | 7.69 | 16.60 | 1.61 |
| 2019 | 6228.37 | 7130 | 915 | 79.65 | 80.42 | 77.71 | 81.39 | 3.51 | 8.92 | 10.65 | 0.77 |
| 2020 | 5432.69 | 6235 | 915 | 68.40 | 72.47 | 67.59 | 70.98 | 6.78 | 5.27 | 22.26 | 4.07 |
| 2021 | 6792.92 | 7554 | 915 | 85.63 | 86.67 | 84.75 | 86.23 | 2.61 | 2.32 | 11.00 | 1.04 |
| 2022 | 5407.68 | 6467 | 915 | 69.85 | 84.59 | 67.47 | 73.82 | 0.63 | 0.53 | 14.88 | 14.74 |
| 2023 | 5694.38 | 6859 | 915 | 75.69 | 97.40 | 71.04 | 78.30 | 2.55 | 2.55 | 0.05 | 21.71 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 85 | | | 292 | 1 |
| B. Refuelling without maintenance | | | | 84 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 972 | 7 | |
| D. Inspection, maintenance or repair without refuelling | | | | 14 | | |
| E. Testing of plant systems or components | | | | 2 | 0 | |
| H. Nuclear regulatory requirements | | | | | 43 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 0 | | | 17 |
| L. Human factor related | | | | | 19 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 5 |
| O. Load dispatching, prioritization | | | 42 | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 20 | 38 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | 1771 | | | 61 |
| Z. Other | | | | | 30 | 0 |
| Subtotal | | 85 | 1813 | 1072 | 411 | 124 |
| Total | | 1898 | | | 1607 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 19 |
| 12. Reactor I&C Systems | | 15 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 70 |
| 15. Reactor Cooling Systems | | 16 |
| 16. Steam generation systems | | 30 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 4 |
| 31. Turbine and auxiliaries | 20 | 22 |
| 32. Feedwater and Main Steam System | | 14 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 90 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | 66 | 35 |
| 42. Electrical Power Supply Systems | | 17 |
| Total | 86 | 343 |

2023 Operating Experience

DE-33

EMSLAND

GERMANY

Status at end of year : **Permanent Shutdown**
 Operator : KLE (Kernkraftwerke Lippe-Ems GmbH)
 Owner : RWE/PEL (1. (75%) RWE Power AG)
 Reactor Supplier : KWU (KRAFTWERK UNION, AG)
 Turbine Supplier : KWU (KRAFTWERK UNION, AG)



Reactor Unit Details

Reactor type and model : PWR / Konvoi
 Thermal power : 3850 MWth
 Gross electrical power : 1406 MWe
 Reference unit power (net) : 1335 MWe

Key Dates

Construction Date : 1982-08-10
 Grid Date : 1988-04-19
 Commercial Date : 1988-06-20
 Age at end of year : 35 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.2
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 32000
 Active core diameter [m] : 3.6
 Active core height/length [m] : 3.9
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 16.4
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 326
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 0.62

Secondary systems

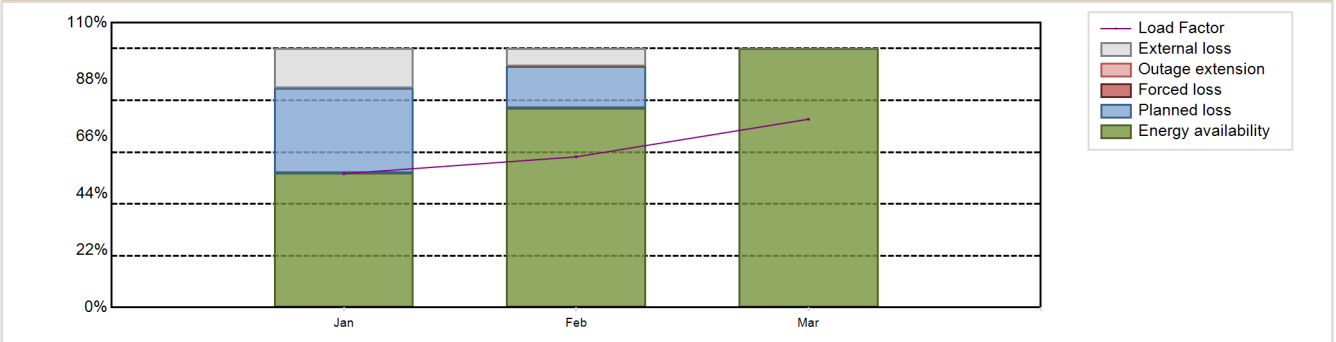
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.05
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 2103.9 GW(e).h
 Energy Availability Factor (EAF) : 76.31 %
 Unit Capability Factor (UCF) : 83.67 %
 Load Factor (LF) : 60.96 %
 Operating Factor (OF) : 83.66 %
 Forced Loss Rate (FLR) : 0.01 %
 Unplanned Capability Loss Factor (UCL) : 0.01 %
 Planned Unavailability Factor (PUF) : 16.32 %
 Externally cause unavailability (XUF) : 7.37 %
 Total off-line time : 353 hours

Annual Summary

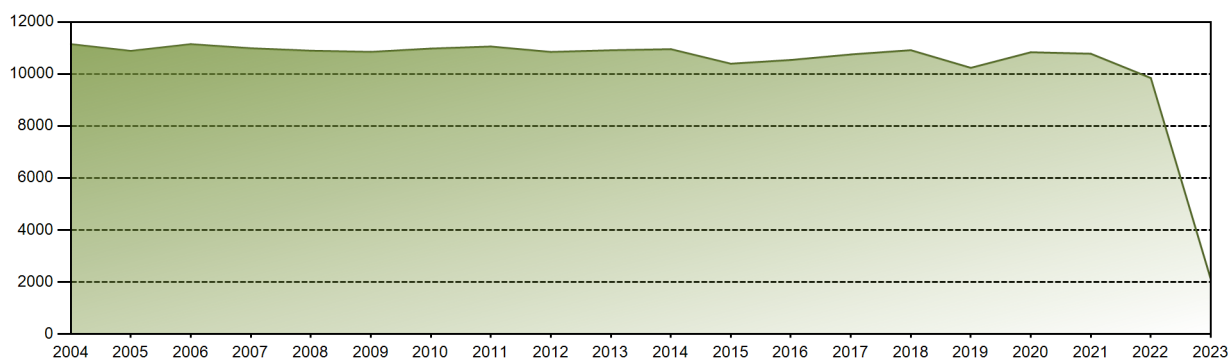


| | Oct | Nov | Dec | Apr | May | Jun | Jul | Aug | Sep | Jan | Feb | Mar | Annual |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|--------|--------|---------|
| GW(e)-h | | | | | | | | | | 513.41 | 521.97 | 722.36 | 1757.74 |
| EAF [%] | | | | | | | | | | 51.94 | 77.05 | 100.00 | 76.31 |
| UCF [%] | | | | | | | | | | 67.20 | 83.83 | 100.00 | 83.67 |
| LF [%] | | | | | | | | | | 51.69 | 58.18 | 72.73 | 60.96 |
| OF [%] | | | | | | | | | | 67.20 | 83.78 | 100.00 | 83.66 |
| FLR [%] | | | | | | | | | | 0.00 | 0.03 | 0.00 | 0.01 |
| UCL [%] | | | | | | | | | | 0.00 | 0.03 | 0.00 | 0.01 |
| PUF [%] | | | | | | | | | | 32.80 | 16.15 | 0.00 | 16.32 |
| XUF [%] | | | | | | | | | | 15.26 | 6.78 | 0.00 | 7.37 |

Historical Summary

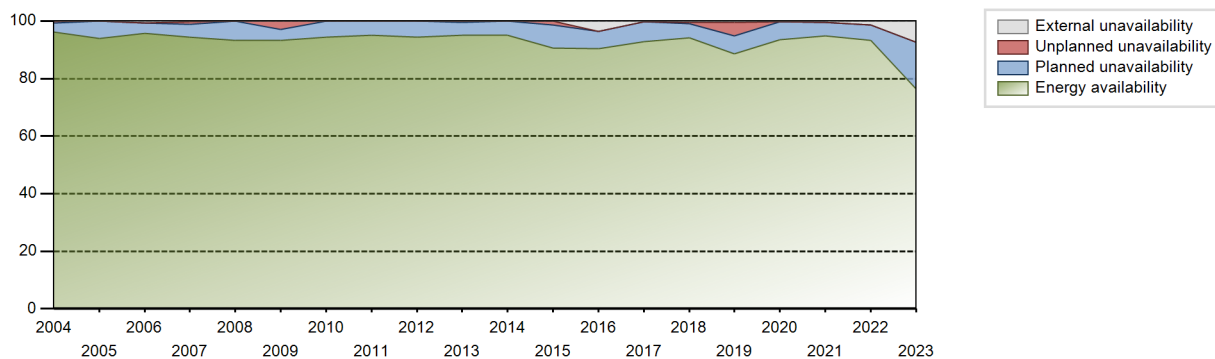
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 372718.97 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.34 % |
| Cumulative Energy Availability Factor (EAF) | : 93.21 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.56 % |
| Cumulative Unit Capability Factor (UCF) | : 93.51 % | Cumulative Planned Unavailability Factor (PUF) | : 5.93 % |
| Cumulative Load Factor (LF) | : 92.48 % | Cumulative Externally cause unavailability (XUF) | : 0.3 % |
| Cumulative Operating Factor (OF) | : 93.66 % | | |

Electricity Production (net) [GWh]

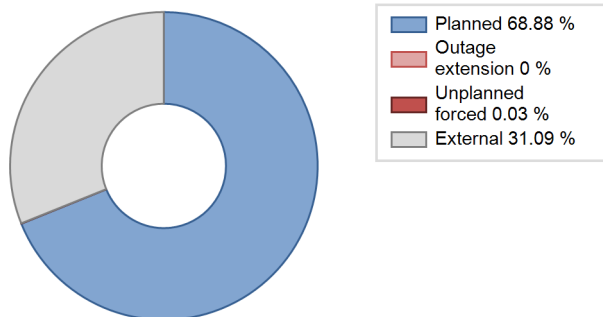


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 5694.91 | 4516 | 1262 | 96.27 | 96.27 | 98.06 | 96.54 | 3.68 | 3.68 | 0.05 | 0.00 |
| 1989 | 9857.21 | 7794 | 1242 | 88.65 | 88.65 | 90.60 | 88.97 | 1.23 | 1.10 | 10.25 | 0.00 |
| 1990 | 10039.24 | 7956 | 1256 | 90.37 | 90.37 | 91.18 | 90.82 | 0.14 | 0.13 | 9.50 | 0.00 |
| 1991 | 9287.28 | 7304 | 1242 | 81.99 | 81.99 | 85.36 | 83.38 | 0.01 | 0.01 | 18.00 | 0.00 |
| 1992 | 10158.05 | 7933 | 1290 | 90.16 | 90.16 | 89.65 | 90.31 | 1.93 | 1.77 | 8.07 | 0.00 |
| 1993 | 10477.10 | 8147 | 1290 | 92.92 | 92.92 | 92.71 | 93.00 | 0.00 | 0.00 | 7.08 | 0.00 |
| 1994 | 10526.69 | 8193 | 1290 | 93.43 | 93.43 | 93.15 | 93.53 | 0.56 | 0.53 | 6.04 | 0.00 |
| 1995 | 10495.72 | 8168 | 1290 | 93.09 | 93.09 | 92.88 | 93.24 | 1.75 | 1.66 | 5.25 | 0.00 |
| 1996 | 10557.29 | 8195 | 1290 | 93.19 | 93.19 | 93.17 | 93.29 | 0.04 | 0.04 | 6.77 | 0.00 |
| 1997 | 10650.19 | 8298 | 1290 | 94.58 | 94.58 | 94.25 | 94.73 | 0.05 | 0.05 | 5.37 | 0.00 |
| 1998 | 10794.75 | 8388 | 1290 | 95.69 | 95.69 | 95.53 | 95.75 | 0.11 | 0.10 | 4.21 | 0.00 |
| 1999 | 10729.18 | 8413 | 1290 | 95.96 | 95.96 | 94.95 | 96.04 | 0.00 | 0.00 | 4.04 | 0.00 |
| 2000 | 10801.99 | 8339 | 1329 | 94.91 | 94.91 | 94.14 | 94.93 | 0.00 | 0.00 | 5.09 | 0.00 |
| 2001 | 10933.15 | 8257 | 1329 | 93.80 | 94.15 | 93.91 | 94.26 | 0.30 | 0.29 | 5.57 | 0.35 |
| 2002 | 11242.30 | 8497 | 1329 | 96.86 | 96.86 | 96.57 | 97.00 | 0.11 | 0.10 | 3.04 | 0.00 |
| 2003 | 11096.98 | 8401 | 1329 | 95.84 | 95.84 | 95.32 | 95.90 | 0.01 | 0.01 | 4.15 | 0.00 |
| 2004 | 11147.20 | 8456 | 1329 | 96.08 | 96.08 | 95.49 | 96.27 | 0.10 | 0.70 | 3.23 | 0.00 |
| 2005 | 10887.83 | 8239 | 1329 | 93.92 | 93.92 | 93.51 | 94.04 | 0.00 | 0.00 | 6.08 | 0.00 |
| 2006 | 11147.60 | 8461 | 1329 | 95.80 | 96.43 | 95.75 | 96.59 | 0.03 | 0.03 | 3.55 | 0.63 |
| 2007 | 10989.22 | 8311 | 1329 | 94.43 | 94.70 | 94.38 | 94.86 | 0.16 | 0.88 | 4.42 | 0.27 |
| 2008 | 10896.15 | 8211 | 1329 | 93.37 | 93.45 | 93.34 | 93.48 | 0.00 | 0.00 | 6.55 | 0.08 |
| 2009 | 10849.24 | 8194 | 1329 | 93.25 | 93.27 | 93.19 | 93.54 | 2.81 | 2.82 | 3.92 | 0.02 |
| 2010 | 10977.96 | 8286 | 1329 | 94.41 | 94.42 | 94.30 | 94.59 | 0.08 | 0.07 | 5.50 | 0.01 |
| 2011 | 11055.52 | 8339 | 1329 | 94.97 | 95.06 | 94.96 | 95.19 | 0.00 | 0.00 | 4.94 | 0.08 |
| 2012 | 10847.66 | 8314 | 1329 | 94.50 | 94.50 | 92.92 | 94.65 | 0.06 | 0.06 | 5.44 | 0.00 |
| 2013 | 10912.11 | 8328 | 1329 | 94.95 | 94.95 | 93.73 | 95.07 | 0.41 | 0.39 | 4.66 | 0.00 |
| 2014 | 10954.90 | 8341 | 1335 | 95.14 | 95.14 | 93.88 | 95.22 | 0.00 | 0.00 | 4.86 | 0.00 |
| 2015 | 10396.15 | 7980 | 1335 | 90.60 | 90.60 | 88.90 | 91.10 | 0.03 | 1.46 | 7.94 | 0.00 |
| 2016 | 10539.68 | 8279 | 1335 | 90.44 | 94.13 | 89.88 | 94.25 | 0.00 | 0.00 | 5.86 | 3.70 |
| 2017 | 10751.53 | 8171 | 1335 | 92.93 | 93.13 | 91.94 | 93.28 | 0.01 | 0.01 | 6.87 | 0.20 |
| 2018 | 10915.03 | 8303 | 1335 | 94.16 | 94.67 | 93.33 | 94.78 | 0.03 | 0.51 | 4.82 | 0.51 |
| 2019 | 10237.09 | 7814 | 1335 | 88.70 | 89.12 | 87.54 | 89.20 | 0.00 | 4.83 | 6.05 | 0.42 |
| 2020 | 10836.45 | 8242 | 1335 | 93.61 | 93.76 | 92.41 | 93.83 | 0.07 | 0.06 | 6.18 | 0.15 |
| 2021 | 10779.48 | 8360 | 1335 | 94.85 | 95.37 | 92.17 | 95.43 | 0.00 | 0.00 | 4.63 | 0.51 |
| 2022 | 9846.05 | 8311 | 1335 | 93.36 | 94.83 | 84.19 | 94.87 | 0.00 | 0.00 | 5.17 | 1.47 |
| 2023 | 2103.90 | 2167 | 1335 | 76.31 | 83.67 | 60.96 | 83.66 | 0.01 | 0.01 | 16.32 | 7.37 |

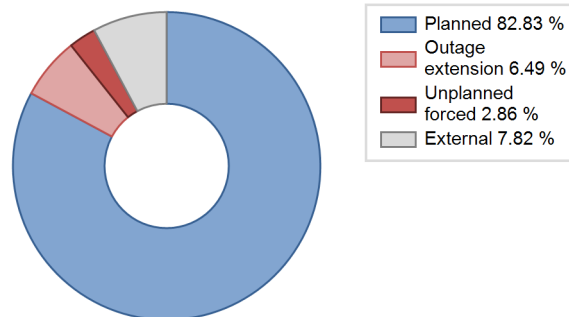
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1 | | | 41 | |
| B. Refuelling without maintenance | 353 | | | 10 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 473 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 3 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 2 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 4 | | |
| Z. Other | | | | | 2 | |
| Subtotal | 353 | 1 | | 490 | 45 | 0 |
| Total | | 354 | | | 535 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 1 | 0 |
| 12. Reactor I&C Systems | | 6 |
| 13. Reactor Auxiliary Systems | | 0 |
| 15. Reactor Cooling Systems | | 11 |
| 21. Fuel Handling and Storage Facilities | | 12 |
| 31. Turbine and auxiliaries | | 2 |
| 41. Main Generator Systems | | 8 |
| 42. Electrical Power Supply Systems | | 1 |
| Total | 1 | 40 |

2023 Operating Experience

DE-31

ISAR-2

GERMANY

Status at end of year : **Permanent Shutdown**
 Operator : PElektra (PreussenElektra GmbH)
 Owner : PEL/SwM (1. (75%) PreussenElektra GmbH)
 Reactor Supplier : KWU (KRAFTWERK UNION, AG)
 Turbine Supplier : KWU (KRAFTWERK UNION, AG)



Reactor Unit Details

Reactor type and model : PWR / Konvoi
 Thermal power : 3950 MWth
 Gross electrical power : 1485 MWe
 Reference unit power (net) : 1410 MWe

Key Dates

Construction Date : 1982-09-15
 Grid Date : 1988-01-22
 Commercial Date : 1988-04-09
 Age at end of year : 35 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2/MOX
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.2
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 20
 Average discharge burnup [MWd/t] : 32000
 Active core diameter [m] : 3.6
 Active core height/length [m] : 3.9
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 16.4
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 328
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 0.52

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.43
 Output voltage [kV] : 35
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

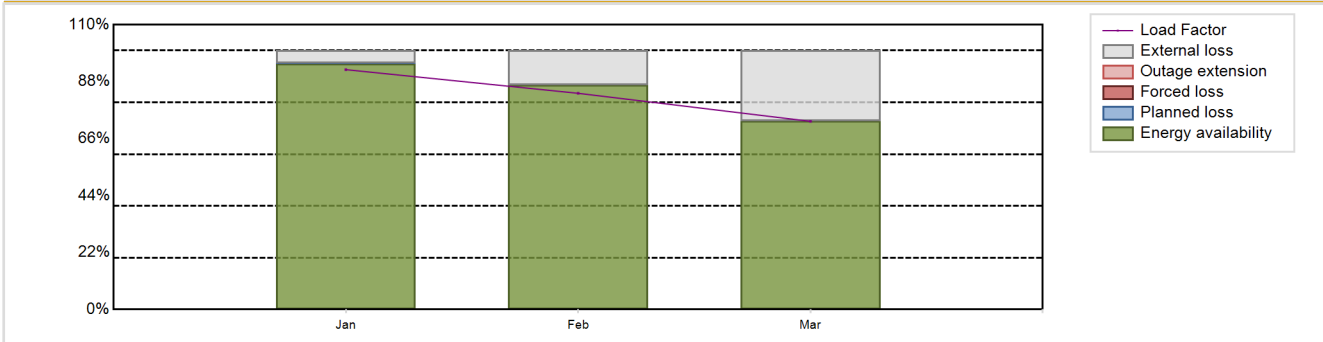
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 2834.05 GW(e).h
 Energy Availability Factor (EAF) : 84.78 %
 Unit Capability Factor (UCF) : 99.96 %
 Load Factor (LF) : 82.92 %
 Operating Factor (OF) : 100 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.04 %
 Externally cause unavailability (XUF) : 15.18 %
 Total off-line time : 0 hours

Annual Summary

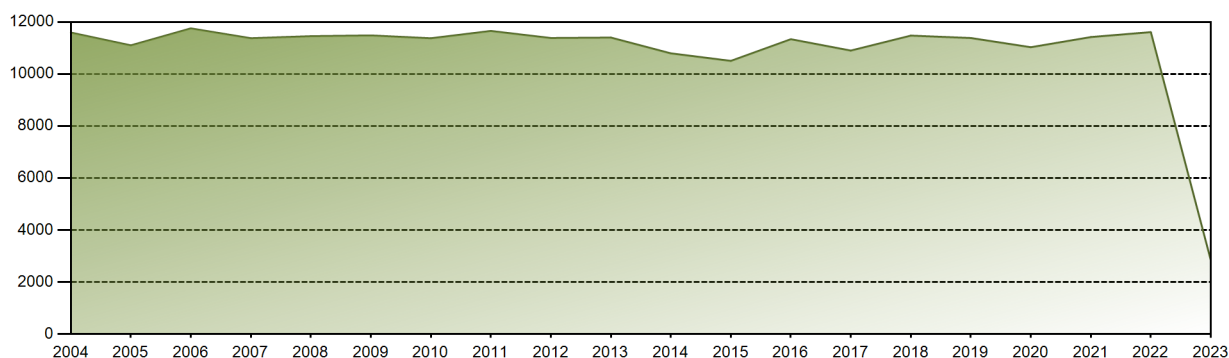


| | Oct | Nov | Dec | Apr | May | Jun | Jul | Aug | Sep | Jan | Feb | Mar | Annual |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|--------|--------|---------|
| GW(e)-h | | | | | | | | | | 971.79 | 791.28 | 762.44 | 2525.50 |
| EAF [%] | | | | | | | | | | 94.99 | 86.72 | 72.81 | 84.78 |
| UCF [%] | | | | | | | | | | 99.89 | 100.00 | 100.00 | 99.96 |
| LF [%] | | | | | | | | | | 92.64 | 83.51 | 72.68 | 82.92 |
| OF [%] | | | | | | | | | | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | | | | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | | | | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | | | | | | | | | | 0.11 | 0.00 | 0.00 | 0.04 |
| XUF [%] | | | | | | | | | | 4.90 | 13.28 | 27.19 | 15.18 |

Historical Summary

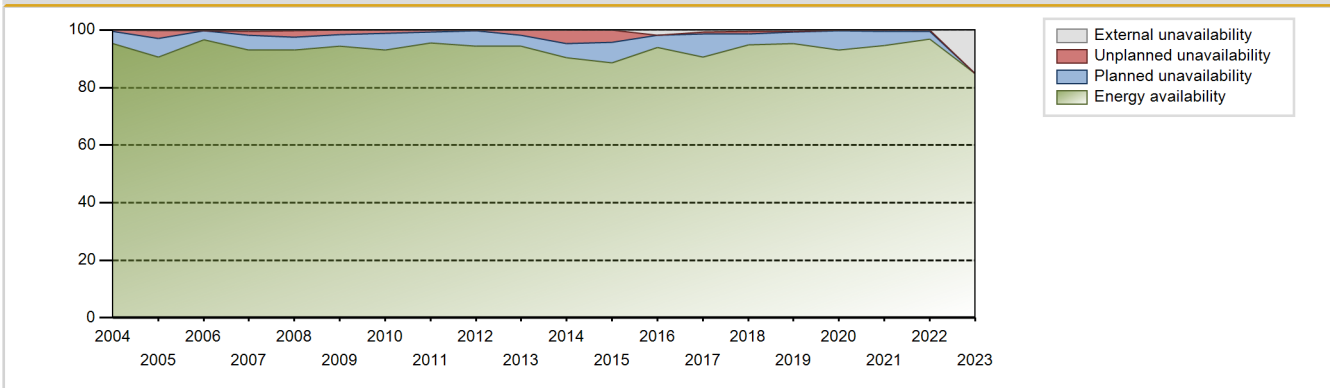
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 382692.07 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.85 % |
| Cumulative Energy Availability Factor (EAF) | : 92.45 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.26 % |
| Cumulative Unit Capability Factor (UCF) | : 92.86 % | Cumulative Planned Unavailability Factor (PUF) | : 5.88 % |
| Cumulative Load Factor (LF) | : 89.78 % | Cumulative Externally cause unavailability (XUF) | : 0.41 % |
| Cumulative Operating Factor (OF) | : 93.49 % | | |

Electricity Production (net) [GWh]

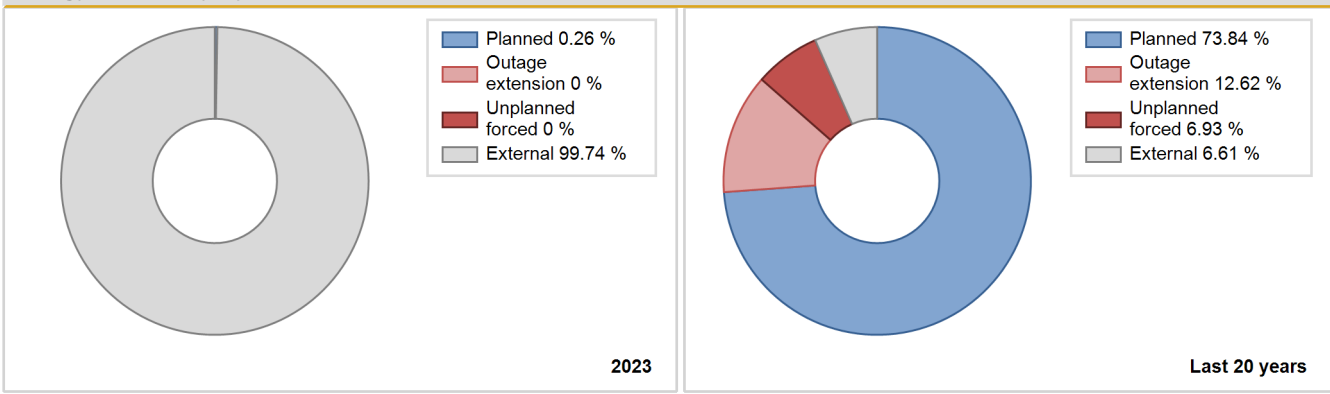


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 6023.00 | 6177 | 1323 | 95.09 | 95.09 | 69.65 | 93.58 | 4.81 | 4.81 | 0.11 | 0.00 |
| 1989 | 7728.92 | 6876 | 1310 | 73.41 | 73.41 | 67.35 | 78.49 | 12.96 | 10.93 | 15.65 | 0.00 |
| 1990 | 9271.36 | 7915 | 1310 | 84.94 | 84.94 | 80.79 | 90.35 | 0.58 | 0.49 | 14.57 | 0.00 |
| 1991 | 9699.19 | 7732 | 1318 | 87.78 | 87.78 | 83.98 | 88.26 | 1.54 | 1.38 | 10.84 | 0.00 |
| 1992 | 9843.49 | 7917 | 1320 | 89.93 | 89.93 | 84.90 | 90.13 | 0.36 | 0.32 | 9.75 | 0.00 |
| 1993 | 10192.97 | 8052 | 1330 | 88.08 | 91.26 | 87.49 | 91.92 | 0.03 | 0.03 | 8.71 | 3.18 |
| 1994 | 10499.86 | 8209 | 1330 | 93.14 | 93.14 | 90.12 | 93.71 | 1.00 | 0.94 | 5.92 | 0.00 |
| 1995 | 10040.31 | 7891 | 1332 | 89.85 | 89.85 | 86.01 | 90.08 | 0.18 | 0.16 | 9.99 | 0.00 |
| 1996 | 10265.10 | 7989 | 1338 | 88.52 | 90.65 | 87.29 | 90.95 | 0.08 | 0.07 | 9.27 | 2.13 |
| 1997 | 10906.39 | 8258 | 1365 | 94.10 | 94.10 | 91.21 | 94.27 | 0.02 | 0.02 | 5.88 | 0.00 |
| 1998 | 10758.10 | 8356 | 1365 | 93.60 | 93.61 | 89.97 | 95.39 | 1.65 | 1.57 | 4.82 | 0.01 |
| 1999 | 11610.87 | 8465 | 1380 | 96.51 | 96.51 | 96.05 | 96.63 | 0.00 | 0.00 | 3.49 | 0.00 |
| 2000 | 11291.15 | 8311 | 1400 | 94.50 | 94.50 | 91.82 | 94.62 | 0.05 | 0.04 | 5.46 | 0.00 |
| 2001 | 11731.31 | 8506 | 1400 | 97.14 | 97.14 | 95.66 | 97.10 | 0.01 | 0.01 | 2.84 | 0.00 |
| 2002 | 11512.23 | 8350 | 1400 | 95.10 | 95.10 | 93.87 | 95.32 | 0.07 | 0.06 | 4.84 | 0.00 |
| 2003 | 11671.59 | 8491 | 1400 | 95.93 | 96.67 | 95.17 | 96.93 | 0.29 | 0.28 | 3.05 | 0.75 |
| 2004 | 11595.28 | 8395 | 1400 | 95.39 | 95.39 | 94.29 | 95.57 | 0.05 | 0.57 | 4.05 | 0.00 |
| 2005 | 11102.56 | 7976 | 1400 | 90.52 | 90.87 | 90.53 | 91.05 | 0.02 | 2.57 | 6.55 | 0.35 |
| 2006 | 11755.26 | 8494 | 1400 | 96.61 | 96.82 | 95.85 | 96.96 | 0.01 | 0.01 | 3.18 | 0.20 |
| 2007 | 11377.49 | 8200 | 1400 | 93.05 | 93.43 | 92.76 | 93.60 | 0.00 | 1.48 | 5.09 | 0.38 |
| 2008 | 11456.15 | 8217 | 1400 | 93.15 | 93.33 | 93.16 | 93.55 | 1.10 | 2.36 | 4.31 | 0.18 |
| 2009 | 11484.85 | 8277 | 1410 | 94.32 | 94.32 | 93.37 | 94.49 | 0.00 | 1.65 | 4.03 | 0.00 |
| 2010 | 11375.28 | 8162 | 1410 | 92.99 | 92.99 | 92.10 | 93.17 | 0.00 | 1.21 | 5.81 | 0.00 |
| 2011 | 11655.84 | 8378 | 1410 | 95.48 | 95.48 | 94.37 | 95.64 | 0.00 | 0.67 | 3.85 | 0.00 |
| 2012 | 11385.03 | 8299 | 1410 | 94.31 | 94.31 | 91.92 | 94.48 | 0.00 | 0.37 | 5.32 | 0.00 |
| 2013 | 11402.06 | 8400 | 1410 | 94.29 | 94.31 | 92.31 | 95.89 | 1.63 | 1.84 | 3.85 | 0.02 |
| 2014 | 10794.90 | 8350 | 1410 | 90.48 | 90.55 | 87.40 | 95.32 | 4.77 | 4.72 | 4.73 | 0.07 |
| 2015 | 10505.19 | 7798 | 1410 | 88.67 | 88.75 | 85.05 | 89.02 | 0.00 | 4.16 | 7.10 | 0.08 |
| 2016 | 11338.88 | 8420 | 1410 | 93.97 | 95.68 | 91.55 | 95.86 | 0.00 | 0.00 | 4.32 | 1.71 |
| 2017 | 10901.56 | 8019 | 1410 | 90.50 | 91.15 | 88.26 | 91.54 | 0.50 | 0.71 | 8.14 | 0.64 |
| 2018 | 11477.22 | 8363 | 1410 | 94.85 | 95.24 | 92.92 | 95.47 | 0.24 | 0.97 | 3.79 | 0.39 |
| 2019 | 11384.22 | 8405 | 1410 | 95.28 | 95.77 | 92.17 | 95.95 | 0.10 | 0.16 | 4.07 | 0.49 |
| 2020 | 11030.83 | 8183 | 1410 | 92.99 | 92.99 | 89.06 | 93.16 | 0.10 | 0.18 | 6.83 | 0.00 |
| 2021 | 11421.16 | 8304 | 1410 | 94.62 | 94.62 | 92.47 | 94.79 | 0.10 | 0.43 | 4.95 | 0.00 |
| 2022 | 11610.81 | 8520 | 1410 | 96.87 | 96.88 | 94.00 | 97.26 | 0.50 | 0.49 | 2.63 | 0.02 |
| 2023 | 2834.05 | 2520 | 1410 | 84.78 | 99.96 | 82.92 | 100.00 | 0.00 | 0.00 | 0.04 | 15.18 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 65 | |
| B. Refuelling without maintenance | | | | 10 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 457 | 6 | |
| D. Inspection, maintenance or repair without refuelling | | | | 6 | | |
| E. Testing of plant systems or components | | | | 0 | 1 | |
| H. Nuclear regulatory requirements | | 1 | | | 0 | |
| L. Human factor related | | | | | 7 | |
| Z. Other | | | | | 1 | |
| Subtotal | | 1 | | 473 | 80 | |
| Total | | 1 | | | 553 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 9 |
| 15. Reactor Cooling Systems | | 12 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 0 |
| 31. Turbine and auxiliaries | | 4 |
| 32. Feedwater and Main Steam System | | 12 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 27 |
| 42. Electrical Power Supply Systems | | 0 |
| Total | | 64 |

2023 Operating Experience

DE-44 **NECKARWESTHEIM-2** **GERMANY**

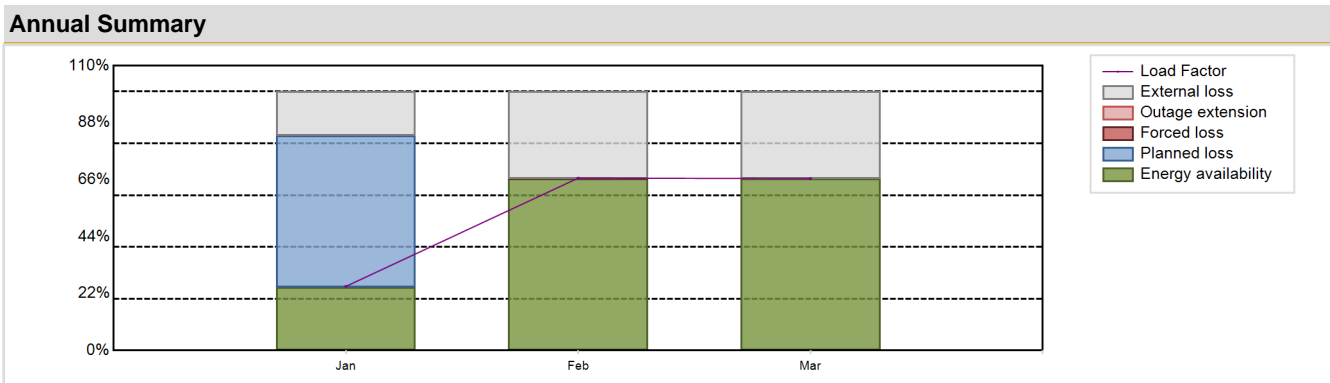
Status at end of year : **Permanent Shutdown**
 Operator : EnKK (EnBW Kernkraft GmbH)
 Owner : EnKK (EnBW Kernkraft GmbH)
 Reactor Supplier : KWU (KRAFTWERK UNION, AG)
 Turbine Supplier : KWU (KRAFTWERK UNION, AG)



| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------|--------------------|--------------|
| Reactor type and model | : PWR / Konvoi | Construction Date | : 1982-11-09 |
| Thermal power | : 3850 MWth | Grid Date | : 1989-01-03 |
| Gross electrical power | : 1400 MWe | Commercial Date | : 1989-04-15 |
| Reference unit power (net) | : 1310 MWe | Age at end of year | : 34 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 325.6 |
| Fuel material | : UO2/MOX | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.52 |
| Average fuel enrichment [% of U235] | : 2.0 | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 23 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 46000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.6 | HP cylinder inlet steam pressure [MPa] | : 6.23 |
| Active core height/length [m] | : 3.9 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 193 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 16.4 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 1785.06 GW(e).h | Forced Loss Rate (FLR) | : 0.03 % |
| Energy Availability Factor (EAF) | : 51.96 % | Unplanned Capability Loss Factor (UCL) | : 0.03 % |
| Unit Capability Factor (UCF) | : 79.79 % | Planned Unavailability Factor (PUF) | : 20.19 % |
| Load Factor (LF) | : 52.12 % | Externally cause unavailability (XUF) | : 27.83 % |
| Operating Factor (OF) | : 79.77 % | Total off-line time | : 437 hours |

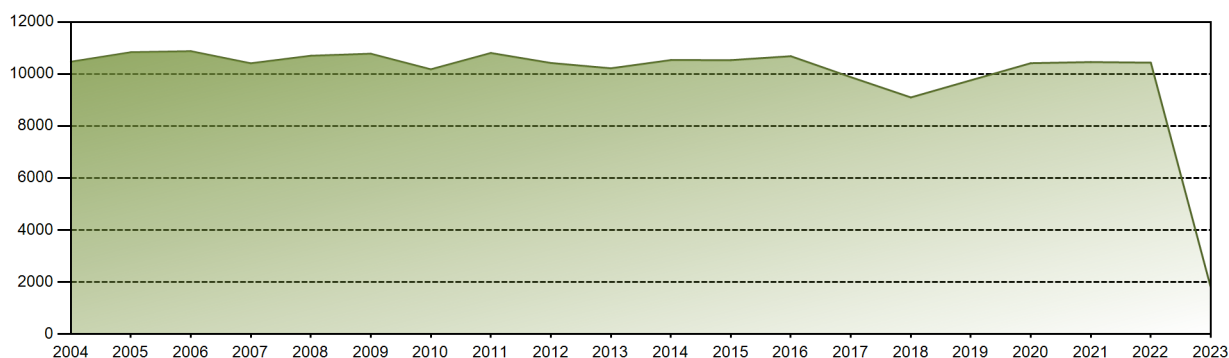


| | Oct | Nov | Dec | Apr | May | Jun | Jul | Aug | Sep | Jan | Feb | Mar | Annual |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|--------|--------|---------|
| GW(e)-h | | | | | | | | | | 241.40 | 586.22 | 647.08 | 1474.70 |
| EAF [%] | | | | | | | | | | 24.46 | 66.33 | 66.48 | 51.96 |
| UCF [%] | | | | | | | | | | 41.40 | 99.91 | 100.00 | 79.79 |
| LF [%] | | | | | | | | | | 24.77 | 66.59 | 66.39 | 52.12 |
| OF [%] | | | | | | | | | | 41.40 | 100.00 | 99.87 | 79.77 |
| FLR [%] | | | | | | | | | | 0.00 | 0.09 | 0.00 | 0.03 |
| UCL [%] | | | | | | | | | | 0.00 | 0.09 | 0.00 | 0.03 |
| PUF [%] | | | | | | | | | | 58.60 | 0.00 | 0.00 | 20.19 |
| XUF [%] | | | | | | | | | | 16.94 | 33.58 | 33.52 | 27.83 |

Historical Summary

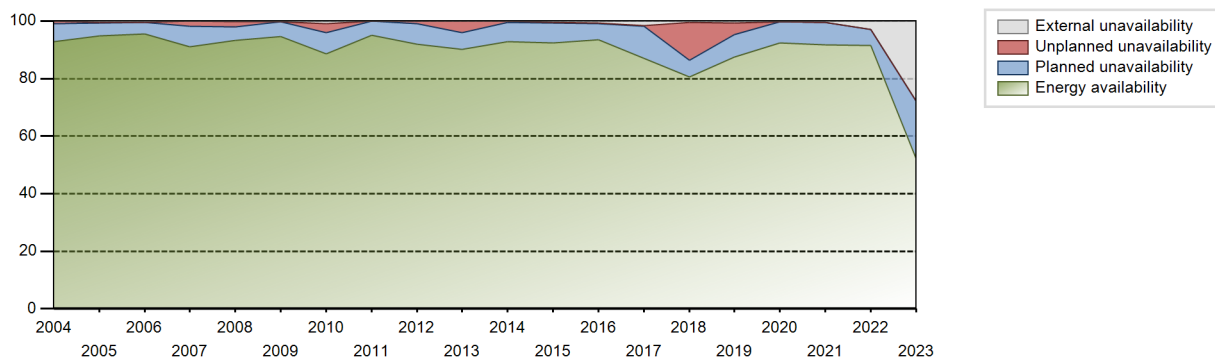
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 351204.03 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.89 % |
| Cumulative Energy Availability Factor (EAF) | : 91.98 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.18 % |
| Cumulative Unit Capability Factor (UCF) | : 92.52 % | Cumulative Planned Unavailability Factor (PUF) | : 6.3 % |
| Cumulative Load Factor (LF) | : 90.96 % | Cumulative Externally cause unavailability (XUF) | : 0.54 % |
| Cumulative Operating Factor (OF) | : 92.74 % | | |

Electricity Production (net) [GWh]

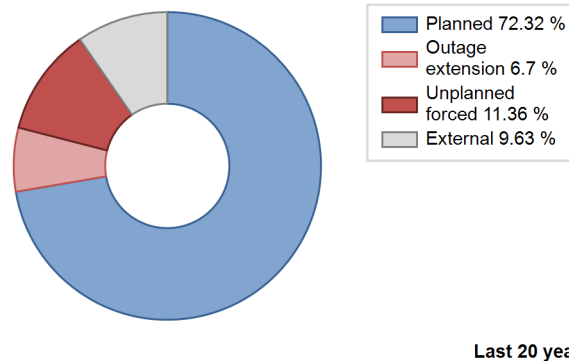
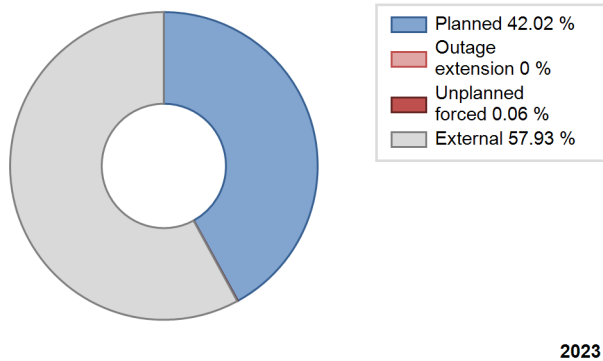


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 8673.22 | 8205 | 1225 | 99.76 | 99.76 | 84.22 | 94.74 | 0.00 | 0.00 | 0.24 | 0.00 |
| 1990 | 9693.91 | 7958 | 1225 | 90.21 | 90.21 | 90.34 | 90.84 | 0.27 | 0.24 | 9.55 | 0.00 |
| 1991 | 9434.93 | 7932 | 1225 | 90.52 | 90.52 | 87.92 | 90.55 | 0.14 | 0.13 | 9.35 | 0.00 |
| 1992 | 10204.58 | 8094 | 1269 | 91.58 | 91.58 | 91.55 | 92.14 | 0.09 | 0.08 | 8.35 | 0.00 |
| 1993 | 9912.15 | 8163 | 1269 | 89.03 | 89.03 | 89.17 | 93.18 | 0.04 | 0.04 | 10.93 | 0.00 |
| 1994 | 10320.67 | 8215 | 1269 | 93.60 | 93.60 | 92.84 | 93.78 | 0.15 | 0.14 | 6.26 | 0.00 |
| 1995 | 10532.05 | 8351 | 1269 | 94.69 | 94.69 | 94.74 | 95.33 | 0.00 | 0.00 | 5.31 | 0.00 |
| 1996 | 10614.28 | 8419 | 1269 | 95.10 | 95.10 | 95.22 | 95.84 | 0.00 | 0.00 | 4.90 | 0.00 |
| 1997 | 10111.62 | 8028 | 1269 | 91.55 | 91.55 | 90.96 | 91.64 | 0.00 | 0.00 | 8.45 | 0.00 |
| 1998 | 10610.81 | 8411 | 1269 | 96.00 | 96.00 | 95.45 | 96.02 | 0.00 | 0.00 | 4.00 | 0.00 |
| 1999 | 10460.93 | 8435 | 1269 | 96.09 | 96.09 | 94.10 | 96.29 | 0.04 | 0.04 | 3.87 | 0.00 |
| 2000 | 10473.89 | 8450 | 1269 | 96.20 | 96.20 | 93.96 | 96.20 | 0.00 | 0.00 | 3.80 | 0.00 |
| 2001 | 10423.94 | 8363 | 1269 | 94.18 | 95.40 | 93.77 | 95.47 | 0.00 | 0.00 | 4.60 | 1.22 |
| 2002 | 9787.51 | 7777 | 1269 | 88.67 | 88.67 | 88.05 | 88.78 | 6.64 | 6.30 | 5.03 | 0.00 |
| 2003 | 10544.97 | 8408 | 1269 | 95.80 | 95.80 | 94.86 | 95.98 | 1.28 | 1.24 | 2.96 | 0.00 |
| 2004 | 10470.68 | 8165 | 1269 | 92.87 | 92.87 | 93.93 | 92.95 | 0.00 | 1.02 | 6.11 | 0.00 |
| 2005 | 10836.41 | 8371 | 1305 | 94.81 | 95.38 | 94.79 | 95.56 | 0.17 | 0.16 | 4.47 | 0.56 |
| 2006 | 10877.47 | 8405 | 1305 | 95.41 | 95.90 | 95.15 | 95.95 | 0.00 | 0.00 | 4.10 | 0.49 |
| 2007 | 10411.09 | 8002 | 1310 | 91.07 | 91.13 | 90.72 | 91.35 | 1.84 | 1.70 | 7.17 | 0.05 |
| 2008 | 10701.91 | 8245 | 1310 | 93.26 | 93.47 | 93.00 | 93.86 | 0.00 | 1.93 | 4.61 | 0.20 |
| 2009 | 10779.73 | 8307 | 1310 | 94.59 | 94.75 | 93.94 | 94.83 | 0.00 | 0.00 | 5.25 | 0.16 |
| 2010 | 10180.15 | 7864 | 1310 | 88.62 | 89.49 | 88.71 | 89.77 | 0.13 | 3.23 | 7.28 | 0.87 |
| 2011 | 10807.81 | 8319 | 1310 | 94.95 | 94.96 | 94.18 | 94.97 | 0.06 | 0.06 | 4.99 | 0.01 |
| 2012 | 10424.21 | 8098 | 1310 | 91.83 | 91.83 | 90.59 | 92.19 | 0.01 | 1.03 | 7.15 | 0.00 |
| 2013 | 10218.79 | 7906 | 1310 | 90.05 | 90.05 | 89.05 | 90.25 | 4.22 | 3.97 | 5.98 | 0.00 |
| 2014 | 10535.82 | 8159 | 1310 | 92.88 | 92.88 | 91.81 | 93.14 | 0.04 | 0.58 | 6.54 | 0.00 |
| 2015 | 10532.84 | 8158 | 1310 | 92.42 | 92.90 | 91.78 | 93.13 | 0.15 | 0.14 | 6.95 | 0.49 |
| 2016 | 10684.13 | 8318 | 1310 | 93.52 | 94.26 | 92.85 | 94.69 | 0.17 | 0.16 | 5.58 | 0.74 |
| 2017 | 9880.27 | 7791 | 1310 | 86.97 | 88.60 | 86.10 | 88.94 | 0.19 | 0.17 | 11.24 | 1.63 |
| 2018 | 9099.36 | 7121 | 1310 | 80.54 | 81.00 | 79.29 | 81.29 | 14.01 | 13.19 | 5.81 | 0.46 |
| 2019 | 9758.34 | 7700 | 1310 | 87.40 | 88.00 | 85.04 | 87.90 | 0.08 | 4.18 | 7.82 | 0.60 |
| 2020 | 10415.99 | 8141 | 1310 | 92.33 | 92.61 | 90.52 | 92.68 | 0.06 | 0.05 | 7.33 | 0.28 |
| 2021 | 10459.26 | 8082 | 1310 | 91.75 | 92.31 | 91.14 | 92.26 | 0.03 | 0.03 | 7.67 | 0.56 |
| 2022 | 10435.38 | 8272 | 1310 | 91.55 | 94.42 | 90.94 | 94.43 | 0.00 | 0.00 | 5.58 | 2.86 |
| 2023 | 1785.06 | 2083 | 1310 | 51.96 | 79.79 | 52.12 | 79.77 | 0.03 | 0.03 | 20.19 | 27.83 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 23 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 505 | | |
| D. Inspection, maintenance or repair without refuelling | 436 | | | 27 | | |
| H. Nuclear regulatory requirements | | 2 | | | 0 | |
| L. Human factor related | | | | | 13 | |
| O. Load dispatching, prioritization | | | | | | 0 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 10 | |
| Subtotal | 436 | 2 | | 532 | 46 | 0 |
| Total | | 438 | | | 578 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 17 |
| 12. Reactor I&C Systems | | 3 |
| 21. Fuel Handling and Storage Facilities | | 10 |
| 32. Feedwater and Main Steam System | | 0 |
| 41. Main Generator Systems | | 2 |
| Total | | 32 |

2023 Operating Experience

HU-1

PAKS-1

HUNGARY

Status at end of year : **Operational**
 Operator : PAKS Zrt (PAKS NUCLEAR POWER PLANT, LTD.)
 Owner : MVM Zrt. (HUNGARIAN POWER COMPANIES LTD.)
 Reactor Supplier : AEE (ATOMENERGOEXPORT)
 Turbine Supplier : KTP (Kharkiv Turbine Plant "Turboatom")



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1485 MWth
 Gross electrical power : 509 MWe
 Reference unit power (net) : 479 MWe

Key Dates

Construction Date : 1974-08-01
 Grid Date : 1982-12-28
 Commercial Date : 1983-08-10
 Age at end of year : 41 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.6
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 30
 Average discharge burnup [MWd/t] : 37000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.42
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.5
 Reactor outlet temperature [°C] : 297
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.15

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.2
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

Non-electrical applications

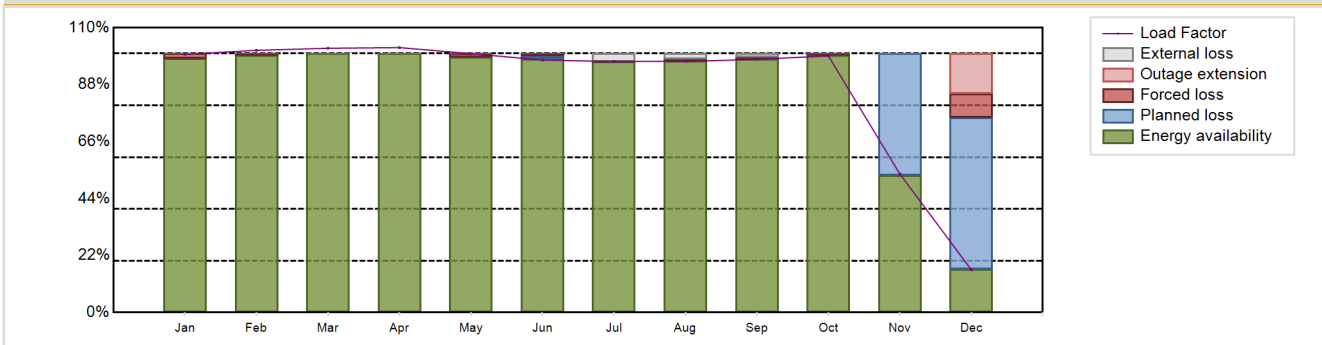
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3715.12 GW(e).h
 Energy Availability Factor (EAF) : 87.81 %
 Unit Capability Factor (UCF) : 88.37 %
 Load Factor (LF) : 88.54 %
 Operating Factor (OF) : 89.95 %

Forced Loss Rate (FLR) : 1.52 %
 Unplanned Capability Loss Factor (UCL) : 2.68 %
 Planned Unavailability Factor (PUF) : 8.95 %
 Externally cause unavailability (XUF) : 0.56 %
 Total off-line time : 880 hours

Annual Summary

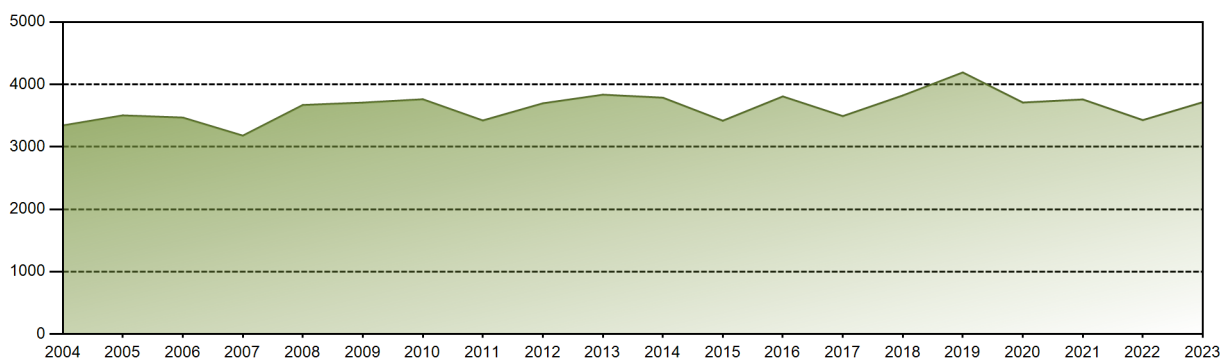


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|---------|
| GW(e)-h | 355.33 | 325.98 | 363.21 | 352.86 | 356.31 | 336.26 | 345.53 | 345.52 | 337.23 | 353.64 | 184.50 | 58.77 | 3715.12 |
| EAF [%] | 98.03 | 99.25 | 100.00 | 100.00 | 98.62 | 97.92 | 96.96 | 97.04 | 97.78 | 99.40 | 53.03 | 16.71 | 87.81 |
| UCF [%] | 98.03 | 99.25 | 100.00 | 100.00 | 98.62 | 97.92 | 99.99 | 99.20 | 99.23 | 99.40 | 53.03 | 16.71 | 88.37 |
| LF [%] | 99.71 | 101.27 | 102.05 | 102.31 | 99.98 | 97.50 | 96.96 | 96.95 | 97.78 | 99.10 | 53.50 | 16.49 | 88.54 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 53.61 | 26.61 | 89.95 |
| FLR [%] | 1.97 | 0.75 | 0.00 | 0.00 | 1.38 | 0.77 | 0.01 | 0.80 | 0.77 | 0.59 | 0.00 | 35.35 | 1.52 |
| UCL [%] | 1.97 | 0.75 | 0.00 | 0.00 | 1.38 | 0.76 | 0.01 | 0.80 | 0.77 | 0.59 | 0.00 | 24.66 | 2.68 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.31 | 0.00 | 0.00 | 0.00 | 0.01 | 46.97 | 58.63 | 8.95 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.04 | 2.16 | 1.45 | 0.00 | 0.00 | 0.00 | 0.56 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 138789.28 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.7 % |
| Cumulative Energy Availability Factor (EAF) | : 86.72 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.07 % |
| Cumulative Unit Capability Factor (UCF) | : 86.89 % | Cumulative Planned Unavailability Factor (PUF) | : 11.04 % |
| Cumulative Load Factor (LF) | : 87.58 % | Cumulative Externally cause unavailability (XUF) | : 0.16 % |
| Cumulative Operating Factor (OF) | : 87.87 % | | |

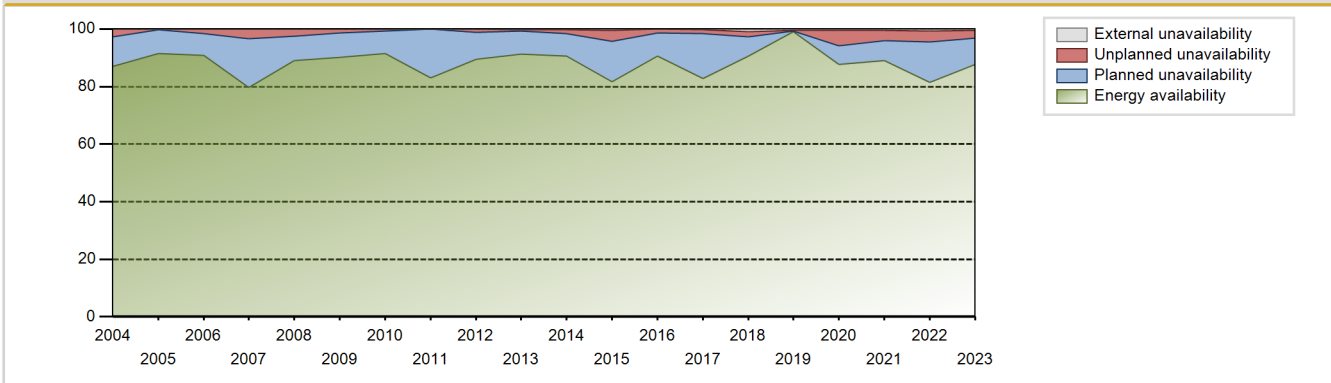
Electricity Production (net) [GWh]



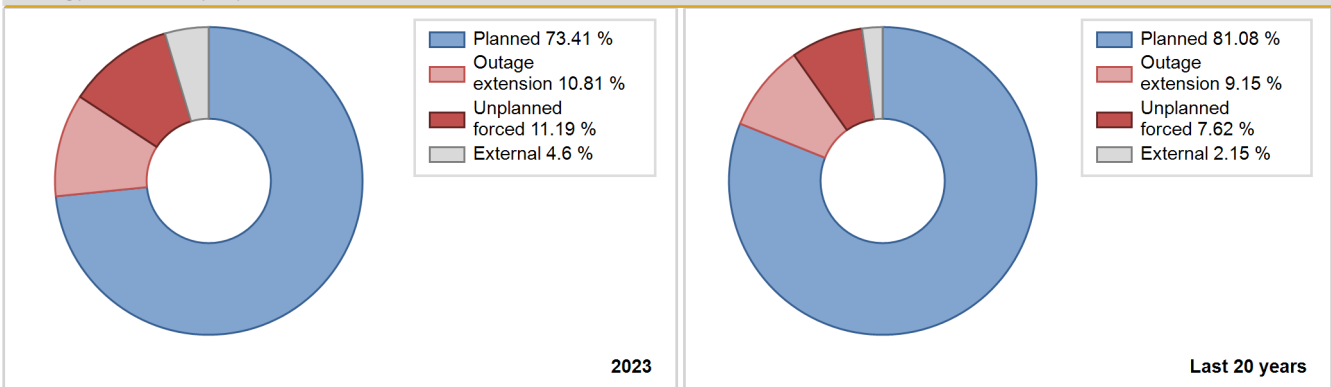
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 2299.70 | 7106 | 410 | 91.00 | 91.00 | 91.00 | 99.73 | 9.00 | 9.00 | 0.00 | 0.00 |
| 1984 | 2595.30 | 6901 | 403 | 75.63 | 75.73 | 73.25 | 78.56 | 1.28 | 0.98 | 23.29 | 0.10 |
| 1985 | 2997.30 | 7491 | 410 | 84.15 | 84.15 | 83.45 | 85.51 | 1.01 | 0.86 | 14.99 | 0.00 |
| 1986 | 3114.64 | 7718 | 410 | 87.11 | 87.11 | 86.72 | 88.11 | 0.69 | 0.61 | 12.28 | 0.00 |
| 1987 | 2883.09 | 7107 | 415 | 79.20 | 79.20 | 79.31 | 81.13 | 0.56 | 0.45 | 20.35 | 0.00 |
| 1988 | 3076.94 | 7737 | 415 | 85.83 | 85.83 | 84.41 | 88.08 | 3.88 | 3.47 | 10.70 | 0.00 |
| 1989 | 3182.18 | 7929 | 415 | 87.68 | 87.68 | 87.53 | 90.51 | 1.00 | 0.88 | 11.44 | 0.00 |
| 1990 | 3216.83 | 7837 | 415 | 87.22 | 87.22 | 88.49 | 89.46 | 3.83 | 3.48 | 9.31 | 0.00 |
| 1991 | 2883.91 | 6823 | 410 | 75.08 | 75.08 | 80.30 | 77.89 | 7.82 | 6.37 | 18.55 | 0.00 |
| 1992 | 3498.85 | 7629 | 430 | 84.92 | 84.94 | 92.63 | 86.85 | 5.50 | 4.95 | 10.11 | 0.02 |
| 1993 | 3512.43 | 7637 | 430 | 85.80 | 85.80 | 93.25 | 87.18 | 4.98 | 4.50 | 9.70 | 0.00 |
| 1994 | 3441.51 | 8031 | 430 | 89.81 | 89.86 | 91.36 | 91.68 | 1.34 | 1.22 | 8.92 | 0.05 |
| 1995 | 3056.32 | 7088 | 430 | 79.54 | 79.64 | 81.14 | 80.91 | 3.61 | 2.98 | 17.38 | 0.10 |
| 1996 | 3472.68 | 8033 | 430 | 90.62 | 90.74 | 91.94 | 91.45 | 0.76 | 0.70 | 8.57 | 0.11 |
| 1997 | 3328.48 | 7646 | 430 | 86.95 | 87.04 | 88.36 | 87.28 | 1.24 | 1.09 | 11.87 | 0.09 |
| 1998 | 3487.73 | 8095 | 430 | 92.37 | 92.41 | 92.59 | 92.41 | 0.39 | 0.36 | 7.23 | 0.04 |
| 1999 | 3117.54 | 7240 | 430 | 81.25 | 81.61 | 82.76 | 82.65 | 1.21 | 1.00 | 17.39 | 0.36 |
| 2000 | 3192.12 | 7268 | 430 | 82.27 | 82.53 | 84.51 | 82.74 | 4.10 | 3.53 | 13.95 | 0.26 |
| 2001 | 3514.87 | 8069 | 437 | 91.61 | 91.77 | 91.82 | 92.11 | 0.18 | 0.17 | 8.07 | 0.15 |
| 2002 | 3330.66 | 7909 | 437 | 90.08 | 90.21 | 87.01 | 90.29 | 0.07 | 0.07 | 9.72 | 0.13 |
| 2003 | 3097.84 | 7197 | 437 | 80.96 | 80.96 | 80.91 | 82.15 | 3.43 | 3.04 | 16.00 | 0.00 |
| 2004 | 3342.33 | 7692 | 437 | 87.07 | 87.07 | 87.07 | 87.57 | 0.21 | 2.70 | 10.23 | 0.00 |
| 2005 | 3503.53 | 8029 | 437 | 91.52 | 91.52 | 91.52 | 91.66 | 0.18 | 0.25 | 8.23 | 0.00 |
| 2006 | 3468.50 | 7979 | 437 | 90.83 | 90.83 | 90.61 | 91.08 | 0.26 | 1.48 | 7.68 | 0.00 |
| 2007 | 3179.36 | 6933 | 470 | 79.71 | 79.71 | 79.74 | 79.14 | 0.52 | 3.33 | 16.96 | 0.00 |
| 2008 | 3670.29 | 7824 | 470 | 88.94 | 88.94 | 88.90 | 89.07 | 2.35 | 2.59 | 8.47 | 0.00 |
| 2009 | 3708.04 | 7926 | 470 | 90.19 | 90.19 | 90.06 | 90.48 | 0.34 | 1.34 | 8.47 | 0.00 |
| 2010 | 3762.00 | 8031 | 470 | 91.46 | 91.46 | 91.37 | 91.68 | 0.00 | 0.67 | 7.87 | 0.00 |
| 2011 | 3422.07 | 7291 | 470 | 83.12 | 83.12 | 83.12 | 83.23 | 0.09 | 0.08 | 16.80 | 0.00 |
| 2012 | 3697.01 | 7881 | 470 | 89.57 | 89.57 | 89.55 | 89.72 | 0.47 | 1.24 | 9.19 | 0.00 |
| 2013 | 3834.70 | 8009 | 470 | 91.29 | 91.45 | 93.14 | 91.43 | 0.02 | 0.59 | 7.97 | 0.16 |
| 2014 | 3787.47 | 8022 | 470 | 90.51 | 90.69 | 91.99 | 91.58 | 0.82 | 1.48 | 7.83 | 0.18 |
| 2015 | 3418.04 | 7194 | 470 | 81.59 | 82.00 | 83.02 | 82.12 | 0.00 | 3.94 | 14.06 | 0.41 |
| 2016 | 3806.89 | 8056 | 470 | 90.69 | 90.80 | 92.21 | 91.71 | 0.95 | 1.17 | 8.03 | 0.10 |
| 2017 | 3492.07 | 7421 | 470 | 82.88 | 83.23 | 84.82 | 84.71 | 1.38 | 1.17 | 15.60 | 0.35 |
| 2018 | 3822.70 | 8103 | 479 | 90.59 | 91.46 | 91.10 | 92.50 | 0.68 | 1.83 | 6.71 | 0.87 |
| 2019 | 4192.05 | 8760 | 479 | 99.16 | 99.73 | 99.90 | 100.00 | 0.19 | 0.19 | 0.08 | 0.57 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2020 | 3709.65 | 8151 | 479 | 87.60 | 88.11 | 88.17 | 92.79 | 4.97 | 5.28 | 6.61 | 0.51 |
| 2021 | 3759.42 | 7926 | 479 | 88.95 | 89.43 | 89.59 | 90.48 | 3.17 | 3.54 | 7.03 | 0.48 |
| 2022 | 3428.09 | 7197 | 479 | 81.41 | 82.17 | 81.70 | 82.16 | 1.38 | 3.69 | 14.14 | 0.76 |
| 2023 | 3715.12 | 7880 | 479 | 87.81 | 88.37 | 88.54 | 89.95 | 1.52 | 2.68 | 8.95 | 0.56 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 114 | | | 96 | |
| C. Inspection, maintenance or repair combined with refuelling | 766 | | | 936 | 17 | |
| D. Inspection, maintenance or repair without refuelling | | | | 14 | | |
| E. Testing of plant systems or components | | | | | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 1 | |
| Z. Other | | | | | 9 | |
| Subtotal | 766 | 114 | | 950 | 123 | 0 |
| Total | | 880 | | | 1073 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 0 |
| 12. Reactor I&C Systems | | 20 |
| 13. Reactor Auxiliary Systems | | 5 |
| 14. Safety Systems | | 12 |
| 15. Reactor Cooling Systems | | 8 |
| 16. Steam generation systems | 114 | 13 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 10 |
| 32. Feedwater and Main Steam System | | 7 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | | 9 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 3 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | 114 | 99 |

Highlights (2023)

Operation at full power in base load mode

2023 Operating Experience

HU-2

PAKS-2

HUNGARY

Status at end of year : **Operational**
 Operator : PAKS Zrt (PAKS NUCLEAR POWER PLANT, LTD.)
 Owner : MVM Zrt. (HUNGARIAN POWER COMPANIES LTD.)
 Reactor Supplier : AEE (ATOMENERGOEXPORT)
 Turbine Supplier : KTP (Kharkiv Turbine Plant "Turboatom")



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1485 MWth
 Gross electrical power : 506 MWe
 Reference unit power (net) : 479 MWe

Key Dates

Construction Date : 1974-08-01
 Grid Date : 1984-09-06
 Commercial Date : 1984-11-14
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.82
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 30
 Average discharge burnup [MWd/t] : 37000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.42
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.5
 Reactor outlet temperature [°C] : 297
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.15

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.315
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

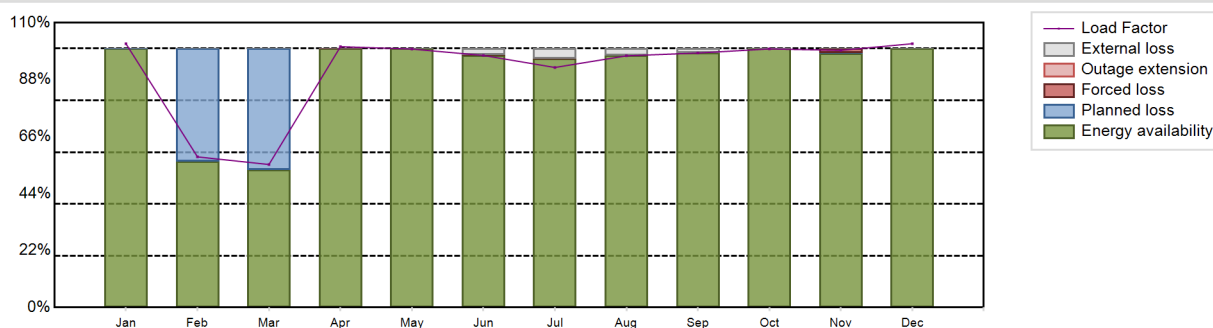
Non-electrical applications : DH

Annual Production Results (2023)

Net Energy Production : 3863.62 GW(e).h
 Energy Availability Factor (EAF) : 91.63 %
 Unit Capability Factor (UCF) : 92.5 %
 Load Factor (LF) : 92.08 %
 Operating Factor (OF) : 93.26 %
 Equivalent non-electrical energy generated (NEG) : 0.02 GW(e).h

Forced Loss Rate (FLR) : 0.16 %
 Unplanned Capability Loss Factor (UCL) : 0.15 %
 Planned Unavailability Factor (PUF) : 7.35 %
 Externally cause unavailability (XUF) : 0.87 %
 Total off-line time : 590 hours

Annual Summary

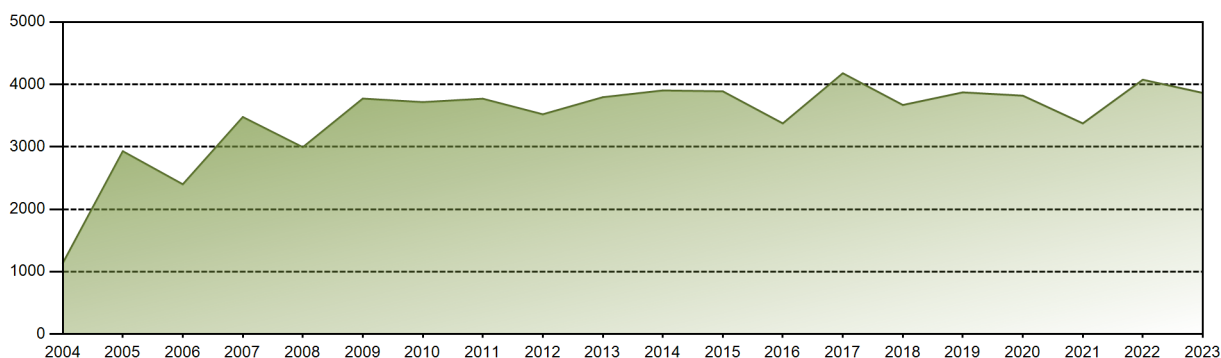


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 363.01 | 187.28 | 196.59 | 347.41 | 355.72 | 335.75 | 330.40 | 346.39 | 338.99 | 356.37 | 342.57 | 363.13 | 3863.62 |
| EAF [%] | 99.99 | 56.45 | 53.16 | 99.99 | 100.00 | 97.45 | 96.22 | 97.33 | 98.29 | 100.00 | 98.11 | 100.00 | 91.63 |
| UCF [%] | 99.99 | 56.45 | 53.16 | 99.99 | 100.00 | 99.70 | 99.99 | 100.00 | 100.00 | 100.00 | 98.11 | 100.00 | 92.50 |
| LF [%] | 101.86 | 58.18 | 55.24 | 100.73 | 99.82 | 97.35 | 92.71 | 97.20 | 98.29 | 99.87 | 99.33 | 101.89 | 92.08 |
| OF [%] | 100.00 | 57.44 | 59.08 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.26 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.30 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.30 | 0.01 | 0.00 | 0.00 | 0.00 | 1.52 | 0.00 | 0.15 |
| PUF [%] | 0.01 | 43.55 | 46.84 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 0.00 | 7.35 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.25 | 3.77 | 2.67 | 1.71 | 0.00 | 0.00 | 0.00 | 0.87 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 129604.36 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.99 % |
| Cumulative Energy Availability Factor (EAF) | : 83.35 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.24 % |
| Cumulative Unit Capability Factor (UCF) | : 83.57 % | Cumulative Planned Unavailability Factor (PUF) | : 11.19 % |
| Cumulative Load Factor (LF) | : 84.22 % | Cumulative Externally cause unavailability (XUF) | : 0.22 % |
| Cumulative Operating Factor (OF) | : 84.21 % | | |

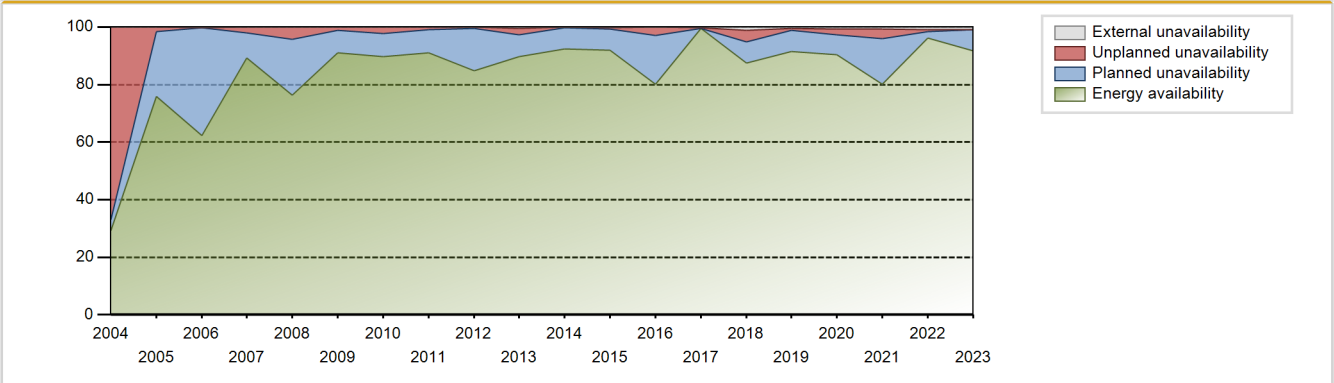
Electricity Production (net) [GWh]



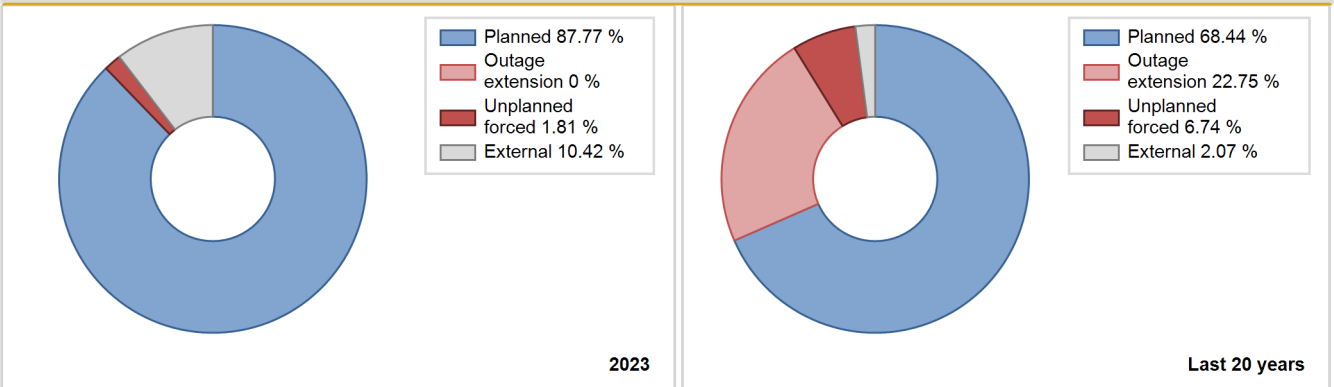
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 921.75 | 2659 | 425 | 94.06 | 94.06 | 97.33 | 99.45 | 1.21 | 1.15 | 4.78 | 0.00 |
| 1985 | 3101.62 | 7695 | 415 | 85.11 | 85.11 | 85.32 | 87.84 | 0.75 | 0.64 | 14.25 | 0.00 |
| 1986 | 3148.27 | 7643 | 415 | 86.01 | 86.01 | 86.60 | 87.25 | 2.11 | 1.85 | 12.14 | 0.00 |
| 1987 | 3193.95 | 7770 | 415 | 85.33 | 85.33 | 87.86 | 88.70 | 3.06 | 2.69 | 11.98 | 0.00 |
| 1988 | 3046.30 | 7352 | 415 | 81.93 | 81.93 | 83.57 | 83.70 | 0.20 | 0.17 | 17.90 | 0.00 |
| 1989 | 3300.66 | 7962 | 415 | 88.63 | 88.63 | 90.79 | 90.89 | 1.01 | 0.91 | 10.46 | 0.00 |
| 1990 | 3338.22 | 7845 | 425 | 87.99 | 87.99 | 89.66 | 89.55 | 3.12 | 2.83 | 9.18 | 0.00 |
| 1991 | 3421.60 | 7912 | 415 | 88.63 | 88.63 | 94.12 | 90.32 | 2.25 | 2.04 | 9.32 | 0.00 |
| 1992 | 3174.93 | 6829 | 433 | 76.00 | 76.01 | 83.47 | 77.74 | 6.63 | 5.40 | 18.59 | 0.02 |
| 1993 | 3568.98 | 7731 | 433 | 87.00 | 87.00 | 94.09 | 88.25 | 0.43 | 0.38 | 12.62 | 0.00 |
| 1994 | 3440.38 | 8000 | 433 | 89.44 | 89.50 | 90.70 | 91.32 | 0.18 | 0.16 | 10.34 | 0.06 |
| 1995 | 3309.08 | 7657 | 433 | 86.45 | 86.63 | 87.24 | 87.41 | 5.62 | 5.16 | 8.21 | 0.18 |
| 1996 | 3019.89 | 7011 | 433 | 79.41 | 79.50 | 79.40 | 79.82 | 5.89 | 4.98 | 15.52 | 0.09 |
| 1997 | 3267.61 | 7807 | 433 | 88.20 | 88.26 | 86.15 | 89.12 | 6.15 | 5.78 | 5.96 | 0.06 |
| 1998 | 3206.72 | 7717 | 433 | 88.21 | 88.27 | 84.54 | 88.09 | 2.83 | 2.57 | 9.16 | 0.06 |
| 1999 | 3246.62 | 7780 | 433 | 89.23 | 90.18 | 85.59 | 88.81 | 2.10 | 1.93 | 7.88 | 0.95 |
| 2000 | 3059.33 | 7073 | 433 | 79.99 | 80.08 | 80.44 | 80.52 | 0.89 | 0.72 | 19.19 | 0.10 |
| 2001 | 3266.89 | 7484 | 441 | 84.76 | 84.94 | 84.57 | 85.43 | 6.50 | 5.91 | 9.15 | 0.18 |
| 2002 | 3338.46 | 7644 | 441 | 86.54 | 86.71 | 86.42 | 87.26 | 1.93 | 2.19 | 11.10 | 0.17 |
| 2003 | 918.84 | 2089 | 441 | 23.80 | 23.80 | 23.78 | 23.85 | 0.00 | 65.27 | 10.94 | 0.00 |
| 2004 | 1137.22 | 2620 | 441 | 29.36 | 29.36 | 29.36 | 29.83 | 4.66 | 66.93 | 3.71 | 0.00 |
| 2005 | 2929.48 | 6669 | 441 | 75.84 | 75.84 | 75.83 | 76.13 | 1.92 | 1.54 | 22.63 | 0.00 |
| 2006 | 2399.56 | 5493 | 441 | 62.34 | 62.59 | 62.11 | 62.71 | 0.03 | 0.02 | 37.39 | 0.25 |
| 2007 | 3477.05 | 7887 | 443 | 89.16 | 89.16 | 89.60 | 90.03 | 2.24 | 2.05 | 8.79 | 0.00 |
| 2008 | 2993.79 | 6669 | 473 | 76.24 | 76.26 | 76.50 | 75.92 | 0.70 | 4.25 | 19.50 | 0.02 |
| 2009 | 3772.51 | 7985 | 473 | 91.14 | 91.14 | 91.05 | 91.15 | 1.13 | 1.04 | 7.82 | 0.00 |
| 2010 | 3715.76 | 7892 | 473 | 89.74 | 89.74 | 89.68 | 90.09 | 1.99 | 2.31 | 7.95 | 0.00 |
| 2011 | 3770.49 | 7978 | 473 | 91.02 | 91.02 | 91.00 | 91.07 | 0.22 | 0.84 | 8.15 | 0.00 |
| 2012 | 3521.36 | 7456 | 473 | 84.77 | 84.77 | 84.75 | 84.88 | 0.48 | 0.41 | 14.82 | 0.00 |
| 2013 | 3794.73 | 7905 | 473 | 89.72 | 90.25 | 91.58 | 90.24 | 2.28 | 2.11 | 7.64 | 0.53 |
| 2014 | 3903.00 | 8127 | 473 | 92.41 | 92.50 | 94.20 | 92.77 | 0.12 | 0.11 | 7.39 | 0.09 |
| 2015 | 3889.01 | 8118 | 473 | 91.91 | 92.25 | 93.86 | 92.67 | 0.47 | 0.44 | 7.31 | 0.34 |
| 2016 | 3375.14 | 7132 | 473 | 80.09 | 80.16 | 81.23 | 81.19 | 0.47 | 2.87 | 16.96 | 0.07 |
| 2017 | 4178.74 | 8760 | 473 | 99.46 | 99.83 | 100.85 | 100.00 | 0.14 | 0.14 | 0.03 | 0.37 |
| 2018 | 3670.36 | 7798 | 477 | 87.44 | 88.51 | 87.84 | 89.02 | 4.43 | 4.10 | 7.38 | 1.07 |
| 2019 | 3872.20 | 8127 | 477 | 91.47 | 92.04 | 92.67 | 92.77 | 0.40 | 0.57 | 7.39 | 0.56 |
| 2020 | 3819.36 | 8175 | 477 | 90.36 | 91.00 | 91.15 | 93.07 | 2.07 | 2.05 | 6.95 | 0.65 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 3375.40 | 7175 | 479 | 80.05 | 80.73 | 80.50 | 81.91 | 2.78 | 3.33 | 15.94 | 0.68 |
| 2022 | 4074.98 | 8504 | 479 | 96.19 | 97.05 | 97.11 | 97.08 | 0.13 | 0.79 | 2.16 | 0.86 |
| 2023 | 3863.62 | 8170 | 479 | 91.63 | 92.50 | 92.08 | 93.26 | 0.16 | 0.15 | 7.35 | 0.87 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 385 | |
| C. Inspection, maintenance or repair combined with refuelling | 590 | | | 892 | 11 | |
| D. Inspection, maintenance or repair without refuelling | | | | 69 | | |
| E. Testing of plant systems or components | | | | 1 | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 15 | |
| Z. Other | | | | | 17 | |
| Subtotal | 590 | | | 962 | 428 | 0 |
| Total | | 590 | | | 1390 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 145 |
| 12. Reactor I&C Systems | | 18 |
| 13. Reactor Auxiliary Systems | | 0 |
| 14. Safety Systems | | 5 |
| 15. Reactor Cooling Systems | | 21 |
| 16. Steam generation systems | | 15 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 13 |
| 21. Fuel Handling and Storage Facilities | | 148 |
| 31. Turbine and auxiliaries | | 13 |
| 32. Feedwater and Main Steam System | | 0 |
| 34. Miscellaneous Systems | | 3 |
| 41. Main Generator Systems | | 10 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 393 |

Highlights (2023)

Operation at full power in base load mode

2023 Operating Experience

HU-3

PAKS-3

HUNGARY

Status at end of year : **Operational**
 Operator : PAKS Zrt (PAKS NUCLEAR POWER PLANT, LTD.)
 Owner : MVM Zrt. (HUNGARIAN POWER COMPANIES LTD.)
 Reactor Supplier : AEE (ATOMENERGOEXPORT)
 Turbine Supplier : KTP (Kharkiv Turbine Plant "Turboatom")



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1485 MWth
 Gross electrical power : 506 MWe
 Reference unit power (net) : 479 MWe

Key Dates

Construction Date : 1979-10-01
 Grid Date : 1986-09-28
 Commercial Date : 1986-12-01
 Age at end of year : 37 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.82
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 30
 Average discharge burnup [MWd/t] : 37000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.42
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.5
 Reactor outlet temperature [°C] : 297
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.15

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.4
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

Non-electrical applications

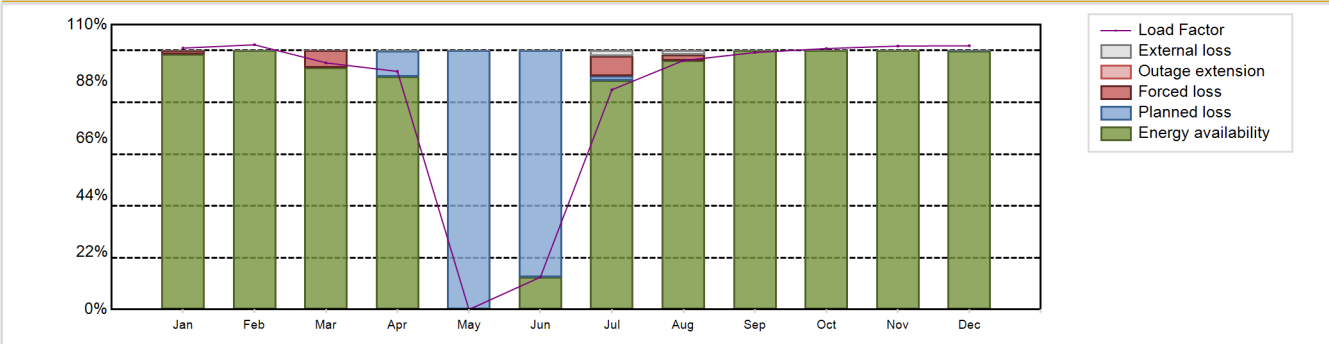
: DH

Annual Production Results (2023)

Net Energy Production : 3449.13 GW(e).h
 Energy Availability Factor (EAF) : 81.47 %
 Unit Capability Factor (UCF) : 81.8 %
 Load Factor (LF) : 82.2 %
 Operating Factor (OF) : 84.47 %
 Equivalent non-electrical energy generated (NEG) : 4.62 GW(e).h

Forced Loss Rate (FLR) : 1.83 %
 Unplanned Capability Loss Factor (UCL) : 1.53 %
 Planned Unavailability Factor (PUF) : 16.68 %
 Externally cause unavailability (XUF) : 0.32 %
 Total off-line time : 1360 hours

Annual Summary

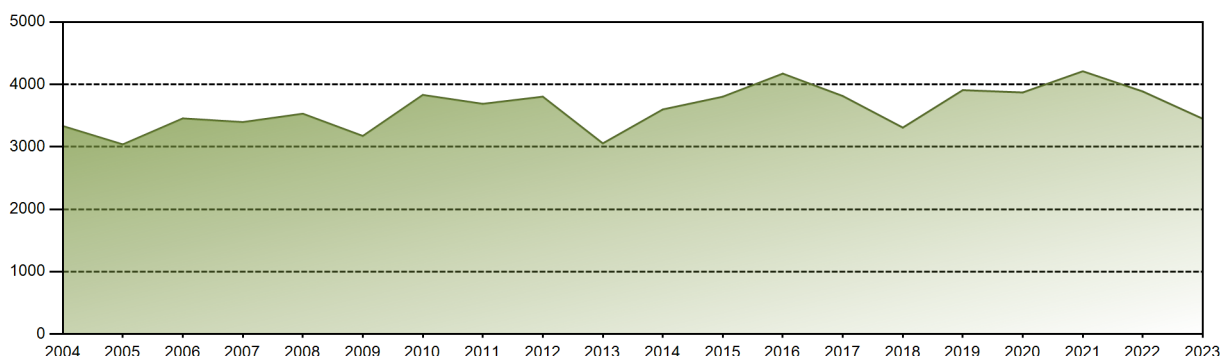


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 359.82 | 329.08 | 339.05 | 317.10 | 0.00 | 43.14 | 302.45 | 342.65 | 342.31 | 359.65 | 350.92 | 362.97 | 3449.13 |
| EAF [%] | 98.65 | 100.00 | 93.35 | 89.94 | 0.00 | 12.42 | 88.36 | 96.23 | 100.00 | 100.00 | 100.00 | 99.75 | 81.47 |
| UCF [%] | 98.65 | 100.00 | 93.35 | 90.03 | 0.00 | 12.42 | 90.41 | 97.89 | 100.00 | 100.00 | 100.00 | 99.75 | 81.80 |
| LF [%] | 100.97 | 102.23 | 95.27 | 91.94 | 0.00 | 12.51 | 84.87 | 96.15 | 99.25 | 100.78 | 101.75 | 101.85 | 82.20 |
| OF [%] | 100.00 | 100.00 | 94.48 | 90.42 | 0.00 | 29.72 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 84.47 |
| FLR [%] | 1.35 | 0.00 | 6.65 | 0.00 | 0.00 | 0.00 | 8.01 | 2.11 | 0.00 | 0.00 | 0.00 | 0.00 | 1.83 |
| UCL [%] | 1.35 | 0.00 | 6.65 | 0.00 | 0.00 | 0.00 | 7.88 | 2.11 | 0.00 | 0.00 | 0.00 | 0.00 | 1.53 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 9.97 | 100.00 | 87.58 | 1.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 16.68 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 2.06 | 1.66 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 128512.3 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.58 % |
| Cumulative Energy Availability Factor (EAF) | : 87.44 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.99 % |
| Cumulative Unit Capability Factor (UCF) | : 87.82 % | Cumulative Planned Unavailability Factor (PUF) | : 10.19 % |
| Cumulative Load Factor (LF) | : 88.29 % | Cumulative Externally cause unavailability (XUF) | : 0.38 % |
| Cumulative Operating Factor (OF) | : 88.48 % | | |

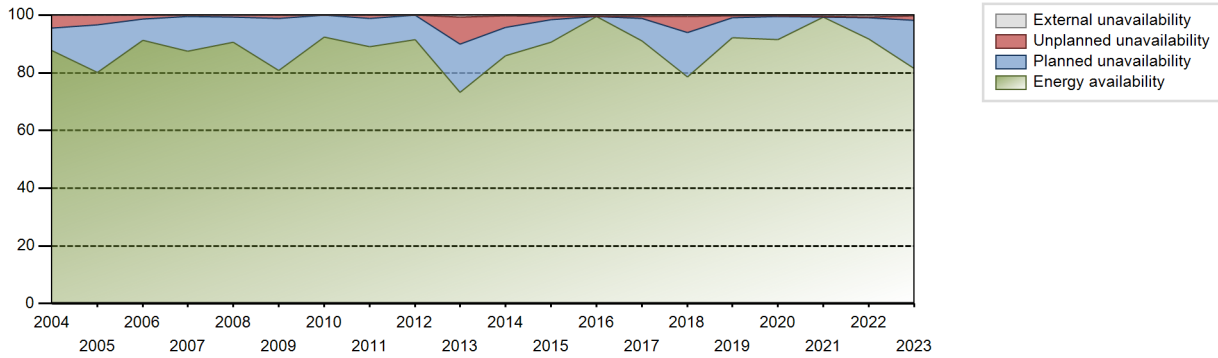
Electricity Production (net) [GWh]



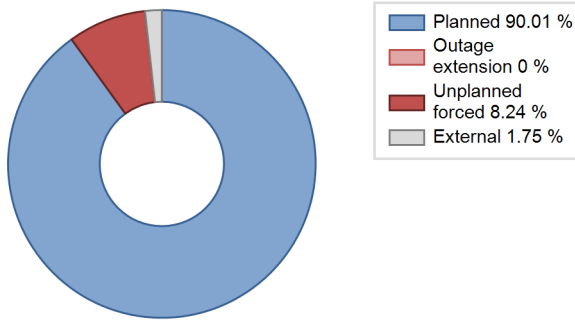
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 718.54 | 2109 | 427 | 99.65 | 99.65 | 101.72 | 100.00 | 0.00 | 0.00 | 0.35 | 0.00 |
| 1987 | 3209.58 | 7648 | 415 | 86.95 | 86.95 | 88.29 | 87.31 | 0.92 | 0.81 | 12.24 | 0.00 |
| 1988 | 3300.93 | 7874 | 415 | 88.09 | 88.09 | 90.55 | 89.64 | 1.12 | 0.99 | 10.92 | 0.00 |
| 1989 | 3140.52 | 7343 | 415 | 82.41 | 82.41 | 86.39 | 83.82 | 2.15 | 1.81 | 15.78 | 0.00 |
| 1990 | 3273.39 | 7755 | 435 | 85.64 | 85.64 | 85.90 | 88.53 | 4.39 | 3.93 | 10.43 | 0.00 |
| 1991 | 3256.00 | 7580 | 410 | 84.19 | 84.19 | 90.66 | 86.53 | 6.82 | 6.16 | 9.65 | 0.00 |
| 1992 | 3587.32 | 7852 | 433 | 87.47 | 87.70 | 94.32 | 89.39 | 3.49 | 3.17 | 9.13 | 0.23 |
| 1993 | 3177.93 | 6950 | 433 | 77.40 | 77.63 | 83.78 | 79.34 | 1.05 | 0.82 | 21.55 | 0.23 |
| 1994 | 3375.99 | 7884 | 433 | 88.53 | 88.64 | 89.00 | 90.00 | 0.41 | 0.36 | 11.00 | 0.11 |
| 1995 | 3392.81 | 7911 | 433 | 88.99 | 89.16 | 89.45 | 90.31 | 3.29 | 3.03 | 7.80 | 0.17 |
| 1996 | 3429.38 | 8136 | 433 | 90.84 | 90.91 | 90.16 | 92.62 | 2.04 | 1.89 | 7.20 | 0.07 |
| 1997 | 3066.09 | 7136 | 433 | 80.91 | 81.10 | 80.83 | 81.46 | 5.11 | 4.37 | 14.53 | 0.19 |
| 1998 | 3294.11 | 7566 | 433 | 87.98 | 88.02 | 86.85 | 86.37 | 6.17 | 5.79 | 6.20 | 0.04 |
| 1999 | 3445.71 | 8058 | 433 | 92.19 | 92.28 | 90.84 | 91.99 | 0.47 | 0.43 | 7.29 | 0.09 |
| 2000 | 3517.25 | 8163 | 433 | 92.76 | 93.04 | 92.47 | 92.93 | 0.73 | 0.68 | 6.28 | 0.28 |
| 2001 | 3040.40 | 7159 | 433 | 80.31 | 80.72 | 80.16 | 81.72 | 2.68 | 2.22 | 17.06 | 0.42 |
| 2002 | 3256.84 | 7900 | 433 | 90.36 | 90.48 | 85.86 | 90.18 | 0.38 | 0.35 | 9.17 | 0.12 |
| 2003 | 3008.34 | 7746 | 433 | 80.47 | 87.85 | 79.31 | 88.42 | 0.85 | 0.88 | 11.27 | 7.37 |
| 2004 | 3333.25 | 7732 | 433 | 87.64 | 87.64 | 87.64 | 88.02 | 1.86 | 4.45 | 7.91 | 0.00 |
| 2005 | 3038.71 | 7088 | 433 | 80.10 | 80.10 | 80.11 | 80.91 | 3.96 | 3.39 | 16.50 | 0.00 |
| 2006 | 3454.91 | 8007 | 433 | 91.18 | 91.18 | 91.08 | 91.40 | 0.25 | 1.40 | 7.42 | 0.00 |
| 2007 | 3396.00 | 7691 | 443 | 87.53 | 87.53 | 87.51 | 87.80 | 0.45 | 0.40 | 12.07 | 0.00 |
| 2008 | 3530.43 | 7962 | 443 | 90.63 | 90.69 | 90.73 | 90.64 | 0.72 | 0.65 | 8.65 | 0.06 |
| 2009 | 3174.02 | 7078 | 473 | 80.88 | 80.88 | 80.88 | 80.80 | 0.12 | 1.21 | 17.91 | 0.00 |
| 2010 | 3831.50 | 8123 | 473 | 92.48 | 92.48 | 92.47 | 92.73 | 0.04 | 0.04 | 7.49 | 0.00 |
| 2011 | 3688.74 | 7823 | 473 | 89.04 | 89.04 | 89.03 | 89.30 | 0.58 | 1.10 | 9.86 | 0.00 |
| 2012 | 3803.60 | 8080 | 473 | 91.56 | 91.56 | 91.55 | 91.99 | 0.00 | 0.00 | 8.44 | 0.00 |
| 2013 | 3054.56 | 6480 | 473 | 73.20 | 73.92 | 73.72 | 73.97 | 0.05 | 9.35 | 16.73 | 0.72 |
| 2014 | 3598.71 | 7620 | 473 | 86.02 | 86.30 | 86.85 | 86.99 | 0.00 | 4.01 | 9.70 | 0.28 |
| 2015 | 3803.38 | 8032 | 473 | 90.61 | 91.15 | 91.79 | 91.69 | 0.52 | 1.01 | 7.84 | 0.55 |
| 2016 | 4172.78 | 8784 | 473 | 99.46 | 99.96 | 100.43 | 100.00 | 0.04 | 0.04 | 0.00 | 0.50 |
| 2017 | 3813.11 | 8073 | 473 | 90.95 | 91.43 | 92.03 | 92.16 | 0.06 | 0.79 | 7.79 | 0.48 |
| 2018 | 3307.59 | 7032 | 473 | 78.50 | 78.93 | 79.83 | 80.27 | 6.62 | 5.60 | 15.47 | 0.44 |
| 2019 | 3908.46 | 8133 | 473 | 92.20 | 92.38 | 94.33 | 92.84 | 0.77 | 0.72 | 6.90 | 0.18 |
| 2020 | 3871.06 | 8156 | 473 | 91.55 | 91.75 | 93.17 | 92.85 | 0.37 | 0.34 | 7.92 | 0.19 |
| 2021 | 4210.62 | 8752 | 479 | 99.24 | 99.71 | 100.55 | 99.91 | 0.29 | 0.29 | 0.00 | 0.47 |
| 2022 | 3886.48 | 8178 | 479 | 91.78 | 92.38 | 92.62 | 93.36 | 0.00 | 0.37 | 7.25 | 0.60 |

2023 3449.13 7400 479 81.47 81.80 82.20 84.47 1.83 1.53 16.68 0.32

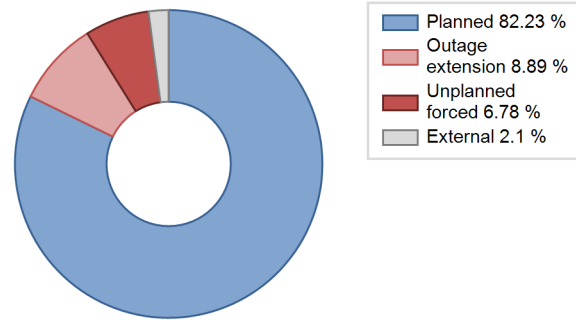
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 41 | | | 129 | |
| C. Inspection, maintenance or repair combined with refuelling | 1319 | | | 839 | 72 | |
| D. Inspection, maintenance or repair without refuelling | | | | 29 | | |
| E. Testing of plant systems or components | | | | 1 | 3 | |
| L. Human factor related | | | | | 0 | |
| Z. Other | | | | | 7 | |
| Subtotal | 1319 | 41 | | 869 | 211 | |
| Total | | 1360 | | | 1080 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1986 to 2023 | |
|--|------------|-----------|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 9 |
| 12. Reactor I&C Systems | | 41 | | 29 |
| 13. Reactor Auxiliary Systems | | | | 2 |
| 14. Safety Systems | | | | 7 |
| 15. Reactor Cooling Systems | | | | 1 |
| 16. Steam generation systems | | | | 1 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 0 |
| 21. Fuel Handling and Storage Facilities | | | | 29 |
| 31. Turbine and auxiliaries | | | | 6 |
| 32. Feedwater and Main Steam System | | | | 14 |
| 34. Miscellaneous Systems | | | | 6 |
| 42. Electrical Power Supply Systems | | | | 31 |
| Total | | 41 | | 135 |

Highlights (2023)

Operation at full power in base load mode

2023 Operating Experience

HU-4

PAKS-4

HUNGARY

Status at end of year : **Operational**
 Operator : PAKS Zrt (PAKS NUCLEAR POWER PLANT, LTD.)
 Owner : MVM Zrt. (HUNGARIAN POWER COMPANIES LTD.)
 Reactor Supplier : AEE (ATOMENERGOEXPORT)
 Turbine Supplier : KTP (Kharkiv Turbine Plant "Turboatom")



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1485 MWth
 Gross electrical power : 506 MWe
 Reference unit power (net) : 479 MWe

Key Dates

Construction Date : 1979-10-01
 Grid Date : 1987-08-16
 Commercial Date : 1987-11-01
 Age at end of year : 36 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.82
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 30
 Average discharge burnup [MWd/t] : 37000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.42
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.5
 Reactor outlet temperature [°C] : 297
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.15

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.4
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

Non-electrical applications

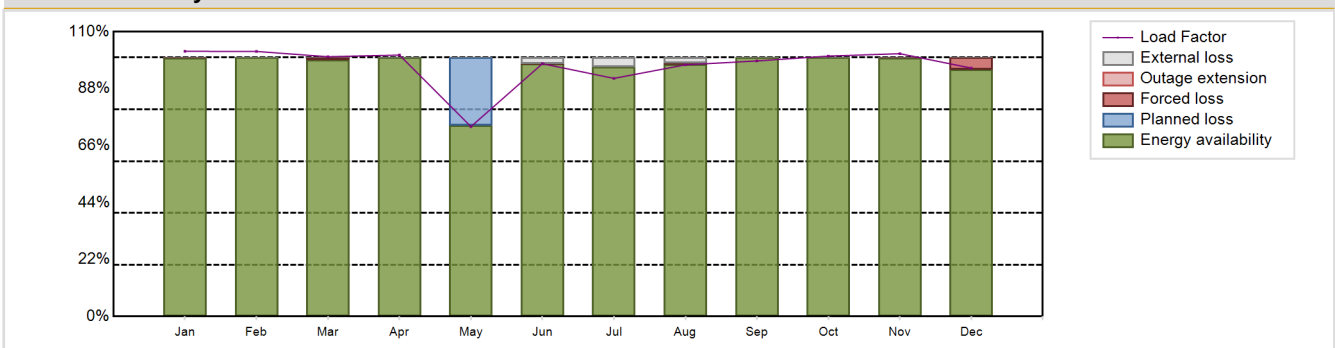
Non-electrical applications : DH

Annual Production Results (2023)

Net Energy Production : 4063.77 GW(e).h
 Energy Availability Factor (EAF) : 96.58 %
 Unit Capability Factor (UCF) : 97.26 %
 Load Factor (LF) : 96.85 %
 Operating Factor (OF) : 97.69 %
 Equivalent non-electrical energy generated (NEG) : 5.82 GW(e).h

Forced Loss Rate (FLR) : 0.53 %
 Unplanned Capability Loss Factor (UCL) : 0.52 %
 Planned Unavailability Factor (PUF) : 2.22 %
 Externally cause unavailability (XUF) : 0.68 %
 Total off-line time : 202 hours

Annual Summary

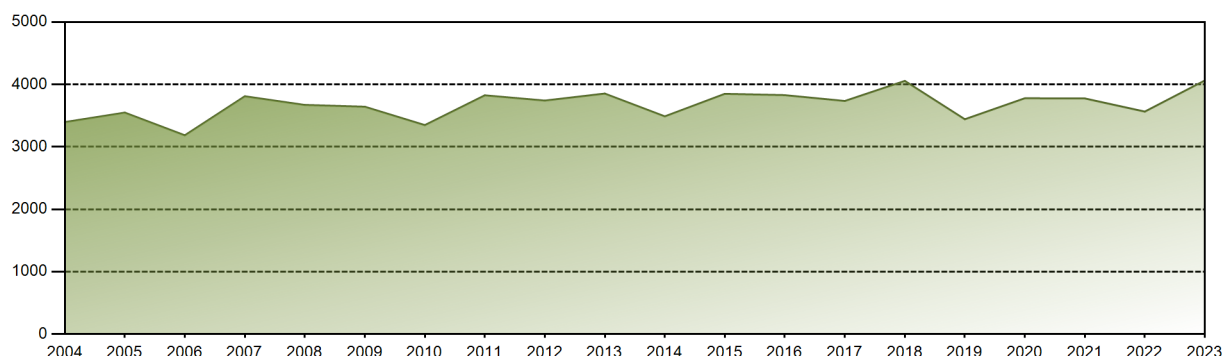


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 365.05 | 329.55 | 357.11 | 348.30 | 261.41 | 336.79 | 327.77 | 346.42 | 340.41 | 358.93 | 350.10 | 341.93 | 4063.77 |
| EAF [%] | 99.94 | 100.00 | 99.01 | 100.00 | 73.89 | 97.65 | 96.43 | 97.29 | 100.00 | 100.00 | 99.98 | 95.51 | 96.58 |
| UCF [%] | 99.94 | 100.00 | 99.01 | 100.00 | 73.89 | 99.99 | 100.00 | 99.43 | 100.00 | 100.00 | 99.98 | 95.51 | 97.26 |
| LF [%] | 102.44 | 102.38 | 100.34 | 100.99 | 73.35 | 97.65 | 91.97 | 97.21 | 98.70 | 100.58 | 101.51 | 95.95 | 96.85 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 75.54 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.31 | 97.69 |
| FLR [%] | 0.06 | 0.00 | 0.99 | 0.00 | 0.00 | 0.01 | 0.00 | 0.57 | 0.00 | 0.00 | 0.02 | 4.49 | 0.53 |
| UCL [%] | 0.06 | 0.00 | 0.99 | 0.00 | 0.00 | 0.01 | 0.00 | 0.57 | 0.00 | 0.00 | 0.02 | 4.49 | 0.52 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 26.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.22 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.34 | 3.57 | 2.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.68 |

Historical Summary

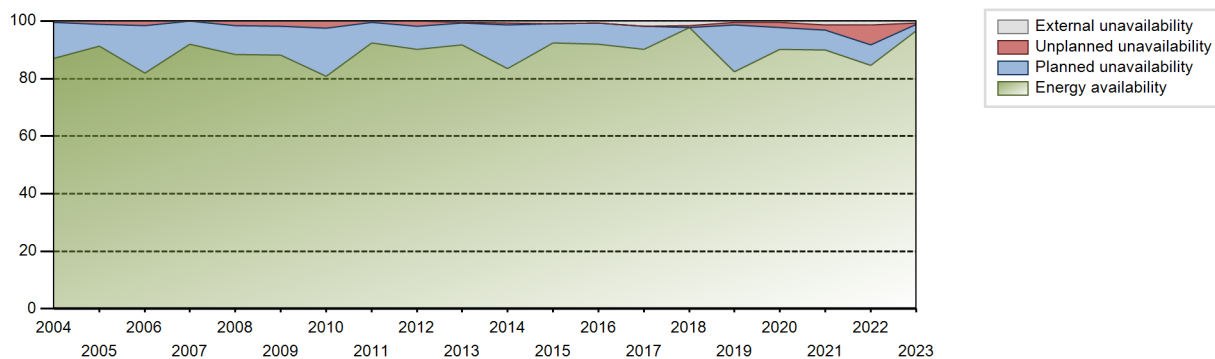
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 128382.75 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.21 % |
| Cumulative Energy Availability Factor (EAF) | : 88.47 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.36 % |
| Cumulative Unit Capability Factor (UCF) | : 88.86 % | Cumulative Planned Unavailability Factor (PUF) | : 9.78 % |
| Cumulative Load Factor (LF) | : 89.48 % | Cumulative Externally cause unavailability (XUF) | : 0.39 % |
| Cumulative Operating Factor (OF) | : 89.73 % | | |

Electricity Production (net) [GWh]

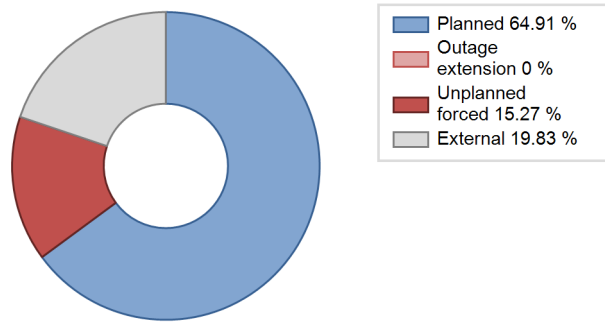


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 1039.12 | 2936 | 425 | 100.00 | 100.00 | 101.77 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1988 | 3200.89 | 7564 | 415 | 85.65 | 85.65 | 87.81 | 86.11 | 3.21 | 2.84 | 11.51 | 0.00 |
| 1989 | 3425.34 | 7974 | 415 | 89.67 | 89.67 | 94.22 | 91.03 | 1.27 | 1.15 | 9.17 | 0.00 |
| 1990 | 3064.45 | 7253 | 435 | 76.69 | 76.69 | 80.42 | 82.80 | 4.04 | 3.23 | 20.08 | 0.00 |
| 1991 | 3342.95 | 7787 | 410 | 86.54 | 86.54 | 93.08 | 88.89 | 3.48 | 3.12 | 10.34 | 0.00 |
| 1992 | 3702.82 | 8082 | 433 | 90.69 | 90.86 | 97.35 | 92.01 | 0.41 | 0.37 | 8.77 | 0.18 |
| 1993 | 3537.22 | 7767 | 430 | 87.05 | 87.48 | 93.91 | 88.66 | 2.37 | 2.12 | 10.40 | 0.44 |
| 1994 | 2971.22 | 7019 | 433 | 78.06 | 78.13 | 78.33 | 80.13 | 1.51 | 1.20 | 20.67 | 0.07 |
| 1995 | 3443.81 | 8049 | 433 | 90.45 | 90.77 | 90.79 | 91.88 | 0.89 | 0.82 | 8.41 | 0.33 |
| 1996 | 3487.53 | 8087 | 433 | 90.71 | 91.31 | 91.69 | 92.07 | 1.06 | 0.97 | 7.72 | 0.60 |
| 1997 | 3487.08 | 8098 | 433 | 91.61 | 92.04 | 91.93 | 92.44 | 0.74 | 0.69 | 7.27 | 0.43 |
| 1998 | 3136.11 | 7389 | 433 | 83.72 | 84.26 | 82.68 | 84.35 | 1.18 | 1.00 | 14.73 | 0.54 |
| 1999 | 3464.00 | 8046 | 433 | 89.27 | 89.33 | 91.32 | 91.85 | 3.95 | 3.68 | 6.99 | 0.06 |
| 2000 | 3578.42 | 8116 | 433 | 92.20 | 92.31 | 94.08 | 92.40 | 0.24 | 0.22 | 7.47 | 0.11 |
| 2001 | 3471.72 | 7916 | 444 | 89.98 | 90.14 | 89.26 | 90.37 | 1.63 | 1.50 | 8.36 | 0.16 |
| 2002 | 3182.88 | 7287 | 444 | 83.14 | 83.35 | 81.83 | 83.18 | 0.94 | 0.79 | 15.86 | 0.21 |
| 2003 | 3607.64 | 8119 | 444 | 92.75 | 92.99 | 92.75 | 92.68 | 0.03 | 0.62 | 6.40 | 0.23 |
| 2004 | 3396.64 | 7878 | 444 | 87.09 | 87.09 | 87.09 | 89.69 | 0.30 | 0.48 | 12.43 | 0.00 |
| 2005 | 3548.78 | 8046 | 444 | 91.24 | 91.24 | 91.24 | 91.85 | 1.10 | 1.08 | 7.68 | 0.00 |
| 2006 | 3185.19 | 7196 | 444 | 81.91 | 81.91 | 81.89 | 82.15 | 0.55 | 1.67 | 16.42 | 0.00 |
| 2007 | 3810.43 | 8078 | 473 | 91.99 | 91.99 | 91.96 | 92.21 | 0.05 | 0.04 | 7.97 | 0.00 |
| 2008 | 3671.44 | 7854 | 473 | 88.40 | 88.40 | 88.37 | 89.41 | 0.51 | 1.70 | 9.91 | 0.00 |
| 2009 | 3643.09 | 7715 | 473 | 88.04 | 88.04 | 87.92 | 88.07 | 0.33 | 1.89 | 10.06 | 0.00 |
| 2010 | 3348.24 | 7091 | 473 | 80.85 | 80.85 | 80.81 | 80.95 | 2.92 | 2.43 | 16.71 | 0.00 |
| 2011 | 3825.62 | 8103 | 473 | 92.34 | 92.34 | 92.33 | 92.50 | 0.42 | 0.39 | 7.27 | 0.00 |
| 2012 | 3741.44 | 7961 | 473 | 90.07 | 90.07 | 90.05 | 90.63 | 2.03 | 1.86 | 8.07 | 0.00 |
| 2013 | 3853.52 | 8076 | 473 | 91.68 | 92.06 | 93.00 | 92.19 | 0.32 | 0.29 | 7.65 | 0.38 |
| 2014 | 3488.55 | 7430 | 473 | 83.52 | 84.28 | 84.19 | 84.82 | 0.65 | 0.55 | 15.17 | 0.76 |
| 2015 | 3849.34 | 8174 | 473 | 92.33 | 93.24 | 92.90 | 93.31 | 0.04 | 0.04 | 6.72 | 0.92 |
| 2016 | 3828.20 | 8153 | 473 | 91.92 | 92.69 | 92.14 | 92.82 | 0.04 | 0.04 | 7.27 | 0.77 |
| 2017 | 3735.00 | 8064 | 473 | 90.14 | 91.86 | 90.14 | 92.05 | 0.17 | 0.16 | 7.98 | 1.72 |
| 2018 | 4056.61 | 8722 | 473 | 97.84 | 99.36 | 97.90 | 99.57 | 0.64 | 0.64 | 0.00 | 1.53 |
| 2019 | 3442.12 | 7315 | 473 | 82.37 | 82.83 | 83.07 | 83.50 | 0.79 | 0.94 | 16.23 | 0.46 |
| 2020 | 3778.60 | 8053 | 473 | 90.19 | 90.70 | 90.94 | 91.68 | 1.49 | 1.76 | 7.55 | 0.51 |
| 2021 | 3775.68 | 8027 | 479 | 89.83 | 91.11 | 90.16 | 91.63 | 0.50 | 1.89 | 7.00 | 1.28 |
| 2022 | 3564.70 | 7968 | 479 | 84.66 | 86.10 | 84.95 | 90.96 | 4.76 | 6.77 | 7.13 | 1.44 |
| 2023 | 4063.77 | 8558 | 479 | 96.58 | 97.26 | 96.85 | 97.69 | 0.53 | 0.52 | 2.22 | 0.68 |

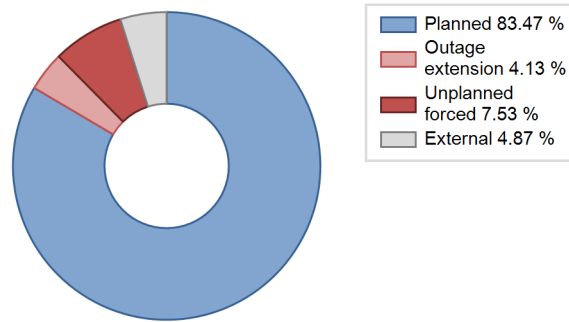
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 20 | | | 65 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 814 | 15 | |
| D. Inspection, maintenance or repair without refuelling | 182 | | | 9 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| L. Human factor related | | | | | 2 | |
| Z. Other | | | | 2 | 2 | |
| Subtotal | 182 | 20 | | 826 | 84 | |
| Total | | 202 | | | 910 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 10 |
| 15. Reactor Cooling Systems | | 18 |
| 16. Steam generation systems | | 14 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | 20 | 12 |
| 32. Feedwater and Main Steam System | | 4 |
| 34. Miscellaneous Systems | | 4 |
| 41. Main Generator Systems | | 0 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | 20 | 65 |

Highlights (2023)

Operation at full power in base load mode

2023 Operating Experience

IN-13 KAIGA-1 INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 1989-09-01 |
| Thermal power | : 801 MWth | Grid Date | : 2000-10-12 |
| Gross electrical power | : 220 MWe | Commercial Date | : 2000-11-16 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 23 years |

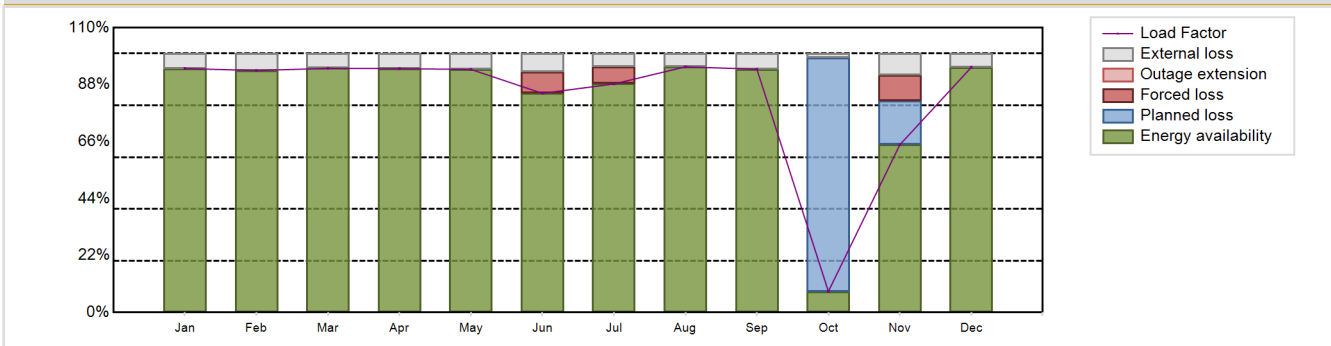
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|----------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 8.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 293 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : D2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 1.73 |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 6700 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 4.5 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 5 | HP cylinder inlet steam pressure [MPa] | : 3.972 |
| Number of fissile fuel assemblies/bundles | : 3672 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 35.3 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : 4 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 1 | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 1472.23 GW(e).h | Forced Loss Rate (FLR) | : 2.25 % |
| Energy Availability Factor (EAF) | : 83.2 % | Unplanned Capability Loss Factor (UCL) | : 2.05 % |
| Unit Capability Factor (UCF) | : 88.9 % | Planned Unavailability Factor (PUF) | : 9.05 % |
| Load Factor (LF) | : 83.2 % | Externally cause unavailability (XUF) | : 5.7 % |
| Operating Factor (OF) | : 88.89 % | Total off-line time | : 973 hours |

Annual Summary

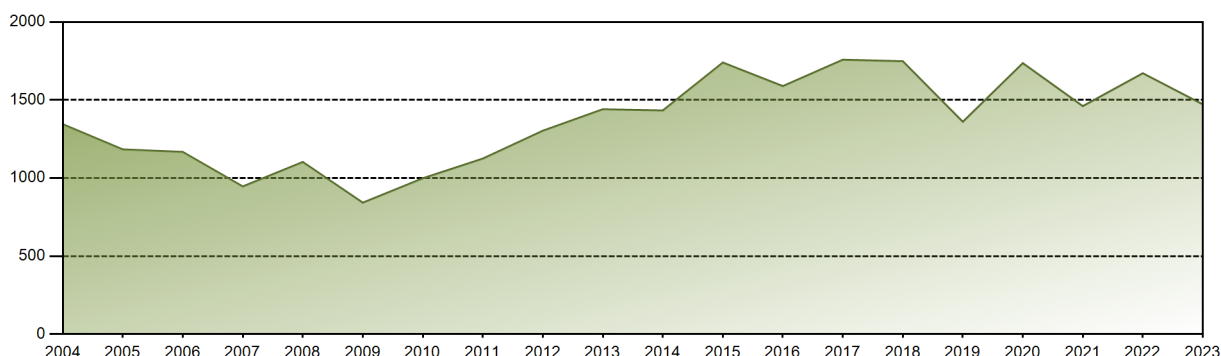


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|--------|---------|
| GW(e)-h | 141.64 | 126.87 | 141.72 | 137.00 | 141.09 | 123.12 | 132.66 | 142.60 | 136.67 | 12.24 | 94.27 | 142.35 | 1472.23 |
| EAF [%] | 94.25 | 93.46 | 94.30 | 94.20 | 93.88 | 84.65 | 88.34 | 94.88 | 93.97 | 8.15 | 64.81 | 94.72 | 83.20 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.79 | 93.54 | 100.00 | 100.00 | 9.87 | 73.02 | 100.00 | 88.90 |
| LF [%] | 94.25 | 93.46 | 94.30 | 94.20 | 93.88 | 84.65 | 88.27 | 94.88 | 93.97 | 8.15 | 64.81 | 94.72 | 83.20 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.81 | 93.41 | 100.00 | 100.00 | 9.81 | 73.06 | 100.00 | 88.89 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.21 | 6.46 | 0.00 | 0.00 | 0.00 | 12.08 | 0.00 | 2.25 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.21 | 6.46 | 0.00 | 0.00 | 0.00 | 10.03 | 0.00 | 2.05 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 90.13 | 16.95 | 0.00 | 9.05 |
| XUF [%] | 5.75 | 6.54 | 5.70 | 5.80 | 6.12 | 7.14 | 5.20 | 5.12 | 6.03 | 1.72 | 8.20 | 5.28 | 5.70 |

Historical Summary

| | | | | | |
|---|---|------------------|---|---|---------|
| Lifetime energy generation | : | 31775.42 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 3.69 % |
| Cumulative Energy Availability Factor (EAF) | : | 78.56 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 3.75 % |
| Cumulative Unit Capability Factor (UCF) | : | 92.02 % | Cumulative Planned Unavailability Factor (PUF) | : | 4.23 % |
| Cumulative Load Factor (LF) | : | 77.86 % | Cumulative Externally cause unavailability (XUF) | : | 13.46 % |
| Cumulative Operating Factor (OF) | : | 91.37 % | | | |

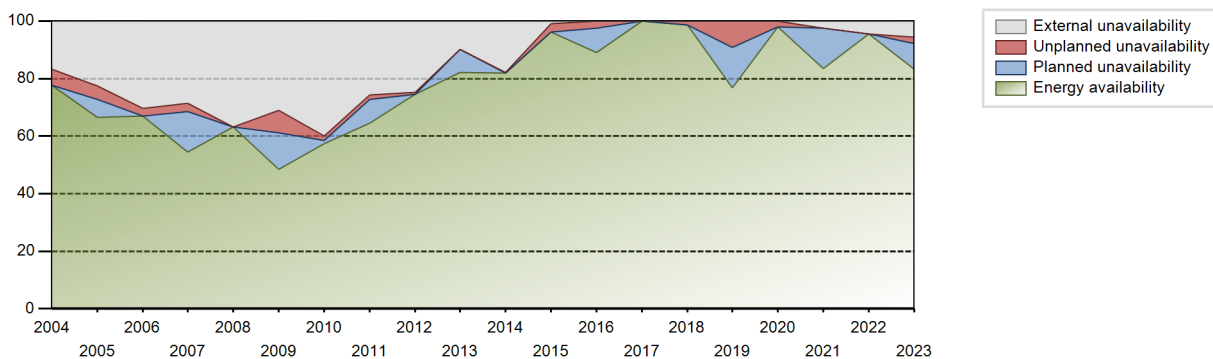
Electricity Production (net) [GWh]



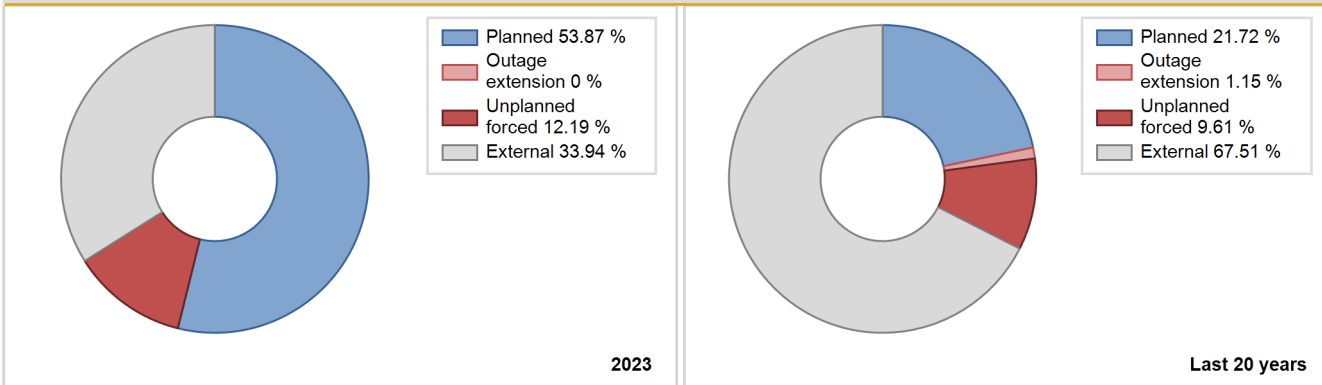
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2000 | 192.32 | 1173 | 200 | 100.00 | 100.00 | 74.50 | 75.94 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 1241.14 | 6316 | 200 | 70.41 | 75.78 | 70.84 | 72.10 | 23.82 | 23.70 | 0.53 | 5.37 |
| 2002 | 1692.93 | 8082 | 202 | 92.36 | 95.62 | 95.67 | 92.26 | 3.11 | 3.06 | 1.31 | 3.26 |
| 2003 | 1336.02 | 7255 | 202 | 83.44 | 87.54 | 75.50 | 82.82 | 12.46 | 12.46 | 0.00 | 4.09 |
| 2004 | 1344.92 | 8181 | 202 | 77.78 | 94.57 | 75.80 | 93.14 | 5.43 | 5.43 | 0.00 | 16.79 |
| 2005 | 1183.58 | 7580 | 202 | 66.47 | 88.93 | 66.89 | 86.53 | 2.98 | 4.67 | 6.40 | 22.47 |
| 2006 | 1167.31 | 8524 | 202 | 66.96 | 97.37 | 65.97 | 97.31 | 2.35 | 2.63 | 0.00 | 30.41 |
| 2007 | 946.25 | 7250 | 202 | 54.40 | 82.86 | 53.48 | 82.76 | 0.04 | 2.91 | 14.23 | 28.46 |
| 2008 | 1103.03 | 8784 | 202 | 63.15 | 100.00 | 62.16 | 100.00 | 0.00 | 0.00 | 0.00 | 36.85 |
| 2009 | 842.14 | 6953 | 202 | 48.57 | 79.58 | 47.59 | 79.37 | 8.88 | 7.75 | 12.67 | 31.01 |
| 2010 | 998.55 | 8535 | 202 | 57.42 | 97.46 | 56.43 | 97.43 | 1.59 | 1.57 | 0.97 | 40.04 |
| 2011 | 1124.79 | 7900 | 202 | 64.55 | 90.30 | 63.56 | 90.18 | 1.73 | 1.59 | 8.11 | 25.75 |
| 2012 | 1303.28 | 8719 | 202 | 74.44 | 99.29 | 73.45 | 99.26 | 0.71 | 0.71 | 0.00 | 24.85 |
| 2013 | 1440.99 | 8049 | 202 | 82.22 | 91.96 | 81.43 | 91.88 | 0.00 | 0.00 | 8.04 | 9.74 |
| 2014 | 1433.14 | 8751 | 202 | 81.98 | 99.90 | 80.99 | 99.90 | 0.10 | 0.10 | 0.00 | 17.92 |
| 2015 | 1740.46 | 8492 | 202 | 96.13 | 96.97 | 98.36 | 96.94 | 3.03 | 3.03 | 0.00 | 0.84 |
| 2016 | 1589.32 | 7904 | 202 | 88.99 | 88.99 | 89.57 | 89.98 | 2.76 | 2.53 | 8.48 | 0.00 |
| 2017 | 1758.47 | 8760 | 202 | 99.92 | 99.92 | 99.38 | 100.00 | 0.08 | 0.08 | 0.00 | 0.00 |
| 2018 | 1748.63 | 8759 | 202 | 98.68 | 98.68 | 98.82 | 99.99 | 1.31 | 1.31 | 0.01 | 0.00 |
| 2019 | 1360.54 | 6811 | 202 | 76.82 | 76.82 | 76.89 | 77.75 | 10.60 | 9.11 | 14.07 | 0.00 |
| 2020 | 1736.35 | 8639 | 202 | 97.98 | 97.98 | 97.86 | 98.35 | 2.02 | 2.02 | 0.00 | 0.00 |
| 2021 | 1460.86 | 7530 | 202 | 83.55 | 86.10 | 82.56 | 85.96 | 0.04 | 0.03 | 13.87 | 2.55 |
| 2022 | 1671.76 | 8760 | 202 | 95.47 | 100.00 | 94.48 | 100.00 | 0.00 | 0.00 | 0.00 | 4.53 |
| 2023 | 1472.23 | 7787 | 202 | 83.20 | 88.90 | 83.20 | 88.89 | 2.25 | 2.05 | 9.05 | 5.70 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2000 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 118 | | | 270 | |
| D. Inspection, maintenance or repair without refuelling | 793 | | | 366 | | |
| E. Testing of plant systems or components | | 62 | | 5 | 7 | |
| H. Nuclear regulatory requirements | | | | | 11 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 69 |
| L. Human factor related | | | | | 10 | |
| Z. Other | | | | | 39 | |
| Subtotal | 793 | 180 | | 371 | 337 | 69 |
| Total | | 973 | | | 777 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2000 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 62 | 52 |
| 12. Reactor I&C Systems | | 20 |
| 13. Reactor Auxiliary Systems | | 9 |
| 14. Safety Systems | 59 | 15 |
| 15. Reactor Cooling Systems | | 11 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 9 |
| 21. Fuel Handling and Storage Facilities | | 3 |
| 31. Turbine and auxiliaries | 49 | 52 |
| 32. Feedwater and Main Steam System | | 13 |
| 34. Miscellaneous Systems | | 8 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | 10 | 112 |
| 42. Electrical Power Supply Systems | | 18 |
| Total | 180 | 322 |

Highlights (2023)

KGS-1 was continuously operating since 13th November 2021 and completed 592 days of continuous operation before it was manually shutdown on 27th June 2023.

2023 Operating Experience

IN-14 KAIGA-2 INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 1989-12-01 |
| Thermal power | : 801 MWth | Grid Date | : 1999-12-02 |
| Gross electrical power | : 220 MWe | Commercial Date | : 2000-03-16 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 24 years |

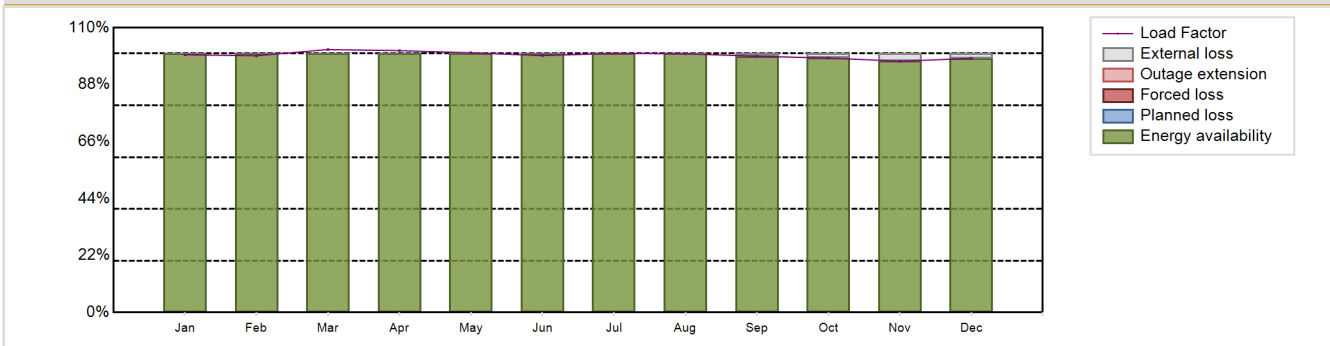
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|----------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 8.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 293 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : D2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 1.73 |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 6700 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 4.5 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 5 | HP cylinder inlet steam pressure [MPa] | : 3.972 |
| Number of fissile fuel assemblies/bundles | : 3672 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 35.3 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : 4 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 1 | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 1759.87 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.37 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 100 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 99.45 % | Externally cause unavailability (XUF) | : 0.63 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

Annual Summary

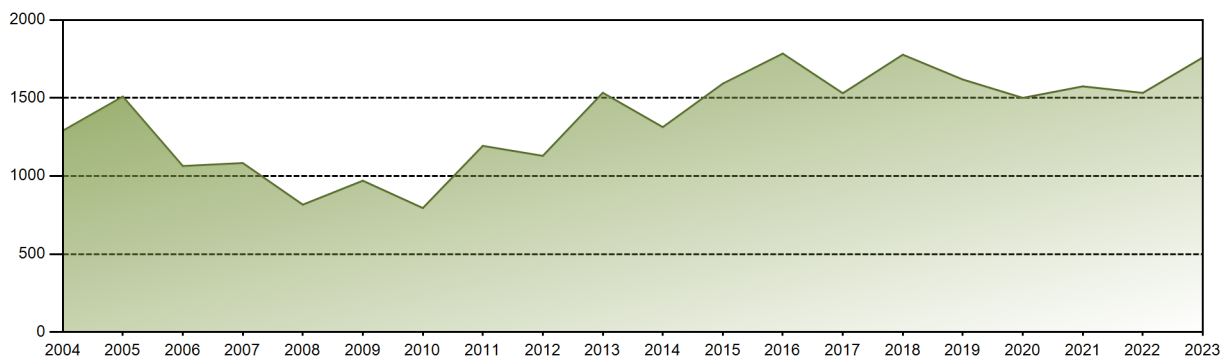


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 149.59 | 134.63 | 152.63 | 147.11 | 150.74 | 144.32 | 150.39 | 150.18 | 143.95 | 147.68 | 141.16 | 147.48 | 1759.87 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.97 | 98.27 | 97.06 | 98.13 | 99.37 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| LF [%] | 99.54 | 99.18 | 101.56 | 101.15 | 100.30 | 99.23 | 100.07 | 99.93 | 98.97 | 98.27 | 97.06 | 98.13 | 99.45 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.03 | 1.73 | 2.94 | 1.87 | 0.63 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 32637.04 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.51 % |
| Cumulative Energy Availability Factor (EAF) | : 78.14 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.41 % |
| Cumulative Unit Capability Factor (UCF) | : 91.05 % | Cumulative Planned Unavailability Factor (PUF) | : 4.55 % |
| Cumulative Load Factor (LF) | : 77.71 % | Cumulative Externally cause unavailability (XUF) | : 12.91 % |
| Cumulative Operating Factor (OF) | : 90.14 % | | |

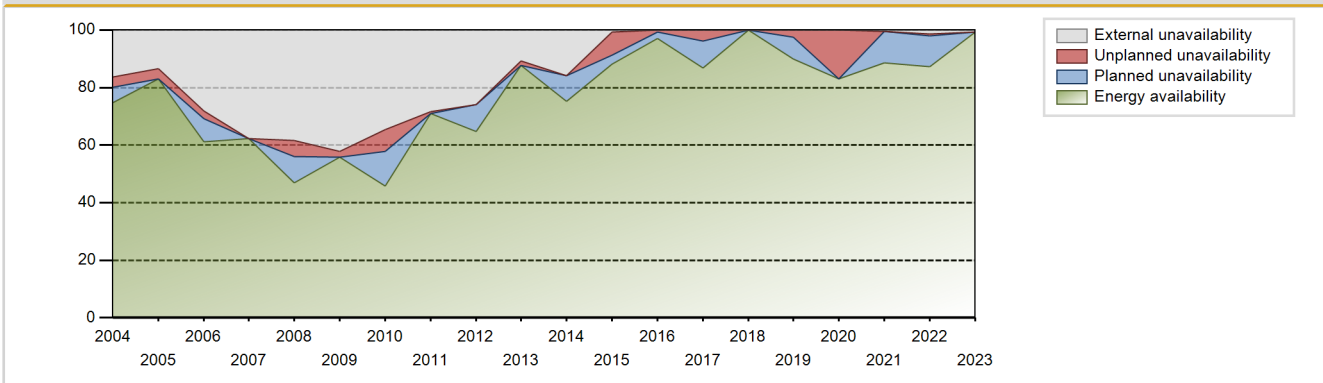
Electricity Production (net) [GWh]



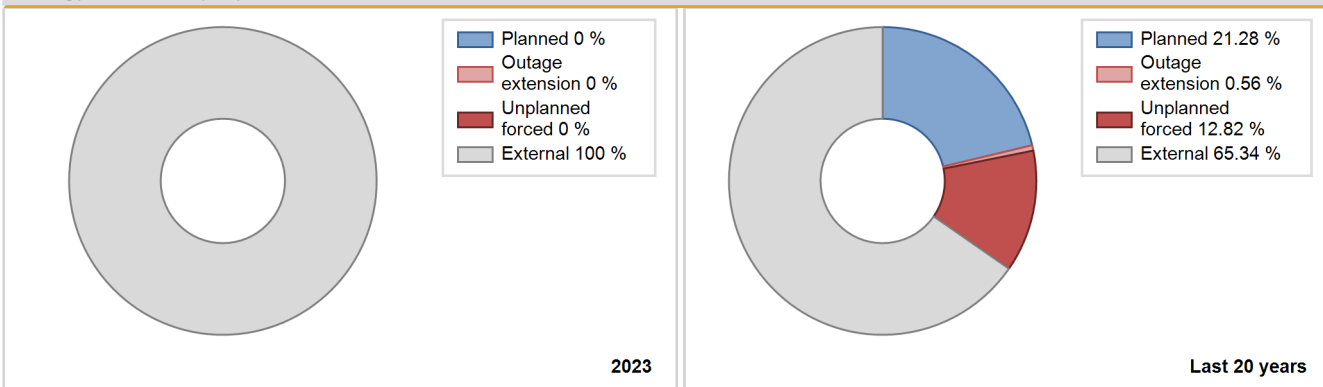
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|--------|--------|-------|-------|-------|-------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2000 | 1086.47 | 5975 | 200 | 80.61 | 80.61 | 76.35 | 79.40 | 19.39 | 19.39 | 0.00 | 0.00 |
| 2001 | 1308.57 | 6670 | 200 | 74.24 | 82.08 | 74.69 | 76.14 | 6.84 | 6.03 | 11.89 | 7.83 |
| 2002 | 1559.24 | 7455 | 202 | 85.78 | 87.53 | 88.12 | 85.10 | 12.47 | 12.47 | 0.00 | 1.75 |
| 2003 | 1412.99 | 7535 | 202 | 86.91 | 88.75 | 79.85 | 86.02 | 11.25 | 11.25 | 0.00 | 1.84 |
| 2004 | 1290.24 | 7732 | 202 | 74.70 | 91.01 | 72.72 | 88.02 | 3.83 | 3.63 | 5.36 | 16.32 |
| 2005 | 1509.37 | 8428 | 202 | 82.92 | 96.41 | 85.30 | 96.21 | 3.37 | 3.59 | 0.00 | 13.49 |
| 2006 | 1064.23 | 7806 | 202 | 61.13 | 89.24 | 60.14 | 89.11 | 2.73 | 2.73 | 8.03 | 28.11 |
| 2007 | 1083.13 | 8757 | 202 | 62.20 | 99.97 | 61.21 | 99.97 | 0.03 | 0.03 | 0.00 | 37.77 |
| 2008 | 816.51 | 7040 | 202 | 47.01 | 85.49 | 46.02 | 80.15 | 3.92 | 5.58 | 8.93 | 38.49 |
| 2009 | 969.97 | 8589 | 202 | 55.81 | 98.07 | 54.82 | 98.05 | 1.93 | 1.93 | 0.00 | 42.26 |
| 2010 | 794.66 | 7031 | 202 | 45.90 | 80.48 | 44.91 | 80.26 | 8.66 | 7.63 | 11.89 | 34.58 |
| 2011 | 1193.28 | 8466 | 202 | 70.97 | 99.22 | 67.44 | 96.64 | 0.78 | 0.78 | 0.00 | 28.26 |
| 2012 | 1129.23 | 7940 | 202 | 64.63 | 90.49 | 63.64 | 90.39 | 0.11 | 0.10 | 9.41 | 25.86 |
| 2013 | 1533.50 | 8613 | 202 | 87.65 | 98.35 | 86.66 | 98.32 | 1.65 | 1.65 | 0.00 | 10.69 |
| 2014 | 1313.47 | 7979 | 202 | 75.22 | 91.18 | 74.23 | 91.08 | 0.00 | 0.00 | 8.82 | 15.96 |
| 2015 | 1592.28 | 7788 | 202 | 88.21 | 89.02 | 89.98 | 88.90 | 8.23 | 7.99 | 3.00 | 0.80 |
| 2016 | 1784.91 | 8585 | 202 | 97.16 | 97.16 | 100.59 | 97.73 | 0.62 | 0.60 | 2.24 | 0.00 |
| 2017 | 1530.48 | 7792 | 202 | 86.90 | 86.90 | 86.49 | 88.95 | 4.28 | 3.88 | 9.21 | 0.00 |
| 2018 | 1777.58 | 8759 | 202 | 99.98 | 99.98 | 100.46 | 99.99 | 0.02 | 0.02 | 0.00 | 0.00 |
| 2019 | 1618.54 | 7860 | 202 | 89.83 | 89.83 | 91.47 | 89.73 | 2.72 | 2.51 | 7.66 | 0.00 |
| 2020 | 1500.83 | 7291 | 202 | 82.93 | 82.93 | 84.58 | 83.00 | 17.07 | 17.07 | 0.00 | 0.00 |
| 2021 | 1574.62 | 7799 | 202 | 88.59 | 89.13 | 88.99 | 89.03 | 0.06 | 0.05 | 10.82 | 0.54 |
| 2022 | 1532.82 | 7752 | 202 | 87.27 | 88.60 | 86.62 | 88.49 | 0.75 | 0.67 | 10.73 | 1.33 |
| 2023 | 1759.87 | 8760 | 202 | 99.37 | 100.00 | 99.45 | 100.00 | 0.00 | 0.00 | 0.00 | 0.63 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2000 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 398 | |
| D. Inspection, maintenance or repair without refuelling | | | | 400 | 1 | |
| E. Testing of plant systems or components | | | | | 1 | |
| H. Nuclear regulatory requirements | | | | 8 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 76 |
| L. Human factor related | | | | | 8 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant , spare part delivery problems etc.) | | | | | | 19 |
| Z. Other | | | | | 5 | |
| Subtotal | | | | 408 | 413 | 95 |
| Total | | 0 | | | 916 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2000 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 23 |
| 12. Reactor I&C Systems | | 72 |
| 13. Reactor Auxiliary Systems | | 9 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 37 |
| 16. Steam generation systems | | 3 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 15 |
| 31. Turbine and auxiliaries | | 145 |
| 32. Feedwater and Main Steam System | | 17 |
| 34. Miscellaneous Systems | | 3 |
| 41. Main Generator Systems | | 70 |
| 42. Electrical Power Supply Systems | | 39 |
| Total | | 435 |

Highlights (2023)

KGS-2 has achieved 100% Availability factor in all the months during the year.
KGS-2 is continuously operating since 9th October 2022 and completed 448days of continuous operation.

2023 Operating Experience

IN-15 KAIGA-3 INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : TURBOATO (TURBOATOM Kharkiv Turbine Manufacture Plant)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 2002-03-30 |
| Thermal power | : 800 MWth | Grid Date | : 2007-04-11 |
| Gross electrical power | : 220 MWe | Commercial Date | : 2007-05-06 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 16 years |

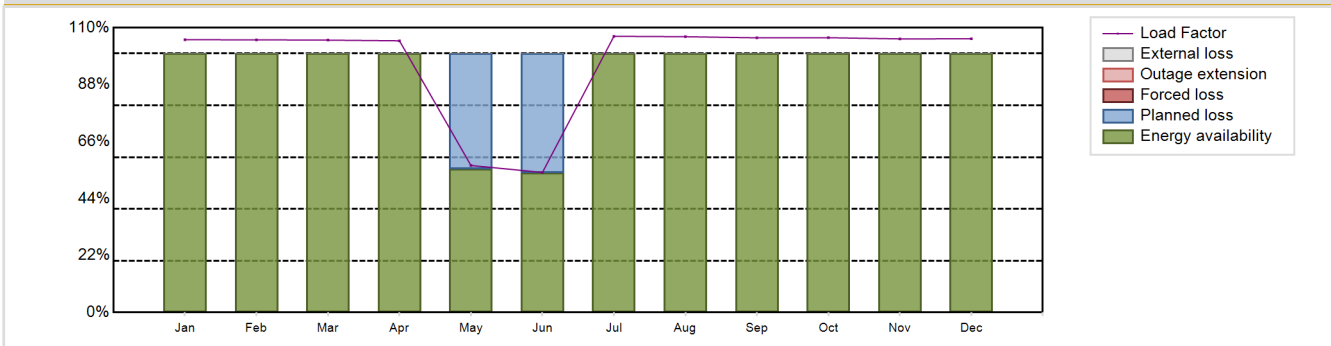
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|--------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 1.5 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : - |
| Refuelling type | : ON-line | Number of SG | : - |
| Moderator material | : - | Containment type | : - |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : - |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : - |
| Average discharge burnup [MWd/t] | : - | Turbine speed [rpm] | : - |
| Active core diameter [m] | : - | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : - | HP cylinder inlet steam pressure [MPa] | : - |
| Number of fissile fuel assemblies/bundles | : - | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : - | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : - | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : - | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 1722.86 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 92.42 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 92.42 % | Planned Unavailability Factor (PUF) | : 7.58 % |
| Load Factor (LF) | : 97.36 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 92.35 % | Total off-line time | : 670 hours |

Annual Summary

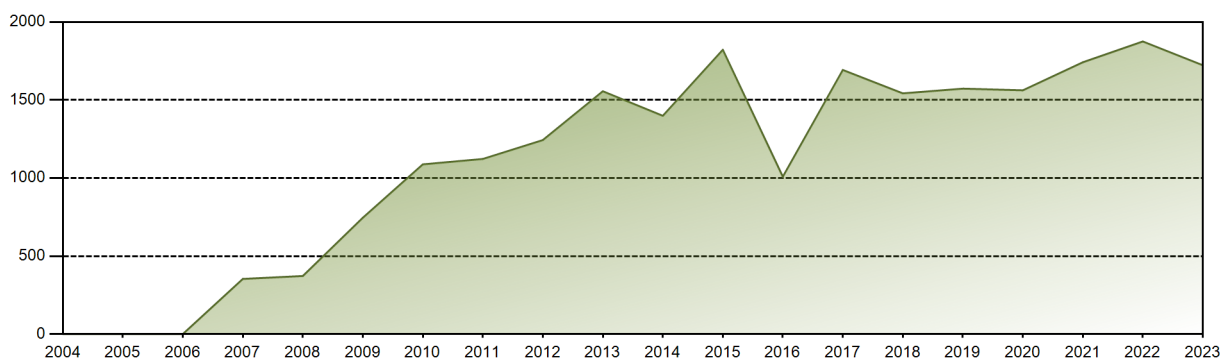


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|-------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 158.31 | 142.97 | 158.11 | 152.63 | 85.37 | 78.68 | 160.33 | 160.10 | 154.29 | 159.50 | 153.70 | 158.88 | 1722.86 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 55.38 | 53.91 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.42 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 55.38 | 53.91 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.42 |
| LF [%] | 105.34 | 105.32 | 105.20 | 104.94 | 56.80 | 54.10 | 106.68 | 106.53 | 106.09 | 106.13 | 105.68 | 105.72 | 97.36 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 54.97 | 53.47 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.35 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 44.62 | 46.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.58 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 22420.24 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.02 % |
| Cumulative Energy Availability Factor (EAF) | : 75.19 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 9.41 % |
| Cumulative Unit Capability Factor (UCF) | : 85.35 % | Cumulative Planned Unavailability Factor (PUF) | : 5.24 % |
| Cumulative Load Factor (LF) | : 75.93 % | Cumulative Externally cause unavailability (XUF) | : 10.17 % |
| Cumulative Operating Factor (OF) | : 83.63 % | | |

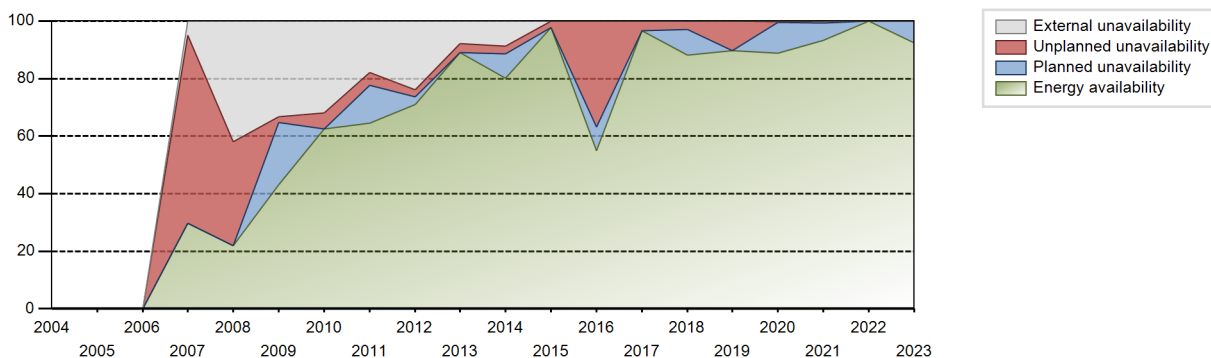
Electricity Production (net) [GWh]



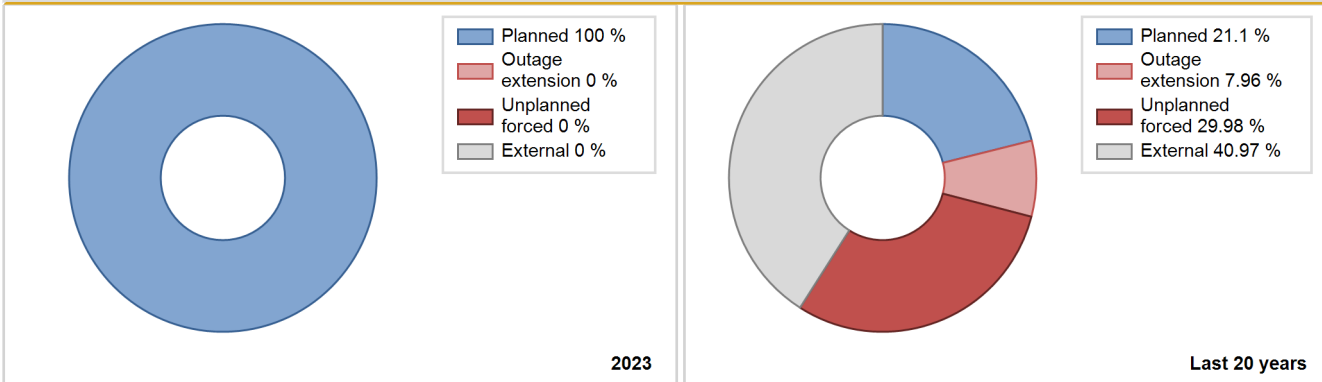
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|--------|--------|-------|-------|-------|-------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2007 | 353.34 | 2181 | 202 | 29.85 | 34.82 | 29.33 | 34.14 | 65.18 | 65.18 | 0.00 | 4.97 |
| 2008 | 372.04 | 2532 | 202 | 21.96 | 63.85 | 20.97 | 28.83 | 36.15 | 36.15 | 0.00 | 41.89 |
| 2009 | 745.45 | 6677 | 202 | 43.12 | 76.46 | 42.13 | 76.22 | 2.50 | 1.96 | 21.58 | 33.35 |
| 2010 | 1087.76 | 8267 | 202 | 62.46 | 94.43 | 61.47 | 94.37 | 5.57 | 5.57 | 0.00 | 31.97 |
| 2011 | 1122.31 | 7145 | 202 | 64.41 | 82.29 | 63.42 | 81.56 | 5.20 | 4.51 | 13.20 | 17.88 |
| 2012 | 1243.34 | 8342 | 202 | 71.06 | 95.03 | 70.07 | 94.97 | 2.42 | 2.36 | 2.61 | 23.97 |
| 2013 | 1556.25 | 8477 | 202 | 88.94 | 96.81 | 87.95 | 96.77 | 3.18 | 3.18 | 0.02 | 7.87 |
| 2014 | 1398.93 | 7768 | 202 | 80.05 | 88.79 | 79.06 | 88.68 | 3.02 | 2.76 | 8.45 | 8.74 |
| 2015 | 1821.94 | 8551 | 202 | 97.64 | 97.64 | 102.96 | 97.61 | 2.36 | 2.36 | 0.00 | 0.00 |
| 2016 | 1008.42 | 4996 | 202 | 54.94 | 54.94 | 56.83 | 56.88 | 6.83 | 36.88 | 8.19 | 0.00 |
| 2017 | 1692.70 | 8712 | 202 | 96.65 | 96.65 | 95.66 | 99.45 | 3.35 | 3.35 | 0.00 | 0.00 |
| 2018 | 1542.62 | 7966 | 202 | 88.17 | 88.17 | 87.18 | 90.94 | 3.22 | 2.94 | 8.89 | 0.00 |
| 2019 | 1572.91 | 7935 | 202 | 89.66 | 89.66 | 88.89 | 90.58 | 10.34 | 10.34 | 0.00 | 0.00 |
| 2020 | 1562.14 | 7816 | 202 | 88.79 | 89.10 | 88.04 | 88.98 | 0.10 | 0.09 | 10.82 | 0.31 |
| 2021 | 1741.94 | 8179 | 202 | 93.34 | 93.44 | 98.44 | 93.37 | 0.65 | 0.61 | 5.95 | 0.09 |
| 2022 | 1875.28 | 8760 | 202 | 100.00 | 100.00 | 105.98 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 1722.86 | 8090 | 202 | 92.42 | 92.42 | 97.36 | 92.35 | 0.00 | 0.00 | 7.58 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2007 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 738 | |
| D. Inspection, maintenance or repair without refuelling | | | | 132 | | |
| E. Testing of plant systems or components | | | | | 29 | |
| H. Nuclear regulatory requirements | 670 | | | 217 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 19 | |
| P. Fire | | | | | 17 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant , spare part delivery problems etc.) | | | | 115 | | 183 |
| Z. Other | | | | | 0 | |
| Subtotal | 670 | | | 464 | 803 | 186 |
| Total | | 670 | | | 1453 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2007 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 214 |
| 12. Reactor I&C Systems | | 3 |
| 13. Reactor Auxiliary Systems | | 19 |
| 14. Safety Systems | | 3 |
| 16. Steam generation systems | | 12 |
| 21. Fuel Handling and Storage Facilities | | 12 |
| 31. Turbine and auxiliaries | | 48 |
| 32. Feedwater and Main Steam System | | 0 |
| 35. All other I&C Systems | | 3 |
| 41. Main Generator Systems | | 623 |
| 42. Electrical Power Supply Systems | | 43 |
| Total | | 980 |

Highlights (2023)

KGS-3 Availability factor was 92.35% during this calendar year.
 KGS-3 reactor operated continuously since 04/06/2021 completing 712 days as on 18/05/2023 post which biennial shutdown(BSD) was taken.

2023 Operating Experience

IN-16 KAIGA-4 INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : TURBOATO (TURBOATOM Kharkiv Turbine Manufacture Plant)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 2002-05-10 |
| Thermal power | : 800 MWth | Grid Date | : 2011-01-19 |
| Gross electrical power | : 220 MWe | Commercial Date | : 2011-01-20 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 12 years |

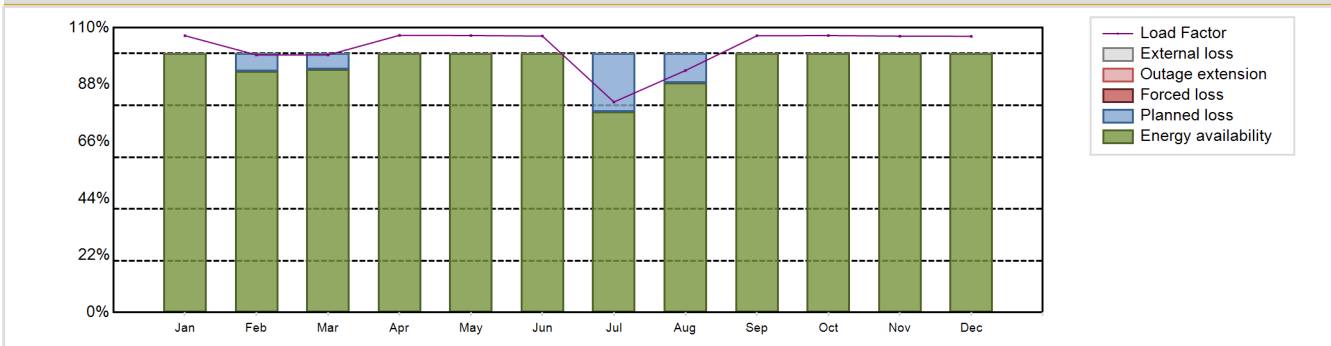
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|--------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 1.05 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : - |
| Refuelling type | : ON-line | Number of SG | : - |
| Moderator material | : - | Containment type | : - |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : - |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : - |
| Average discharge burnup [MWd/t] | : - | Turbine speed [rpm] | : - |
| Active core diameter [m] | : - | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : - | HP cylinder inlet steam pressure [MPa] | : - |
| Number of fissile fuel assemblies/bundles | : - | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : - | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : - | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : - | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 1811.38 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 96.07 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 96.07 % | Planned Unavailability Factor (PUF) | : 3.93 % |
| Load Factor (LF) | : 102.37 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 96.04 % | Total off-line time | : 347 hours |

Annual Summary

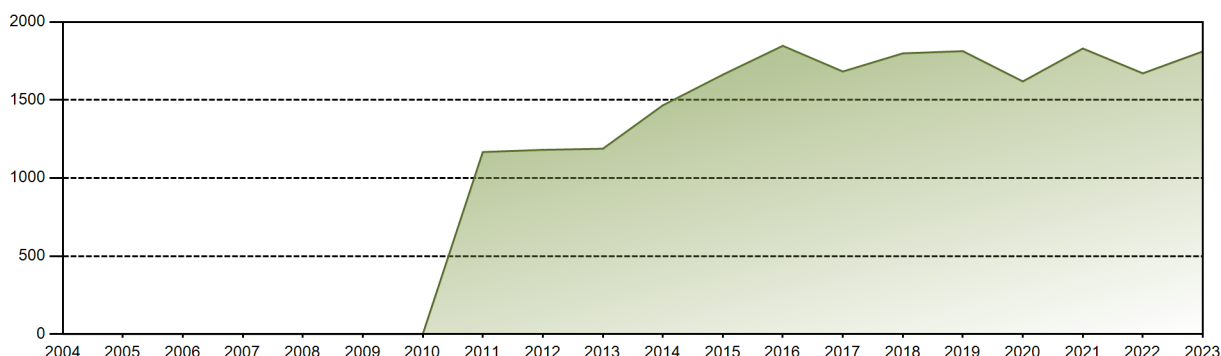


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 160.69 | 135.04 | 149.47 | 155.70 | 160.80 | 155.28 | 122.19 | 140.46 | 155.44 | 160.76 | 155.25 | 160.31 | 1811.38 |
| EAF [%] | 100.00 | 93.06 | 93.82 | 100.00 | 100.00 | 100.00 | 77.61 | 88.61 | 100.00 | 100.00 | 100.00 | 100.00 | 96.07 |
| UCF [%] | 100.00 | 93.06 | 93.82 | 100.00 | 100.00 | 100.00 | 77.61 | 88.61 | 100.00 | 100.00 | 100.00 | 100.00 | 96.07 |
| LF [%] | 106.92 | 99.48 | 99.46 | 107.05 | 106.99 | 106.76 | 81.30 | 93.46 | 106.88 | 106.97 | 106.75 | 106.67 | 102.37 |
| OF [%] | 100.00 | 93.01 | 93.82 | 100.00 | 100.00 | 100.00 | 77.42 | 88.44 | 100.00 | 100.00 | 100.00 | 100.00 | 96.04 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 6.94 | 6.18 | 0.00 | 0.00 | 0.00 | 22.39 | 11.39 | 0.00 | 0.00 | 0.00 | 0.00 | 3.93 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 20735.94 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.89 % |
| Cumulative Energy Availability Factor (EAF) | : 87.12 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.86 % |
| Cumulative Unit Capability Factor (UCF) | : 91.83 % | Cumulative Planned Unavailability Factor (PUF) | : 5.31 % |
| Cumulative Load Factor (LF) | : 90.57 % | Cumulative Externally cause unavailability (XUF) | : 4.72 % |
| Cumulative Operating Factor (OF) | : 91.69 % | | |

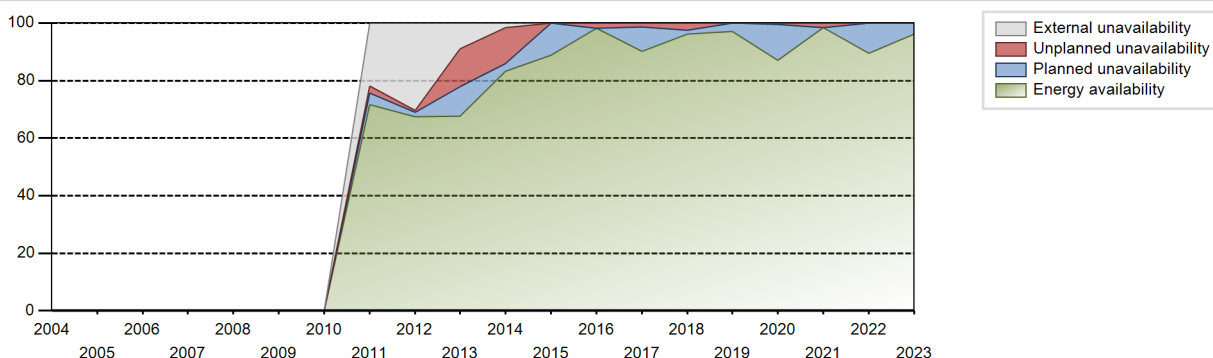
Electricity Production (net) [GWh]



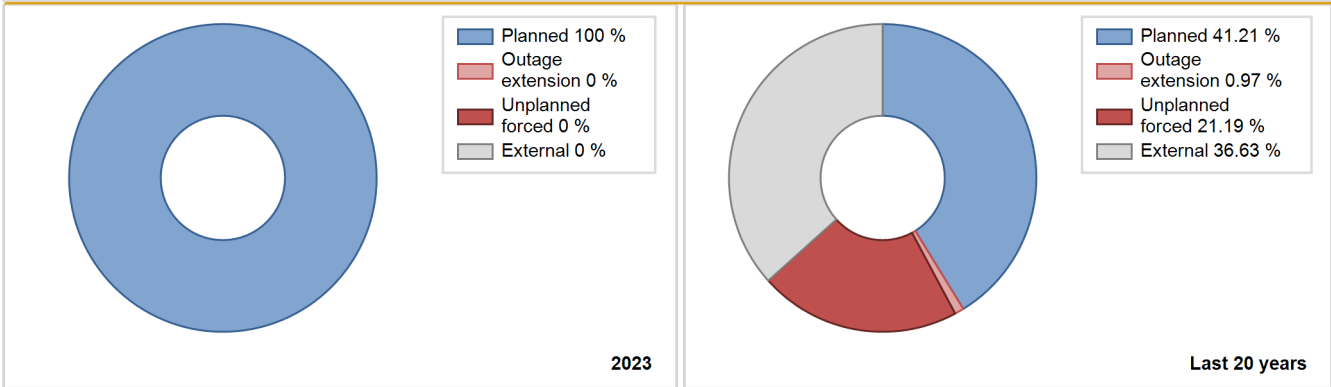
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|-------|-------|-------|-------|-------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2011 | 1166.35 | 7720 | 202 | 71.67 | 93.49 | 70.52 | 92.58 | 2.53 | 2.56 | 3.95 | 21.82 |
| 2012 | 1180.55 | 8585 | 202 | 67.52 | 97.77 | 66.53 | 97.73 | 0.82 | 0.81 | 1.42 | 30.25 |
| 2013 | 1187.63 | 6706 | 202 | 67.73 | 76.78 | 67.12 | 76.55 | 14.60 | 13.13 | 10.09 | 9.06 |
| 2014 | 1465.78 | 7411 | 202 | 83.17 | 84.74 | 82.84 | 84.60 | 12.84 | 12.48 | 2.78 | 1.57 |
| 2015 | 1662.23 | 7770 | 202 | 88.80 | 88.80 | 93.94 | 88.70 | 0.00 | 0.00 | 11.20 | 0.00 |
| 2016 | 1847.31 | 8618 | 202 | 98.12 | 98.12 | 104.11 | 98.11 | 1.88 | 1.88 | 0.00 | 0.00 |
| 2017 | 1682.54 | 7896 | 202 | 90.23 | 90.23 | 95.08 | 90.14 | 0.00 | 1.38 | 8.39 | 0.00 |
| 2018 | 1799.01 | 8415 | 202 | 96.11 | 96.11 | 101.67 | 96.06 | 2.51 | 2.59 | 1.30 | 0.00 |
| 2019 | 1813.17 | 8494 | 202 | 97.00 | 97.00 | 102.47 | 96.96 | 0.00 | 0.00 | 3.00 | 0.00 |
| 2020 | 1619.09 | 7637 | 202 | 87.07 | 87.07 | 91.25 | 86.94 | 0.63 | 0.55 | 12.37 | 0.00 |
| 2021 | 1830.05 | 8609 | 202 | 98.30 | 98.30 | 103.42 | 98.28 | 1.70 | 1.70 | 0.00 | 0.00 |
| 2022 | 1670.85 | 7829 | 202 | 89.41 | 89.48 | 94.42 | 89.37 | 0.03 | 0.03 | 10.49 | 0.07 |
| 2023 | 1811.38 | 8413 | 202 | 96.07 | 96.07 | 102.37 | 96.04 | 0.00 | 0.00 | 3.93 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2011 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 213 | |
| D. Inspection, maintenance or repair without refuelling | 347 | | | 164 | | |
| E. Testing of plant systems or components | | | | 15 | | |
| H. Nuclear regulatory requirements | | | | 291 | 10 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 5 |
| Z. Other | | | | | 30 | |
| Subtotal | 347 | | | 470 | 253 | 5 |
| Total | | 347 | | | 728 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2011 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 14 |
| 12. Reactor I&C Systems | | 8 |
| 16. Steam generation systems | | 25 |
| 21. Fuel Handling and Storage Facilities | | 9 |
| 31. Turbine and auxiliaries | | 55 |
| 32. Feedwater and Main Steam System | | 0 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 127 |
| 42. Electrical Power Supply Systems | | 8 |
| Total | | 251 |

Highlights (2023)

KGS-4 Availability factor was 96.03% during this calendar year.

2023 Operating Experience

IN-9 KAKRAPAR-1 INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 1984-12-01 |
| Thermal power | : 801 MWth | Grid Date | : 1992-11-24 |
| Gross electrical power | : 220 MWe | Commercial Date | : 1993-05-06 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 31 years |

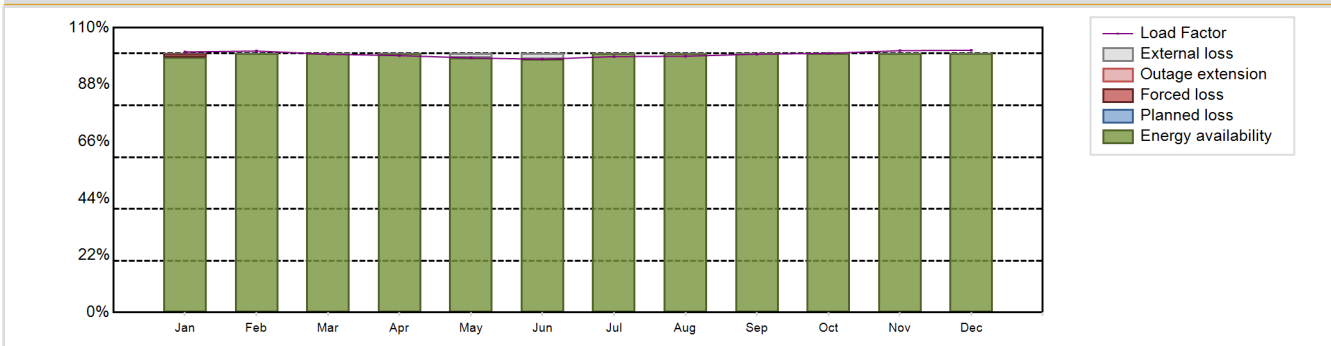
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|----------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 8.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 293 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : D2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 1.25 |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 6500 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 4.5 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 5 | HP cylinder inlet steam pressure [MPa] | : 3.972 |
| Number of fissile fuel assemblies/bundles | : 3672 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 29.57 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : 4 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 1 | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 1764.71 GW(e).h | Forced Loss Rate (FLR) | : 0.13 % |
| Energy Availability Factor (EAF) | : 99.55 % | Unplanned Capability Loss Factor (UCL) | : 0.13 % |
| Unit Capability Factor (UCF) | : 99.87 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 99.73 % | Externally cause unavailability (XUF) | : 0.32 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

Annual Summary

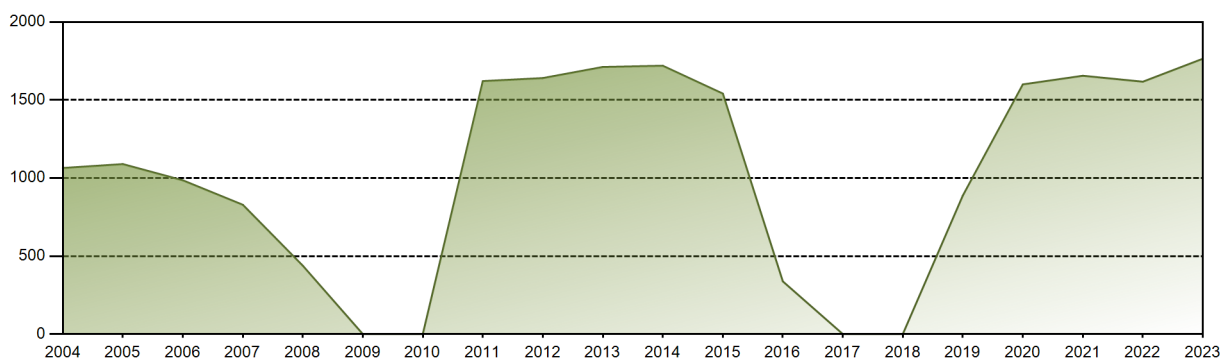


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 151.20 | 137.11 | 149.91 | 144.29 | 147.78 | 142.26 | 148.55 | 148.77 | 145.11 | 150.42 | 147.08 | 152.22 | 1764.71 |
| EAF [%] | 98.52 | 100.00 | 100.00 | 100.00 | 98.33 | 97.82 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.55 |
| UCF [%] | 98.52 | 100.00 | 100.00 | 100.00 | 100.00 | 99.94 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.87 |
| LF [%] | 100.61 | 101.01 | 99.75 | 99.21 | 98.33 | 97.82 | 98.85 | 98.99 | 99.77 | 100.09 | 101.13 | 101.28 | 99.73 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 1.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |
| UCL [%] | 1.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.67 | 2.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 |

Historical Summary

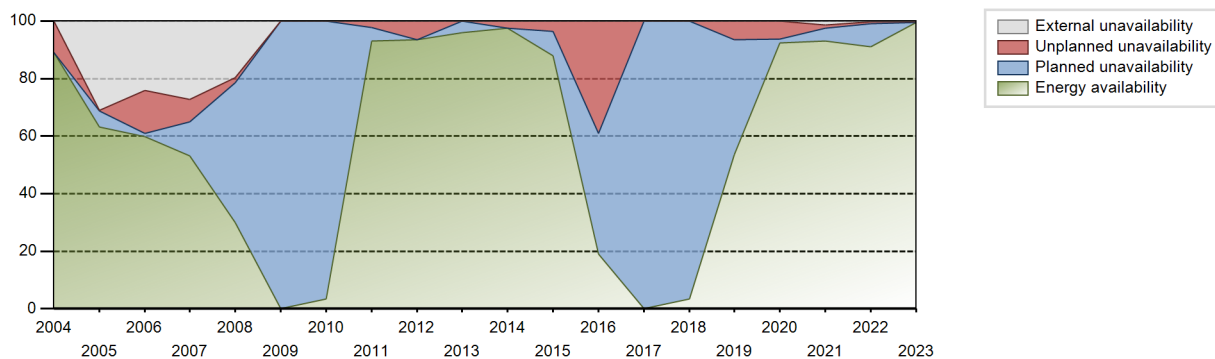
| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 32990.61 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.21 % |
| Cumulative Energy Availability Factor (EAF) | : 64.44 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.97 % |
| Cumulative Unit Capability Factor (UCF) | : 69.01 % | Cumulative Planned Unavailability Factor (PUF) | : 24.02 % |
| Cumulative Load Factor (LF) | : 62.15 % | Cumulative Externally cause unavailability (XUF) | : 4.57 % |
| Cumulative Operating Factor (OF) | : 68.59 % | | |

Electricity Production (net) [GWh]

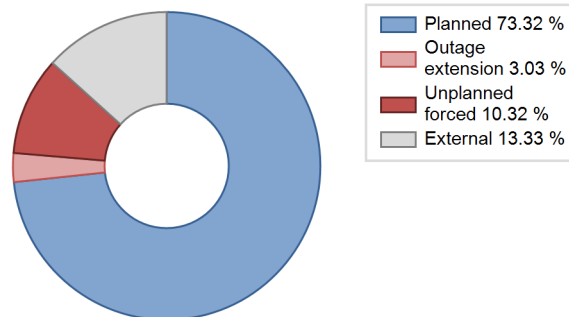
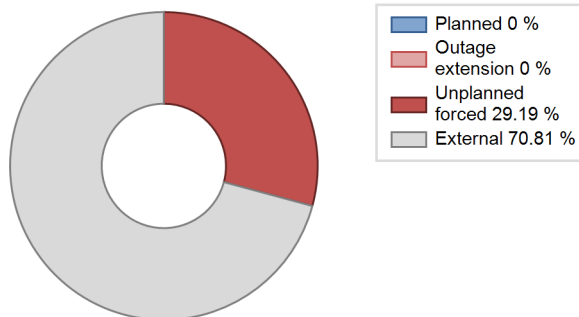


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|--------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1993 | | | | Data not provided | | | | | | | |
| 1994 | 130.28 | 1049 | 194 | 11.98 | 13.24 | 7.67 | 11.97 | 52.21 | 14.46 | 72.30 | 1.25 |
| 1995 | 1089.07 | 6225 | 195 | 66.46 | 70.51 | 63.76 | 71.06 | 26.77 | 25.77 | 3.71 | 4.05 |
| 1996 | 1295.82 | 7539 | 195 | 75.65 | 84.61 | 75.65 | 85.83 | 15.39 | 15.39 | 0.00 | 8.96 |
| 1997 | 906.72 | 5140 | 195 | 52.87 | 58.36 | 53.08 | 58.68 | 20.52 | 15.07 | 26.57 | 5.50 |
| 1998 | 1090.62 | 5987 | 195 | 63.10 | 67.03 | 63.85 | 68.34 | 18.11 | 14.83 | 18.14 | 3.93 |
| 1999 | 1407.12 | 7450 | 195 | 85.08 | 87.72 | 82.37 | 85.05 | 5.30 | 4.91 | 7.37 | 2.64 |
| 2000 | 1645.42 | 8445 | 195 | 94.53 | 95.18 | 96.06 | 96.14 | 4.82 | 4.82 | 0.00 | 0.64 |
| 2001 | 1517.45 | 7690 | 195 | 86.46 | 86.49 | 88.83 | 87.79 | 6.72 | 6.23 | 7.28 | 0.03 |
| 2002 | 1697.79 | 8488 | 202 | 96.74 | 96.79 | 95.95 | 96.89 | 3.21 | 3.21 | 0.00 | 0.04 |
| 2003 | 1419.43 | 7622 | 202 | 81.93 | 87.47 | 80.22 | 87.01 | 1.80 | 1.60 | 10.93 | 5.54 |
| 2004 | 1064.42 | 7416 | 202 | 89.06 | 89.06 | 59.99 | 84.43 | 10.94 | 10.94 | 0.00 | 0.00 |
| 2005 | 1089.40 | 7969 | 202 | 63.14 | 94.21 | 61.56 | 90.97 | 0.00 | 0.17 | 5.62 | 31.06 |
| 2006 | 985.55 | 7316 | 202 | 59.76 | 83.85 | 55.70 | 83.53 | 3.24 | 14.91 | 1.24 | 24.09 |
| 2007 | 828.70 | 6867 | 202 | 53.26 | 80.48 | 46.83 | 78.39 | 0.00 | 7.78 | 11.75 | 27.21 |
| 2008 | 438.12 | 4210 | 202 | 29.97 | 49.70 | 24.69 | 47.93 | 3.44 | 1.77 | 48.53 | 19.73 |
| 2009 | 0.00 | 0 | 202 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2010 | 0.00 | 0 | 202 | 3.47 | 3.47 | 0.00 | 0.00 | 0.00 | 0.00 | 96.53 | 0.00 |
| 2011 | 1621.39 | 8177 | 202 | 93.05 | 93.05 | 91.63 | 93.34 | 2.31 | 2.20 | 4.75 | 0.00 |
| 2012 | 1640.69 | 8186 | 202 | 93.42 | 93.42 | 92.47 | 93.19 | 6.58 | 6.58 | 0.00 | 0.00 |
| 2013 | 1711.81 | 8387 | 202 | 95.89 | 95.89 | 96.74 | 95.74 | 0.00 | 0.00 | 4.11 | 0.00 |
| 2014 | 1719.70 | 8543 | 202 | 97.61 | 97.61 | 97.18 | 97.52 | 2.39 | 2.39 | 0.00 | 0.00 |
| 2015 | 1541.28 | 7699 | 202 | 87.92 | 87.92 | 87.10 | 87.89 | 0.00 | 3.66 | 8.41 | 0.00 |
| 2016 | 337.72 | 1676 | 202 | 19.09 | 19.09 | 19.03 | 19.08 | 67.20 | 39.11 | 41.80 | 0.00 |
| 2017 | 0.00 | 0 | 202 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2018 | 0.00 | 0 | 202 | 3.47 | 3.47 | 0.00 | 0.00 | 0.00 | 0.00 | 96.53 | 0.00 |
| 2019 | 887.73 | 4723 | 202 | 53.63 | 53.63 | 50.17 | 53.92 | 10.95 | 6.59 | 39.77 | 0.00 |
| 2020 | 1600.12 | 8417 | 202 | 92.29 | 92.29 | 90.18 | 95.82 | 6.27 | 6.17 | 1.54 | 0.00 |
| 2021 | 1655.51 | 8370 | 202 | 93.01 | 94.43 | 93.56 | 95.55 | 1.18 | 1.12 | 4.44 | 1.42 |
| 2022 | 1617.43 | 8009 | 202 | 91.14 | 91.43 | 91.41 | 91.43 | 0.77 | 0.71 | 7.87 | 0.29 |
| 2023 | 1764.71 | 8760 | 202 | 99.55 | 99.87 | 99.73 | 100.00 | 0.13 | 0.13 | 0.00 | 0.32 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1993 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 491 | |
| D. Inspection, maintenance or repair without refuelling | | | | 491 | | |
| E. Testing of plant systems or components | | | | 40 | 34 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 741 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 821 | | |
| H. Nuclear regulatory requirements | | | | | 38 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 34 |
| L. Human factor related | | | | | 5 | |
| P. Fire | | | | | 4 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 11 |
| Z. Other | | | | 13 | 2 | 5 |
| Subtotal | | | | 2106 | 574 | 50 |
| Total | | 0 | | | 2730 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1993 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 148 |
| 12. Reactor I&C Systems | | 29 |
| 13. Reactor Auxiliary Systems | | 8 |
| 14. Safety Systems | | 5 |
| 15. Reactor Cooling Systems | | 81 |
| 16. Steam generation systems | | 30 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 9 |
| 21. Fuel Handling and Storage Facilities | | 15 |
| 31. Turbine and auxiliaries | | 63 |
| 32. Feedwater and Main Steam System | | 8 |
| 35. All other I&C Systems | | 33 |
| 41. Main Generator Systems | | 75 |
| 42. Electrical Power Supply Systems | | 43 |
| Total | | 547 |

Highlights (2023)

KAPS-1 reactor and turbine operated for 387 days continuously till 31st December,2023 with 101.67% Capacity factor.

2023 Operating Experience

IN-10 KAKRAPAR-2 INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 1985-04-01 |
| Thermal power | : 801 MWth | Grid Date | : 1995-03-04 |
| Gross electrical power | : 220 MWe | Commercial Date | : 1995-09-01 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 28 years |

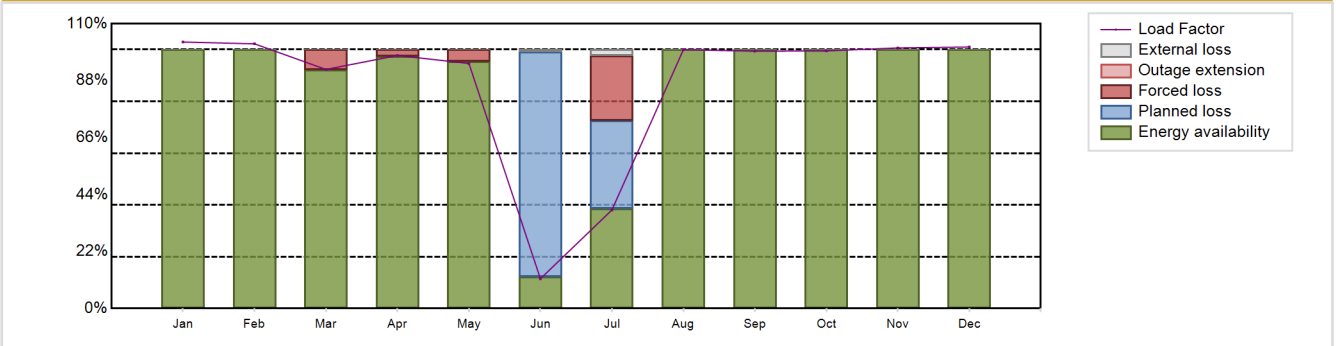
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|----------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 8.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 293 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : D2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 1.25 |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 6500 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 4.5 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 5 | HP cylinder inlet steam pressure [MPa] | : 3.972 |
| Number of fissile fuel assemblies/bundles | : 3672 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 29.57 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : 4 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 1 | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 1533.03 GW(e).h | Forced Loss Rate (FLR) | : 3.78 % |
| Energy Availability Factor (EAF) | : 86.29 % | Unplanned Capability Loss Factor (UCL) | : 3.4 % |
| Unit Capability Factor (UCF) | : 86.56 % | Planned Unavailability Factor (PUF) | : 10.04 % |
| Load Factor (LF) | : 86.64 % | Externally cause unavailability (XUF) | : 0.27 % |
| Operating Factor (OF) | : 86.56 % | Total off-line time | : 1177 hours |

Annual Summary

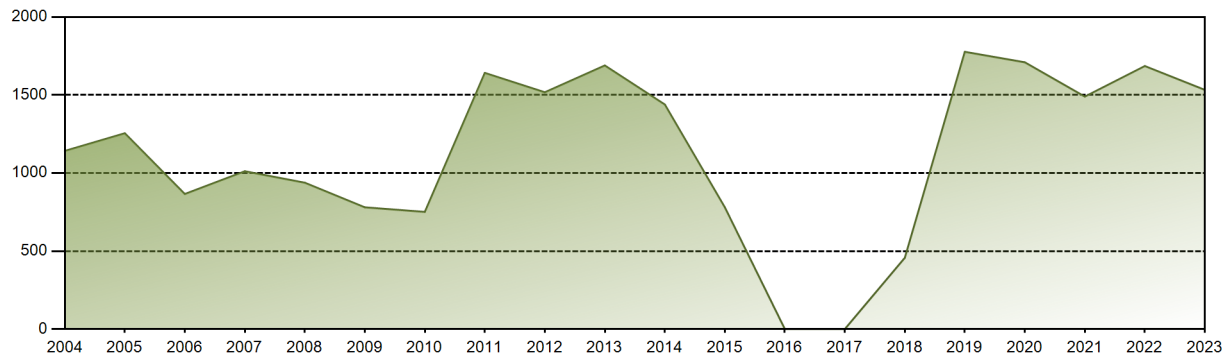


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|-------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 154.69 | 138.76 | 138.77 | 142.13 | 142.22 | 16.74 | 57.21 | 150.25 | 144.55 | 149.54 | 146.38 | 151.79 | 1533.03 |
| EAF [%] | 100.00 | 100.00 | 92.22 | 97.46 | 95.37 | 12.19 | 38.46 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.29 |
| UCF [%] | 100.00 | 100.00 | 92.22 | 97.46 | 95.37 | 12.96 | 40.85 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.56 |
| LF [%] | 102.93 | 102.22 | 92.34 | 97.73 | 94.63 | 11.51 | 38.07 | 99.97 | 99.39 | 99.50 | 100.65 | 101.00 | 86.64 |
| OF [%] | 100.00 | 100.00 | 92.20 | 97.50 | 95.43 | 12.92 | 40.86 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.56 |
| FLR [%] | 0.00 | 0.00 | 7.78 | 2.54 | 4.63 | 0.00 | 38.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.78 |
| UCL [%] | 0.00 | 0.00 | 7.78 | 2.54 | 4.63 | 0.00 | 25.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.40 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 87.04 | 34.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.04 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.77 | 2.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 |

Historical Summary

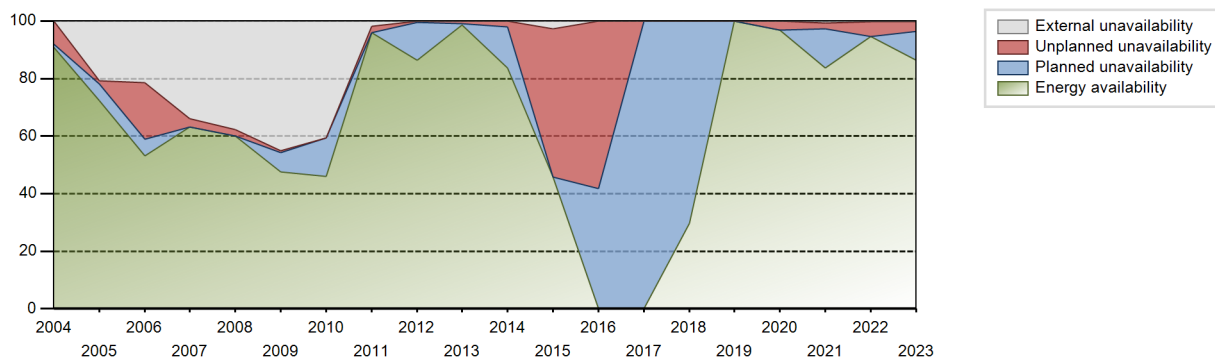
| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 34726.02 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.63 % |
| Cumulative Energy Availability Factor (EAF) | : 71.76 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.2 % |
| Cumulative Unit Capability Factor (UCF) | : 79.83 % | Cumulative Planned Unavailability Factor (PUF) | : 11.96 % |
| Cumulative Load Factor (LF) | : 69.36 % | Cumulative Externally cause unavailability (XUF) | : 8.07 % |
| Cumulative Operating Factor (OF) | : 79.69 % | | |

Electricity Production (net) [GWh]

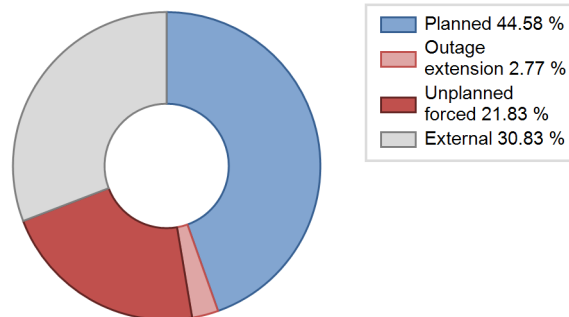
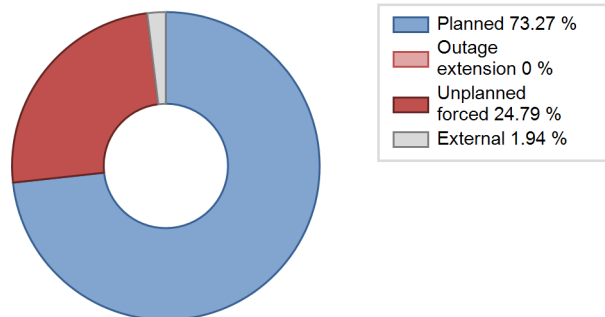


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|--------|-------|--------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1995 | 825.53 | 5401 | 196 | 88.25 | 91.95 | 79.29 | 85.83 | 1.15 | 1.07 | 6.98 | 3.70 |
| 1996 | 1326.81 | 7663 | 195 | 77.46 | 86.25 | 77.46 | 87.24 | 12.65 | 12.50 | 1.25 | 8.79 |
| 1997 | 1093.45 | 6139 | 195 | 63.81 | 66.70 | 64.01 | 70.08 | 27.13 | 24.83 | 8.47 | 2.89 |
| 1998 | 1291.62 | 6932 | 195 | 76.62 | 78.67 | 75.61 | 79.13 | 12.18 | 10.91 | 10.41 | 2.06 |
| 1999 | 1512.28 | 7955 | 195 | 91.14 | 92.38 | 88.53 | 90.81 | 5.08 | 4.94 | 2.67 | 1.25 |
| 2000 | 1489.85 | 7697 | 195 | 85.60 | 85.81 | 86.98 | 87.63 | 6.83 | 6.29 | 7.90 | 0.21 |
| 2001 | 1685.44 | 8500 | 195 | 95.26 | 95.97 | 98.67 | 97.03 | 4.03 | 4.03 | 0.00 | 0.71 |
| 2002 | 1597.13 | 7940 | 202 | 89.19 | 89.49 | 90.26 | 90.64 | 2.50 | 2.65 | 7.87 | 0.29 |
| 2003 | 1613.17 | 8515 | 202 | 92.29 | 97.32 | 91.16 | 97.20 | 2.68 | 2.68 | 0.00 | 5.03 |
| 2004 | 1142.04 | 7658 | 202 | 90.87 | 90.87 | 64.36 | 87.18 | 8.17 | 8.08 | 1.05 | 0.00 |
| 2005 | 1255.04 | 7979 | 202 | 72.25 | 92.94 | 70.93 | 91.08 | 1.36 | 1.28 | 5.78 | 20.69 |
| 2006 | 865.76 | 6473 | 202 | 53.10 | 74.59 | 48.93 | 73.89 | 3.12 | 19.66 | 5.75 | 21.49 |
| 2007 | 1011.68 | 8447 | 202 | 63.15 | 97.04 | 57.17 | 96.43 | 2.96 | 2.96 | 0.00 | 33.90 |
| 2008 | 938.12 | 8596 | 202 | 60.10 | 97.83 | 52.87 | 97.86 | 2.17 | 2.17 | 0.00 | 37.72 |
| 2009 | 780.39 | 7506 | 202 | 47.57 | 92.53 | 44.10 | 85.68 | 0.77 | 0.72 | 6.75 | 44.96 |
| 2010 | 751.12 | 7530 | 202 | 45.91 | 86.46 | 42.45 | 85.96 | 0.00 | 0.00 | 13.54 | 40.55 |
| 2011 | 1641.96 | 8568 | 202 | 95.98 | 97.82 | 92.79 | 97.81 | 2.18 | 2.18 | 0.00 | 1.83 |
| 2012 | 1517.71 | 7639 | 202 | 86.43 | 86.43 | 85.54 | 86.96 | 0.02 | 0.51 | 13.05 | 0.00 |
| 2013 | 1689.37 | 8682 | 202 | 98.63 | 98.63 | 95.47 | 99.11 | 0.86 | 0.85 | 0.52 | 0.00 |
| 2014 | 1439.30 | 7748 | 202 | 83.65 | 83.65 | 81.34 | 88.45 | 1.51 | 1.97 | 14.38 | 0.00 |
| 2015 | 780.65 | 4259 | 202 | 45.80 | 48.62 | 44.12 | 48.62 | 51.38 | 51.38 | 0.00 | 2.82 |
| 2016 | 0.00 | 0 | 202 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 58.20 | 41.80 | 0.00 |
| 2017 | 0.00 | 0 | 202 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2018 | 456.84 | 2411 | 202 | 29.68 | 29.68 | 25.82 | 27.52 | 0.32 | 0.09 | 70.23 | 0.00 |
| 2019 | 1777.01 | 8760 | 202 | 100.00 | 100.00 | 100.42 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 1709.80 | 8546 | 202 | 96.90 | 96.90 | 96.36 | 97.29 | 3.10 | 3.10 | 0.00 | 0.00 |
| 2021 | 1490.01 | 7383 | 202 | 83.62 | 84.28 | 84.20 | 84.28 | 2.27 | 1.96 | 13.77 | 0.66 |
| 2022 | 1685.86 | 8315 | 202 | 94.64 | 94.92 | 95.27 | 94.92 | 5.08 | 5.08 | 0.00 | 0.28 |
| 2023 | 1533.03 | 7583 | 202 | 86.29 | 86.56 | 86.64 | 86.56 | 3.78 | 3.40 | 10.04 | 0.27 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1995 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 298 | | | 647 | |
| D. Inspection, maintenance or repair without refuelling | 880 | | | 373 | 26 | |
| E. Testing of plant systems or components | | | | 5 | 12 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 663 | | |
| H. Nuclear regulatory requirements | | | | | 31 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 18 |
| L. Human factor related | | | | | 5 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 2 |
| Z. Other | | | | | 4 | |
| Subtotal | 880 | 298 | | 1041 | 725 | 20 |
| Total | | 1178 | | | 1786 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1995 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 336 |
| 12. Reactor I&C Systems | | 37 |
| 13. Reactor Auxiliary Systems | | 5 |
| 14. Safety Systems | | 6 |
| 15. Reactor Cooling Systems | | 20 |
| 16. Steam generation systems | | 11 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 19 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | | 81 |
| 32. Feedwater and Main Steam System | 187 | 52 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 38 |
| 42. Electrical Power Supply Systems | 111 | 52 |
| Total | 298 | 667 |

Highlights (2023)

During the year 2023, KAPS-2 had Availability factor of 86.56% and Capability factor of 87.95%.

2023 Operating Experience

IN-30

KAKRAPAR-3

INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

Reactor Unit Details

Reactor type and model : PHWR / PHWR-700
 Thermal power : 2166 MWth
 Gross electrical power : 700 MWe
 Reference unit power (net) : 630 MWe

Key Dates

Construction Date : 2010-11-22
 Grid Date : 2021-01-10
 Commercial Date : 2023-06-30
 Age at end of year : 2 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : -
 Fuel material : -
 Refuelling type : -
 Moderator material : -
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : -
 Active core diameter [m] : -
 Active core height/length [m] : -
 Number of fissile fuel assemblies/bundles : -
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : -
 Number of external reactor coolant loops : -
 Coolant type : -

Operating coolant pressure [MPa] : -
 Reactor outlet temperature [°C] : -
 Number of SG : -
 Containment type : -
 Containment design pressure [MPa] : -

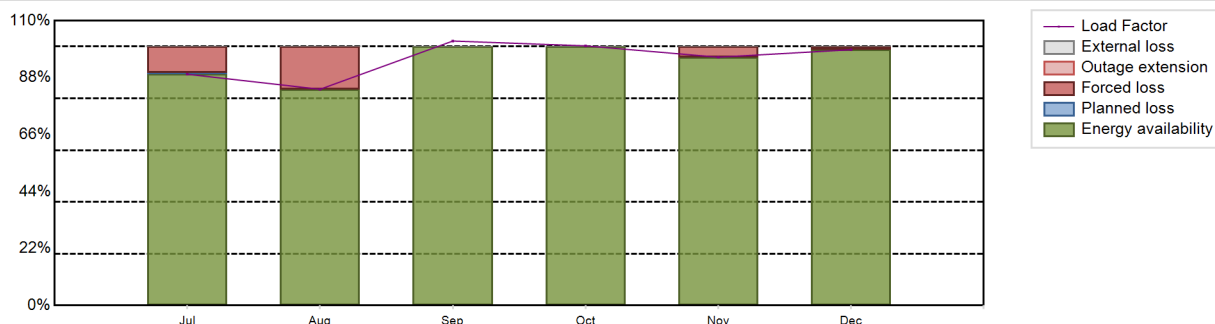
Secondary systems

Number of turbine-generators per unit/reactor : -
 Turbine speed [rpm] : -
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : -
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3422.13 GW(e).h
 Energy Availability Factor (EAF) : 94.55 %
 Unit Capability Factor (UCF) : 94.55 %
 Load Factor (LF) : 94.95 %
 Operating Factor (OF) : 99.89 %
 Forced Loss Rate (FLR) : 5.35 %
 Unplanned Capability Loss Factor (UCL) : 5.35 %
 Planned Unavailability Factor (PUF) : 0.1 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 2317 hours

Annual Summary

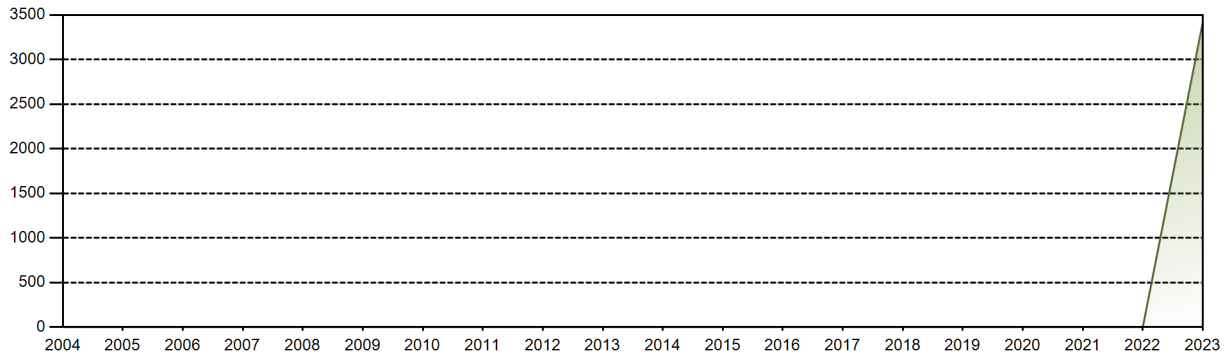


| | Jun | Jan | Feb | Mar | Apr | May | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-----|-----|-----|-----|-----|-----|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | | | | | | | 418.65 | 391.50 | 463.36 | 470.04 | 435.09 | 463.00 | 2641.65 |
| EAF [%] | | | | | | | 89.32 | 83.53 | 100.00 | 100.00 | 95.92 | 98.78 | 94.55 |
| UCF [%] | | | | | | | 89.32 | 83.53 | 100.00 | 100.00 | 95.92 | 98.78 | 94.55 |
| LF [%] | | | | | | | 89.32 | 83.53 | 102.15 | 100.28 | 95.92 | 98.78 | 94.95 |
| OF [%] | | | | | | | 99.46 | 100.00 | 100.00 | 100.00 | 100.00 | 99.87 | 99.89 |
| FLR [%] | | | | | | | 10.15 | 16.47 | 0.00 | 0.00 | 4.08 | 1.22 | 5.35 |
| UCL [%] | | | | | | | 10.09 | 16.47 | 0.00 | 0.00 | 4.08 | 1.22 | 5.35 |
| PUF [%] | | | | | | | 0.59 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 |
| XUF [%] | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|-------------------|---|----------|
| Lifetime energy generation | : 3423.35 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.35 % |
| Cumulative Energy Availability Factor (EAF) | : 94.55 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.35 % |
| Cumulative Unit Capability Factor (UCF) | : 94.55 % | Cumulative Planned Unavailability Factor (PUF) | : 0.1 % |
| Cumulative Load Factor (LF) | : 94.95 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 99.89 % | | |

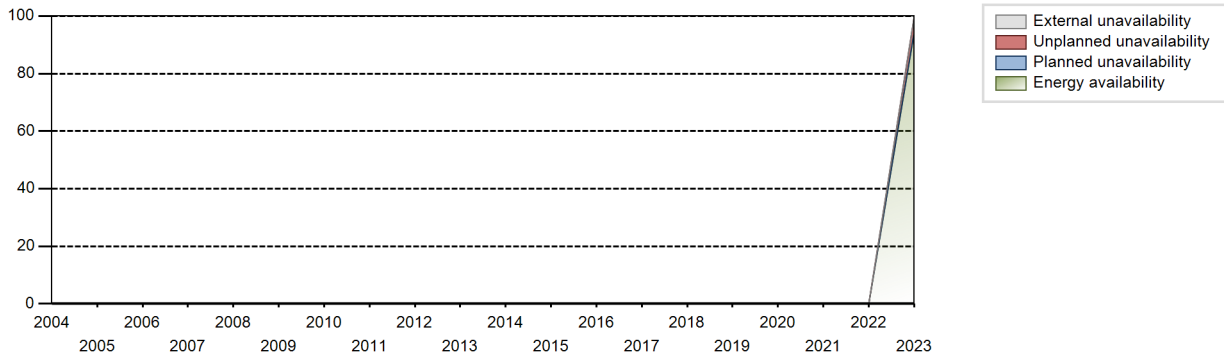
Electricity Production (net) [GWh]



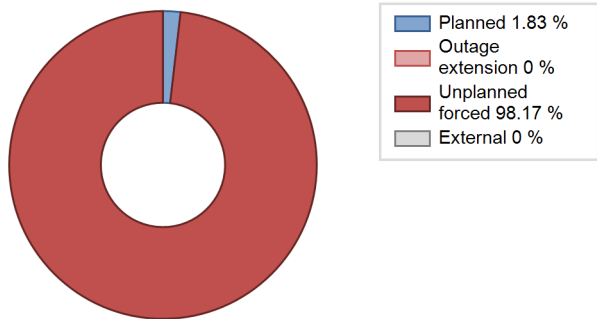
Performance for Years of Commercial Operation

| Year | Energy | Time Online | Reference Unit Power | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------|-------------|----------------------|-------|-------|-------|-------|------|------|------|------|
| | [GW-h] | [Hours] | [MW] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2023 | 3422.13 | 6443 | 630 | 94.55 | 94.55 | 94.95 | 99.89 | 5.35 | 5.35 | 0.10 | 0.00 |

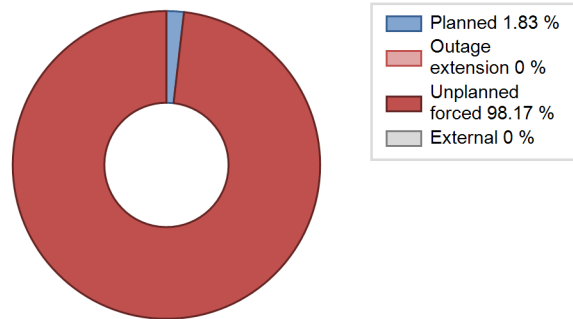
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2023 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 12 | | | 25 | |
| D. Inspection, maintenance or repair without refuelling | 2301 | | | 6117 | | |
| E. Testing of plant systems or components | 4 | | | 9 | | |
| Subtotal | 2305 | 12 | | 6126 | 25 | |
| Total | | 2317 | | | 6151 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2023 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|---|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 2 | | 1 |
| 16. Steam generation systems | | 3 | | 2 |
| 31. Turbine and auxiliaries | | 1 | | 0 |
| 41. Main Generator Systems | | 6 | | 3 |
| 42. Electrical Power Supply Systems | | 1 | | 0 |
| Total | | 13 | | 6 |

Highlights (2023)

KAPP-3 was "Declared Commercial" with effect from 10:00hrs on 30/06/2023.
 On 30/08/2023, KAPS-3, first of a kind PHWR of the country, attained its rated power 700MW(e) safely.

2023 Operating Experience

IN-25

KUDANKULAM-1

INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : MAEP (MINATOMENERGOPROM, MINISTRY OF NUCLEAR POWER AND INDUSTRY)
 Turbine Supplier : JSC ASE (JSC "Atomstroyexport")



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-412 | Construction Date | : 2002-03-31 |
| Thermal power | : 3000 MWth | Grid Date | : 2013-10-22 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 2014-12-31 |
| Reference unit power (net) | : 932 MWe | Age at end of year | : 10 years |

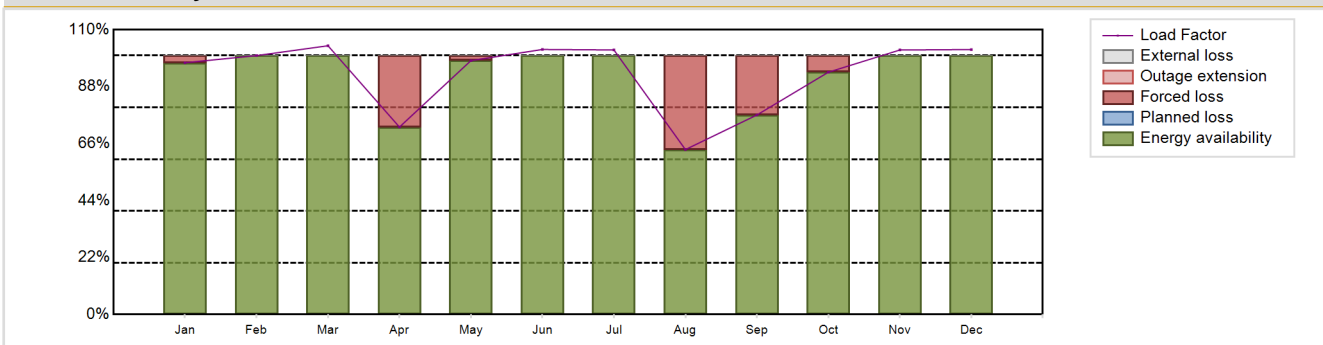
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 2.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 321 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 5.6 |
| Refuelling frequency [month] | : 10 | Secondary systems | |
| Part of the core refuelled [%] | : 30 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 42000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 3.16 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.53 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Number of fissile fuel assemblies/bundles | : 163 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : 121 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 4 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 3 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 7584.74 GW(e).h | Forced Loss Rate (FLR) | : 8.18 % |
| Energy Availability Factor (EAF) | : 91.82 % | Unplanned Capability Loss Factor (UCL) | : 8.18 % |
| Unit Capability Factor (UCF) | : 91.82 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 92.9 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 92.93 % | Total off-line time | : 619 hours |

Annual Summary

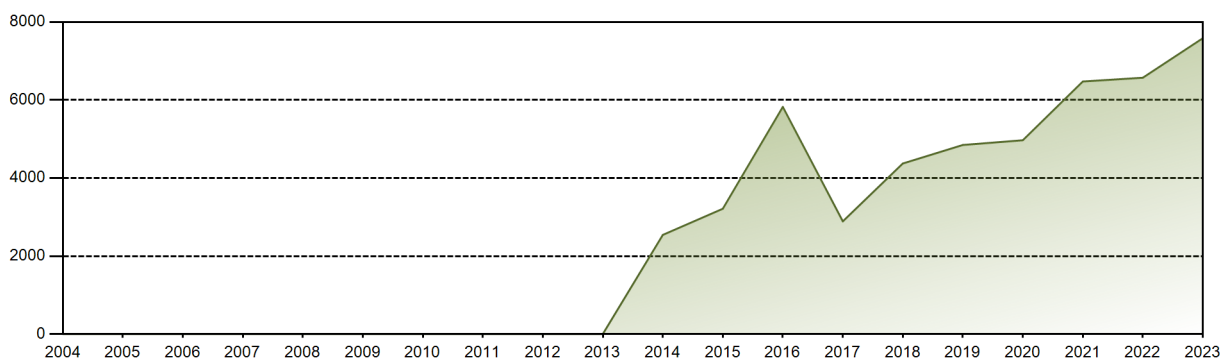


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 674.35 | 626.30 | 719.76 | 485.83 | 680.04 | 686.89 | 708.51 | 441.78 | 517.13 | 648.94 | 685.57 | 709.64 | 7584.74 |
| EAF [%] | 97.25 | 100.00 | 100.00 | 72.40 | 98.07 | 100.00 | 100.00 | 63.71 | 77.06 | 93.59 | 100.00 | 100.00 | 91.82 |
| UCF [%] | 97.25 | 100.00 | 100.00 | 72.40 | 98.07 | 100.00 | 100.00 | 63.71 | 77.06 | 93.59 | 100.00 | 100.00 | 91.82 |
| LF [%] | 97.25 | 100.00 | 103.80 | 72.40 | 98.07 | 102.36 | 102.18 | 63.71 | 77.06 | 93.59 | 102.17 | 102.34 | 92.90 |
| OF [%] | 100.00 | 100.00 | 100.00 | 75.14 | 98.39 | 100.00 | 100.00 | 66.94 | 80.28 | 94.62 | 100.00 | 100.00 | 92.93 |
| FLR [%] | 2.75 | 0.00 | 0.00 | 27.60 | 1.93 | 0.00 | 0.00 | 36.29 | 22.94 | 6.41 | 0.00 | 0.00 | 8.18 |
| UCL [%] | 2.75 | 0.00 | 0.00 | 27.60 | 1.93 | 0.00 | 0.00 | 36.29 | 22.94 | 6.41 | 0.00 | 0.00 | 8.18 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 49289.29 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 16.81 % |
| Cumulative Energy Availability Factor (EAF) | : 63.45 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 13.77 % |
| Cumulative Unit Capability Factor (UCF) | : 64.6 % | Cumulative Planned Unavailability Factor (PUF) | : 21.63 % |
| Cumulative Load Factor (LF) | : 63.69 % | Cumulative Externally cause unavailability (XUF) | : 1.14 % |
| Cumulative Operating Factor (OF) | : 68.23 % | | |

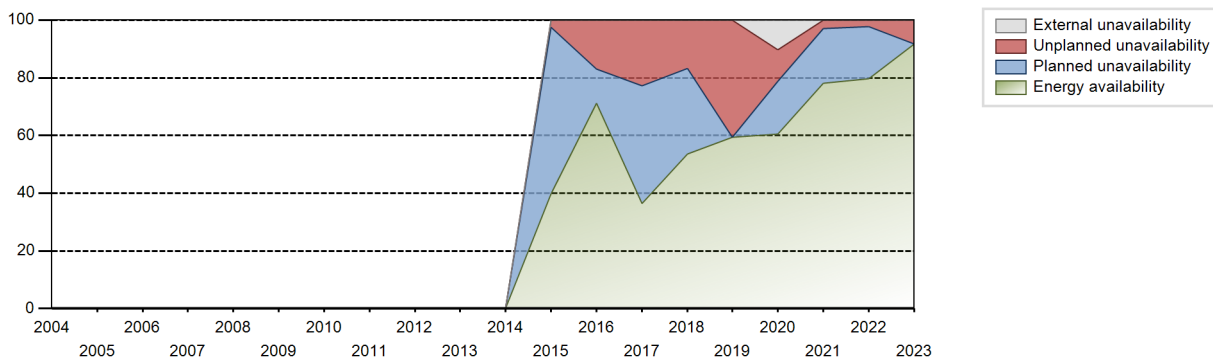
Electricity Production (net) [GWh]



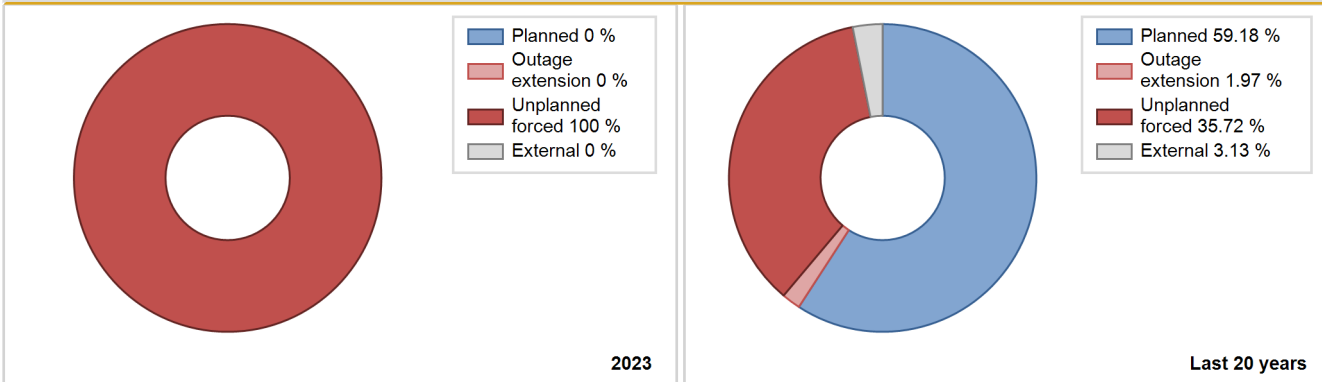
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2014 | 2542.23 | 4212 | 917 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 3212.83 | 3993 | 917 | 39.74 | 39.74 | 40.00 | 45.58 | 5.74 | 2.42 | 57.84 | 0.00 |
| 2016 | 5823.01 | 6828 | 932 | 71.21 | 71.21 | 71.13 | 77.73 | 19.30 | 17.03 | 11.76 | 0.00 |
| 2017 | 2889.26 | 3937 | 932 | 36.53 | 36.53 | 35.39 | 44.94 | 38.43 | 22.80 | 40.67 | 0.00 |
| 2018 | 4372.96 | 4997 | 932 | 53.56 | 53.56 | 53.56 | 57.04 | 23.73 | 16.67 | 29.77 | 0.00 |
| 2019 | 4847.99 | 5349 | 932 | 59.48 | 59.48 | 59.38 | 61.06 | 40.52 | 40.52 | 0.00 | 0.00 |
| 2020 | 4968.80 | 6369 | 932 | 60.49 | 70.74 | 60.69 | 72.51 | 6.86 | 10.92 | 18.34 | 10.25 |
| 2021 | 6475.11 | 6982 | 932 | 78.11 | 78.11 | 79.31 | 79.70 | 2.75 | 2.97 | 18.91 | 0.00 |
| 2022 | 6572.07 | 7228 | 932 | 79.74 | 79.74 | 80.50 | 82.51 | 2.78 | 2.28 | 17.98 | 0.00 |
| 2023 | 7584.74 | 8141 | 932 | 91.82 | 91.82 | 92.90 | 92.93 | 8.18 | 8.18 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2014 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 619 | | | 953 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1768 | | |
| E. Testing of plant systems or components | | | | 3 | | |
| Z. Other | | | | | 59 | |
| Subtotal | | 619 | | 1771 | 1012 | |
| Total | | 619 | | | 2783 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2014 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 7 |
| 12. Reactor I&C Systems | | 9 |
| 15. Reactor Cooling Systems | | 8 |
| 16. Steam generation systems | 425 | 48 |
| 21. Fuel Handling and Storage Facilities | | 6 |
| 31. Turbine and auxiliaries | 142 | 565 |
| 32. Feedwater and Main Steam System | 40 | 33 |
| 33. Circulating Water System | | 2 |
| 35. All other I&C Systems | | 18 |
| 41. Main Generator Systems | 12 | 223 |
| 42. Electrical Power Supply Systems | | 42 |
| Total | 619 | 961 |

Highlights (2023)

KKNPP-1 achieved a Capacity factor of 92.85% during the year.
 KKNPP-1 achieved an Availability factor of 92.92% during the year.

2023 Operating Experience

IN-26

KUDANKULAM-2

INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : MAEP (MINATOMENERGOPROM, MINISTRY OF NUCLEAR POWER AND INDUSTRY)
 Turbine Supplier : JSC ASE (JSC "Atomstroyexport")



Reactor Unit Details

Reactor type and model : PWR / VVER V-412
 Thermal power : 3000 MWth
 Gross electrical power : 1000 MWe
 Reference unit power (net) : 932 MWe

Key Dates

Construction Date : 2002-07-04
 Grid Date : 2016-08-29
 Commercial Date : 2017-03-31
 Age at end of year : 7 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 42000
 Active core diameter [m] : 3.16
 Active core height/length [m] : 3.53
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : 17.6
 Number of control rod assemblies : 121
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 1.27
 Reactor outlet temperature [°C] : 320.1
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 5.6

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

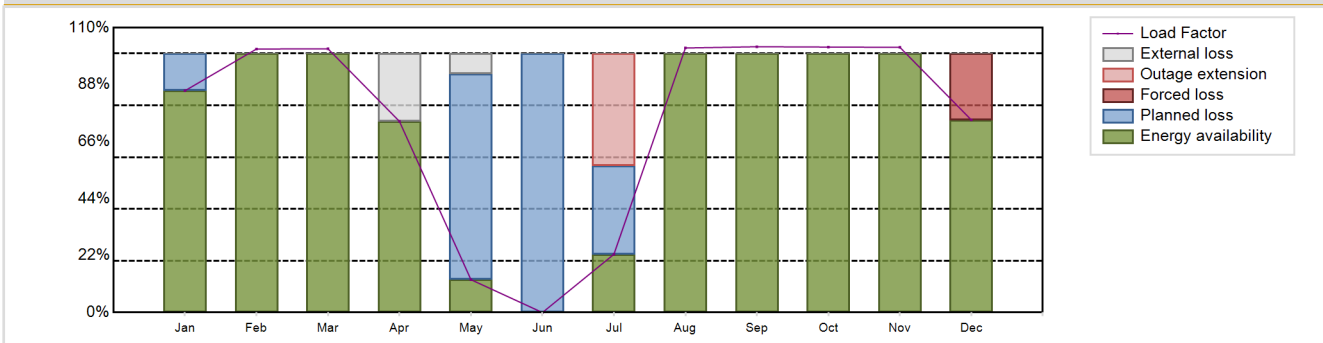
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5988.25 GW(e).h
 Energy Availability Factor (EAF) : 72.24 %
 Unit Capability Factor (UCF) : 75.06 %
 Load Factor (LF) : 73.35 %
 Operating Factor (OF) : 76.64 %

Forced Loss Rate (FLR) : 2.82 %
 Unplanned Capability Loss Factor (UCL) : 5.85 %
 Planned Unavailability Factor (PUF) : 19.09 %
 Externally cause unavailability (XUF) : 2.82 %
 Total off-line time : 2046 hours

Annual Summary

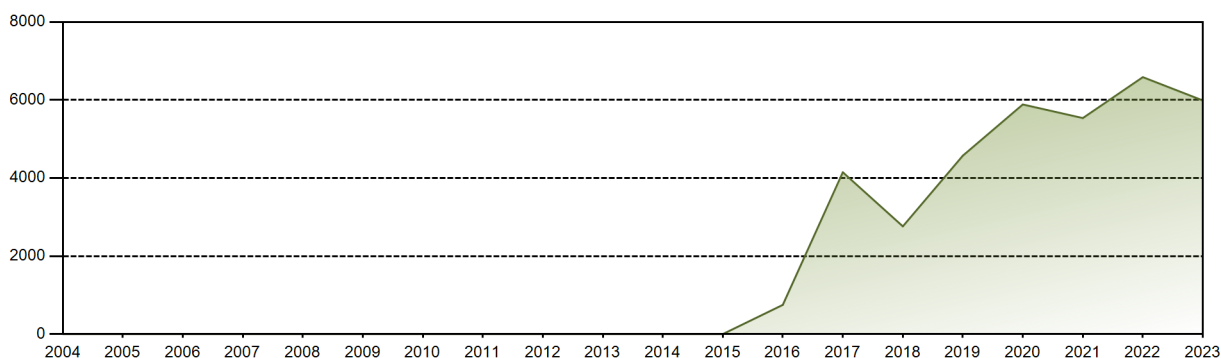


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 593.97 | 637.37 | 706.25 | 495.46 | 88.01 | 0.00 | 155.98 | 708.47 | 688.75 | 710.87 | 687.37 | 515.74 | 5988.25 |
| EAF [%] | 85.66 | 100.00 | 100.00 | 73.83 | 12.69 | 0.00 | 22.49 | 100.00 | 100.00 | 100.00 | 100.00 | 74.38 | 72.24 |
| UCF [%] | 85.66 | 100.00 | 100.00 | 100.00 | 20.60 | 0.00 | 22.49 | 100.00 | 100.00 | 100.00 | 100.00 | 74.38 | 75.06 |
| LF [%] | 85.66 | 101.77 | 101.85 | 73.83 | 12.69 | 0.00 | 22.49 | 102.17 | 102.64 | 102.52 | 102.43 | 74.38 | 73.35 |
| OF [%] | 87.90 | 100.00 | 100.00 | 100.00 | 20.56 | 0.00 | 30.24 | 100.00 | 100.00 | 100.00 | 100.00 | 83.06 | 76.64 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.62 | 2.82 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 43.22 | 0.00 | 0.00 | 0.00 | 0.00 | 25.62 | 5.85 |
| PUF [%] | 14.34 | 0.00 | 0.00 | 0.00 | 79.40 | 100.00 | 34.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 19.09 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 26.17 | 7.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.82 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 36235.03 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 22.5 % |
| Cumulative Energy Availability Factor (EAF) | : 61.69 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 18.82 % |
| Cumulative Unit Capability Factor (UCF) | : 62.1 % | Cumulative Planned Unavailability Factor (PUF) | : 19.07 % |
| Cumulative Load Factor (LF) | : 61.91 % | Cumulative Externally cause unavailability (XUF) | : 0.42 % |
| Cumulative Operating Factor (OF) | : 70.49 % | | |

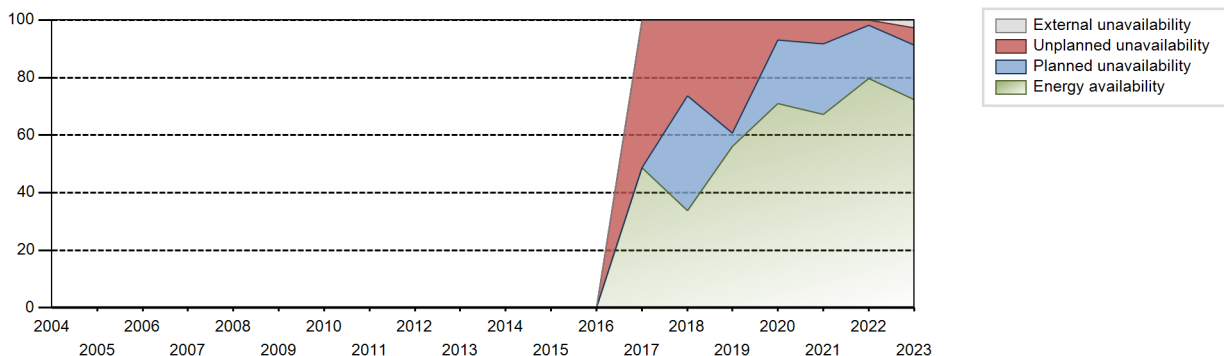
Electricity Production (net) [GWh]



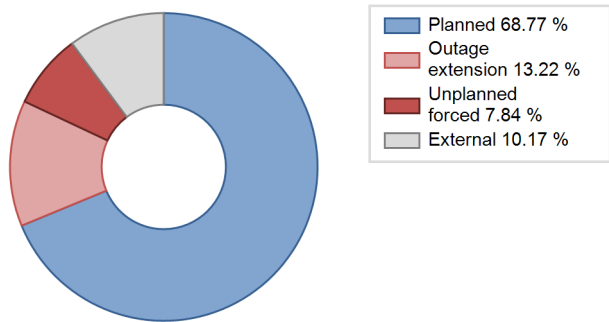
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2017 | 4147.80 | 4991 | 932 | 48.64 | 48.64 | 45.81 | 50.17 | 51.32 | 51.29 | 0.07 | 0.00 |
| 2018 | 2761.23 | 3846 | 932 | 33.82 | 33.82 | 33.82 | 43.90 | 43.78 | 26.34 | 39.84 | 0.00 |
| 2019 | 4573.82 | 8217 | 932 | 56.12 | 56.12 | 56.02 | 93.80 | 41.19 | 39.31 | 4.57 | 0.00 |
| 2020 | 5885.37 | 6446 | 932 | 70.90 | 70.90 | 71.89 | 73.38 | 8.84 | 6.88 | 22.23 | 0.00 |
| 2021 | 5537.43 | 6105 | 932 | 67.24 | 67.24 | 67.82 | 69.69 | 8.98 | 8.29 | 24.47 | 0.00 |
| 2022 | 6586.51 | 7079 | 932 | 79.60 | 79.60 | 80.67 | 80.81 | 2.27 | 1.85 | 18.55 | 0.00 |
| 2023 | 5988.25 | 6714 | 932 | 72.24 | 75.06 | 73.35 | 76.64 | 2.82 | 5.85 | 19.09 | 2.82 |

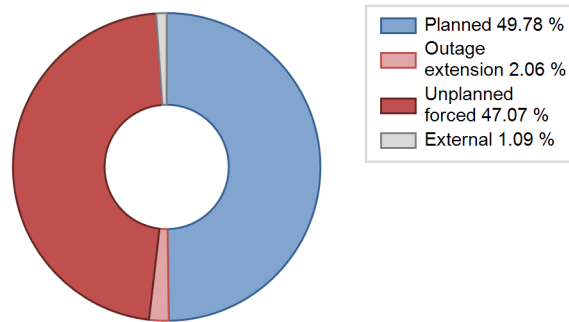
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2017 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 126 | | | 894 | |
| C. Inspection, maintenance or repair combined with refuelling | 1508 | | | 1594 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 17 | | |
| E. Testing of plant systems or components | 90 | | | 13 | 21 | |
| Z. Other | | 322 | | | 48 | |
| Subtotal | 1598 | 448 | | 1624 | 963 | |
| Total | | 2046 | | | 2587 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2017 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 21 |
| 12. Reactor I&C Systems | | | | 8 |
| 15. Reactor Cooling Systems | | | | 59 |
| 31. Turbine and auxiliaries | | | 3 | 68 |
| 32. Feedwater and Main Steam System | | | 123 | 56 |
| 33. Circulating Water System | | | | 1 |
| 35. All other I&C Systems | | | | 17 |
| 41. Main Generator Systems | | | | 653 |
| Total | | | 126 | 883 |

Highlights (2023)

KKNPP-2 achieved Capacity factor of 73.59% during the year.
 KKNPP-2 achieved Availability factor of 76.65% during the year.

2023 Operating Experience

IN-6 MADRAS-2 INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 1972-10-01 |
| Thermal power | : 801 MWth | Grid Date | : 1985-09-20 |
| Gross electrical power | : 220 MWe | Commercial Date | : 1986-03-21 |
| Reference unit power (net) | : 205 MWe | Age at end of year | : 38 years |

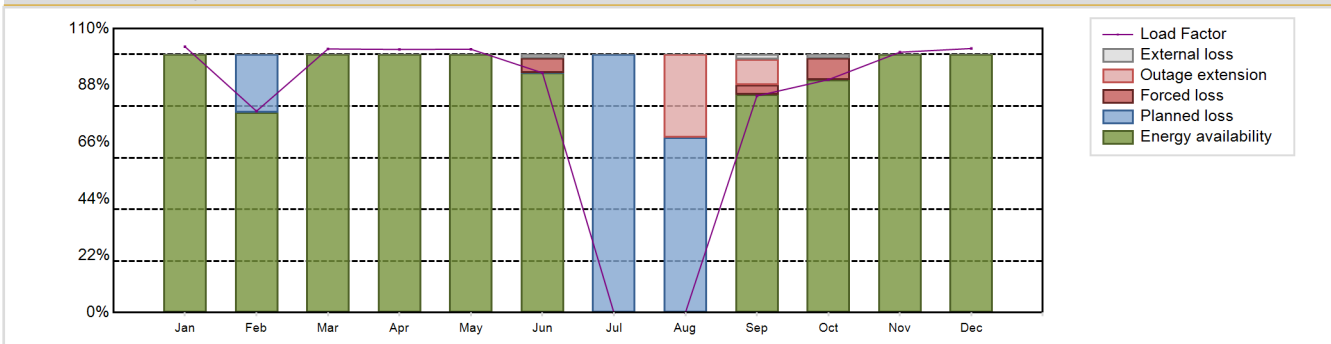
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|---------------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 8.5 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 293 |
| Refuelling type | : ON-line | Number of SG | : 8 |
| Moderator material | : D2O | Containment type | : Confinement |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 1.16 |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 6700 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 4.5 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 5 | HP cylinder inlet steam pressure [MPa] | : 3.972 |
| Number of fissile fuel assemblies/bundles | : 3672 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 35.3 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : - | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 1 | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : DS |

Annual Production Results (2023)

| | | | |
|--|-------------------|--|--------------|
| Net Energy Production | : 1429.96 GW(e).h | Forced Loss Rate (FLR) | : 1.86 % |
| Energy Availability Factor (EAF) | : 78.59 % | Unplanned Capability Loss Factor (UCL) | : 5.05 % |
| Unit Capability Factor (UCF) | : 78.97 % | Planned Unavailability Factor (PUF) | : 15.97 % |
| Load Factor (LF) | : 79.63 % | Externally cause unavailability (XUF) | : 0.38 % |
| Operating Factor (OF) | : 79.45 % | Total off-line time | : 1800 hours |
| Equivalent non-electrical energy generated (NEG) | : 2.53 GW(e).h | | |

Annual Summary

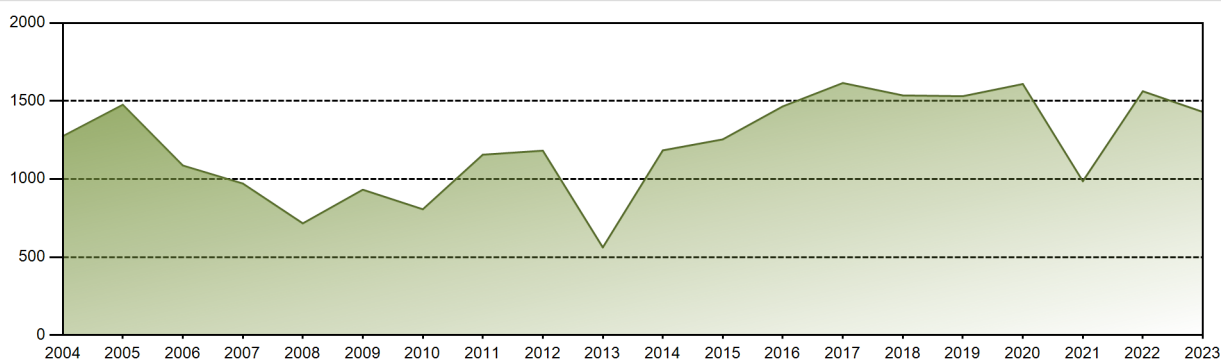


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|---------|
| GW(e)-h | 157.09 | 107.50 | 155.78 | 150.46 | 155.61 | 137.08 | 0.00 | 0.00 | 123.90 | 137.63 | 148.87 | 156.04 | 1429.96 |
| EAF [%] | 100.00 | 77.52 | 100.00 | 100.00 | 100.00 | 92.85 | 0.00 | 0.00 | 84.38 | 90.23 | 100.00 | 100.00 | 78.59 |
| UCF [%] | 100.00 | 77.52 | 100.00 | 100.00 | 100.00 | 94.28 | 0.00 | 0.00 | 86.21 | 91.62 | 100.00 | 100.00 | 78.97 |
| LF [%] | 103.00 | 78.04 | 102.14 | 101.93 | 102.02 | 92.87 | 0.00 | 0.00 | 83.94 | 90.23 | 100.86 | 102.31 | 79.63 |
| OF [%] | 100.00 | 77.53 | 100.00 | 100.00 | 100.00 | 100.00 | 0.00 | 0.00 | 86.25 | 91.67 | 100.00 | 100.00 | 79.45 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.70 | 0.00 | 0.00 | 4.32 | 8.38 | 0.00 | 0.00 | 1.86 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.70 | 0.00 | 32.26 | 13.79 | 8.38 | 0.00 | 0.00 | 5.05 |
| PUF [%] | 0.00 | 22.48 | 0.00 | 0.00 | 0.00 | 0.02 | 100.00 | 67.74 | 0.00 | 0.00 | 0.00 | 0.00 | 15.97 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.43 | 0.00 | 0.00 | 1.83 | 1.38 | 0.00 | 0.00 | 0.38 |

Historical Summary

| | | | | | |
|---|---|------------------|---|---|---------|
| Lifetime energy generation | : | 39478.05 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 15.08 % |
| Cumulative Energy Availability Factor (EAF) | : | 63.67 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 13.63 % |
| Cumulative Unit Capability Factor (UCF) | : | 74.19 % | Cumulative Planned Unavailability Factor (PUF) | : | 12.18 % |
| Cumulative Load Factor (LF) | : | 61.49 % | Cumulative Externally cause unavailability (XUF) | : | 10.51 % |
| Cumulative Operating Factor (OF) | : | 76.11 % | | | |

Electricity Production (net) [GWh]

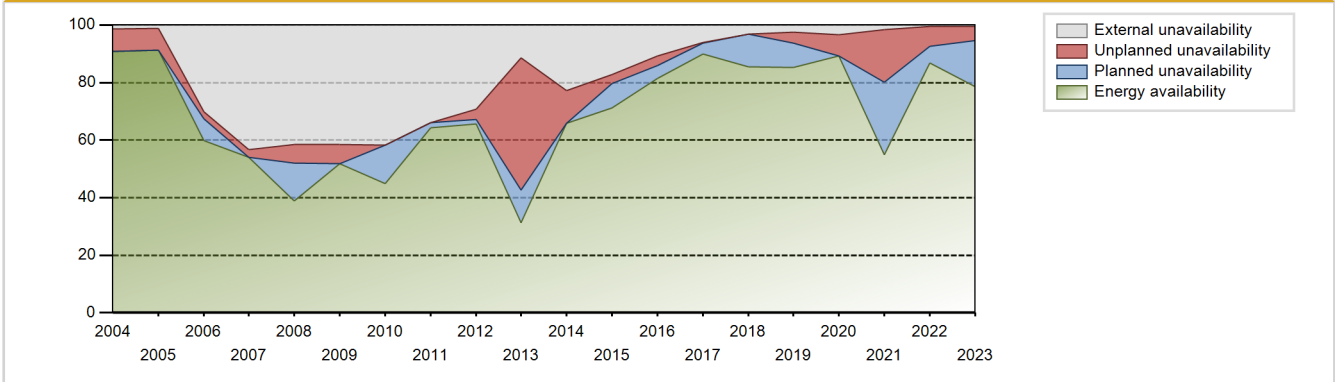


Performance for Years of Commercial Operation

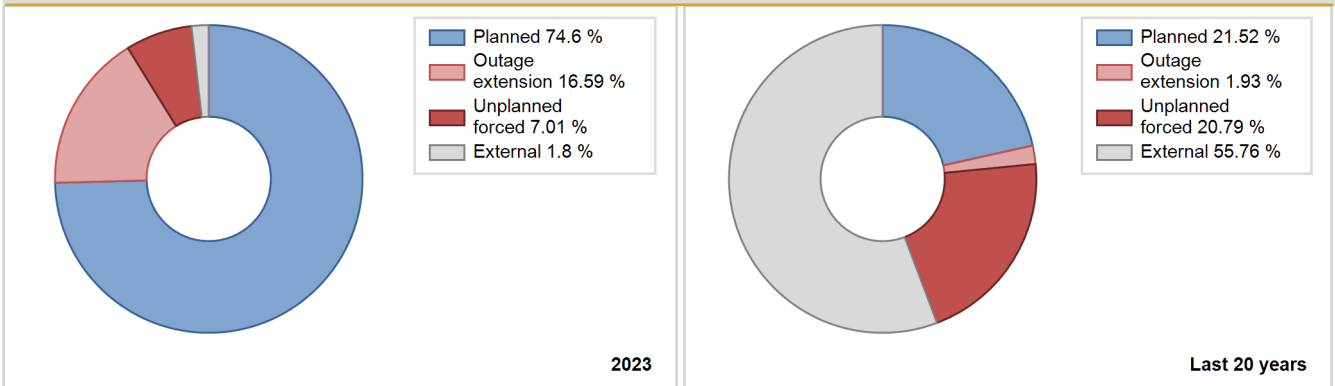
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|-------|-------|-------|-------|-------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 783.74 | 5303 | 220 | 36.50 | 36.50 | 36.50 | 56.27 | 63.49 | 63.49 | 0.01 | 0.00 |
| 1987 | 1066.00 | 6382 | 220 | 55.47 | 62.45 | 55.31 | 72.85 | 32.66 | 30.29 | 7.26 | 6.99 |
| 1988 | 642.00 | 3535 | 220 | 33.22 | 33.22 | 33.22 | 40.24 | 53.14 | 37.68 | 29.10 | 0.00 |
| 1989 | 438.21 | 4350 | 220 | 22.74 | 22.75 | 22.74 | 49.66 | 76.53 | 74.17 | 3.08 | 0.01 |
| 1990 | 1082.36 | 7726 | 215 | 57.19 | 61.60 | 57.47 | 88.20 | 37.09 | 36.32 | 2.08 | 4.41 |
| 1991 | 1082.97 | 7642 | 215 | 86.63 | 87.16 | 57.50 | 87.24 | 12.84 | 12.84 | 0.00 | 0.54 |
| 1992 | 665.18 | 4751 | 194 | 54.21 | 55.22 | 39.03 | 54.09 | 6.84 | 4.06 | 40.72 | 1.01 |
| 1993 | 950.33 | 6625 | 205 | 77.07 | 80.20 | 52.92 | 75.63 | 13.59 | 12.62 | 7.18 | 3.13 |
| 1994 | 1032.14 | 7071 | 194 | 80.88 | 85.49 | 60.73 | 80.72 | 14.51 | 14.51 | 0.00 | 4.61 |
| 1995 | 274.66 | 1871 | 194 | 21.39 | 22.73 | 16.16 | 21.36 | 7.29 | 1.79 | 75.48 | 1.34 |
| 1996 | 1061.91 | 7256 | 161 | 82.17 | 84.72 | 75.12 | 82.60 | 9.73 | 9.13 | 6.15 | 2.55 |
| 1997 | 958.20 | 6464 | 150 | 72.41 | 75.58 | 72.92 | 73.79 | 24.42 | 24.42 | 0.00 | 3.16 |
| 1998 | 1104.22 | 7478 | 150 | 85.39 | 86.96 | 84.04 | 85.37 | 13.04 | 13.04 | 0.00 | 1.57 |
| 1999 | 879.94 | 5755 | 150 | 65.71 | 68.04 | 66.97 | 65.70 | 7.02 | 5.14 | 26.81 | 2.33 |
| 2000 | 1273.39 | 8304 | 150 | 94.56 | 95.72 | 96.64 | 94.54 | 4.28 | 4.28 | 0.00 | 1.15 |
| 2001 | 1119.14 | 7671 | 150 | 87.58 | 88.45 | 85.17 | 87.57 | 9.59 | 9.38 | 2.17 | 0.87 |
| 2002 | 22.71 | 183 | 155 | 1.67 | 1.67 | 1.67 | 2.09 | 0.00 | 0.00 | 98.33 | 0.00 |
| 2003 | 589.13 | 3135 | 155 | 39.98 | 39.98 | 43.39 | 35.79 | 10.48 | 10.43 | 49.59 | 0.00 |
| 2004 | 1274.31 | 7970 | 155 | 90.92 | 92.36 | 93.59 | 90.73 | 7.64 | 7.64 | 0.00 | 1.44 |
| 2005 | 1475.77 | 8165 | 155 | 91.25 | 92.47 | 108.69 | 93.21 | 7.53 | 7.53 | 0.00 | 1.22 |
| 2006 | 1086.59 | 7894 | 202 | 59.92 | 89.97 | 61.41 | 90.11 | 2.75 | 2.54 | 7.49 | 30.05 |
| 2007 | 971.07 | 8537 | 202 | 54.06 | 97.42 | 54.88 | 97.45 | 2.58 | 2.58 | 0.00 | 43.36 |
| 2008 | 715.69 | 7080 | 202 | 38.98 | 80.44 | 40.34 | 80.60 | 7.59 | 6.60 | 12.96 | 41.46 |
| 2009 | 931.47 | 8178 | 205 | 51.87 | 93.36 | 51.87 | 93.36 | 6.64 | 6.64 | 0.00 | 41.49 |
| 2010 | 806.13 | 7596 | 205 | 44.89 | 86.72 | 44.89 | 86.71 | 0.01 | 0.01 | 13.28 | 41.83 |
| 2011 | 1155.83 | 8600 | 205 | 64.36 | 98.17 | 64.36 | 98.17 | 0.01 | 0.01 | 1.81 | 33.81 |
| 2012 | 1181.56 | 8339 | 205 | 65.62 | 94.97 | 65.62 | 94.93 | 3.43 | 3.37 | 1.66 | 29.35 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 2013 | 561.74 | 3735 | 205 | 31.28 | 42.64 | 31.28 | 42.64 | 51.93 | 46.06 | 11.30 | 11.36 |
| 2014 | 1183.61 | 7755 | 205 | 65.91 | 88.66 | 65.91 | 88.53 | 11.34 | 11.34 | 0.00 | 22.75 |
| 2015 | 1254.20 | 7739 | 205 | 71.13 | 88.34 | 69.84 | 88.34 | 3.45 | 3.15 | 8.50 | 17.21 |
| 2016 | 1465.58 | 7865 | 205 | 81.39 | 92.09 | 81.39 | 89.54 | 3.45 | 3.29 | 4.62 | 10.70 |
| 2017 | 1615.20 | 8400 | 205 | 89.94 | 95.89 | 89.94 | 95.89 | 0.37 | 0.36 | 3.75 | 5.95 |
| 2018 | 1535.80 | 7772 | 205 | 85.52 | 88.74 | 85.52 | 88.72 | 0.02 | 0.02 | 11.24 | 3.22 |
| 2019 | 1530.73 | 7681 | 205 | 85.22 | 87.61 | 85.24 | 87.68 | 4.34 | 3.97 | 8.42 | 2.39 |
| 2020 | 1608.90 | 8151 | 205 | 89.35 | 92.68 | 89.35 | 92.79 | 7.32 | 7.32 | 0.00 | 3.34 |
| 2021 | 986.16 | 5628 | 205 | 54.91 | 56.44 | 54.91 | 64.25 | 15.25 | 18.38 | 25.18 | 1.52 |
| 2022 | 1562.47 | 7909 | 205 | 86.88 | 87.31 | 87.01 | 90.29 | 7.36 | 6.94 | 5.75 | 0.44 |
| 2023 | 1429.96 | 6960 | 205 | 78.59 | 78.97 | 79.63 | 79.45 | 1.86 | 5.05 | 15.97 | 0.38 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 402 | | | 774 | |
| D. Inspection, maintenance or repair without refuelling | 151 | | | 655 | | |
| E. Testing of plant systems or components | | | | 38 | 6 | |
| H. Nuclear regulatory requirements | 1248 | | | 65 | 18 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 69 |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 6 |
| P. Fire | | | | | 3 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 357 | | |
| Z. Other | | | | 27 | 7 | |
| Subtotal | 1399 | 402 | | 1142 | 814 | 75 |
| Total | | 1801 | | | 2031 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 165 |
| 12. Reactor I&C Systems | 28 | 42 |
| 13. Reactor Auxiliary Systems | 62 | 11 |
| 14. Safety Systems | | 3 |
| 15. Reactor Cooling Systems | | 110 |
| 16. Steam generation systems | | 65 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 9 |
| 21. Fuel Handling and Storage Facilities | | 58 |
| 31. Turbine and auxiliaries | | 92 |
| 32. Feedwater and Main Steam System | | 25 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | | 8 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | 311 | 41 |
| 42. Electrical Power Supply Systems | | 150 |
| Total | 401 | 787 |

Highlights (2023)

During the year MAPS-2 achieved an average capacity factor of 98.59% and average availability factor of 97.02%.

2023 Operating Experience

IN-7 **NARORA-1** **INDIA**

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 1976-12-01 |
| Thermal power | : 801 MWth | Grid Date | : 1989-07-29 |
| Gross electrical power | : 220 MWe | Commercial Date | : 1991-01-01 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 34 years |

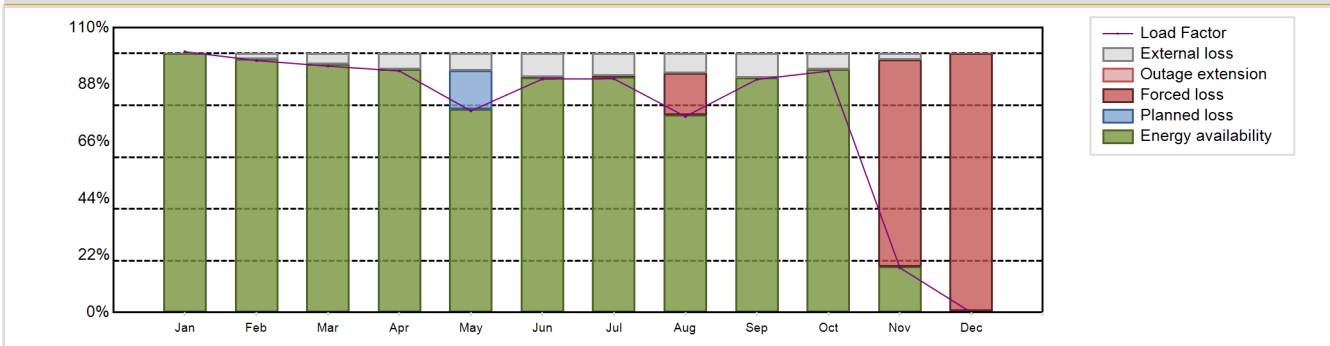
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|----------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 8.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 293.4 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : D2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 1.25 |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 15000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 4.5 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 5 | HP cylinder inlet steam pressure [MPa] | : 3.972 |
| Number of fissile fuel assemblies/bundles | : 3672 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 35.3 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : 4 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 1355.97 GW(e).h | Forced Loss Rate (FLR) | : 16.65 % |
| Energy Availability Factor (EAF) | : 77.11 % | Unplanned Capability Loss Factor (UCL) | : 16.44 % |
| Unit Capability Factor (UCF) | : 82.3 % | Planned Unavailability Factor (PUF) | : 1.26 % |
| Load Factor (LF) | : 76.63 % | Externally cause unavailability (XUF) | : 5.19 % |
| Operating Factor (OF) | : 82.66 % | Total off-line time | : 1519 hours |

Annual Summary

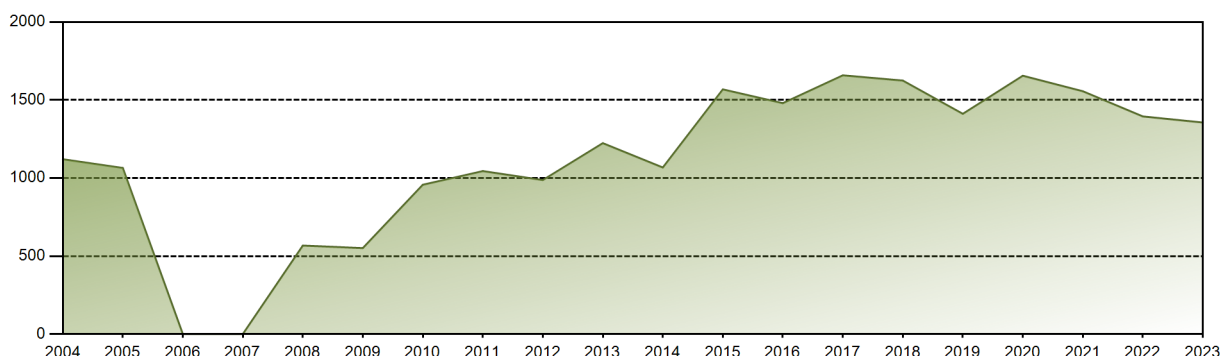


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|---------|
| GW(e)-h | 151.38 | 132.09 | 143.01 | 135.69 | 117.02 | 131.16 | 135.67 | 113.77 | 130.93 | 140.11 | 25.14 | 0.00 | 1355.97 |
| EAF [%] | 100.00 | 97.82 | 95.81 | 93.90 | 78.51 | 90.79 | 90.92 | 76.35 | 90.63 | 93.88 | 17.68 | 0.55 | 77.11 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 85.18 | 99.79 | 99.61 | 83.89 | 100.00 | 100.00 | 20.04 | 0.55 | 82.30 |
| LF [%] | 100.73 | 97.31 | 95.16 | 93.30 | 77.86 | 90.18 | 90.27 | 75.70 | 90.02 | 93.23 | 17.29 | 0.00 | 76.63 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 85.89 | 100.00 | 100.00 | 85.35 | 100.00 | 100.00 | 20.00 | 2.02 | 82.66 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.39 | 16.11 | 0.00 | 0.00 | 79.96 | 99.45 | 16.65 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.39 | 16.11 | 0.00 | 0.00 | 79.96 | 99.45 | 16.44 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 14.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.26 |
| XUF [%] | 0.00 | 2.18 | 4.19 | 6.10 | 6.66 | 9.00 | 8.69 | 7.54 | 9.37 | 6.12 | 2.36 | 0.00 | 5.19 |

Historical Summary

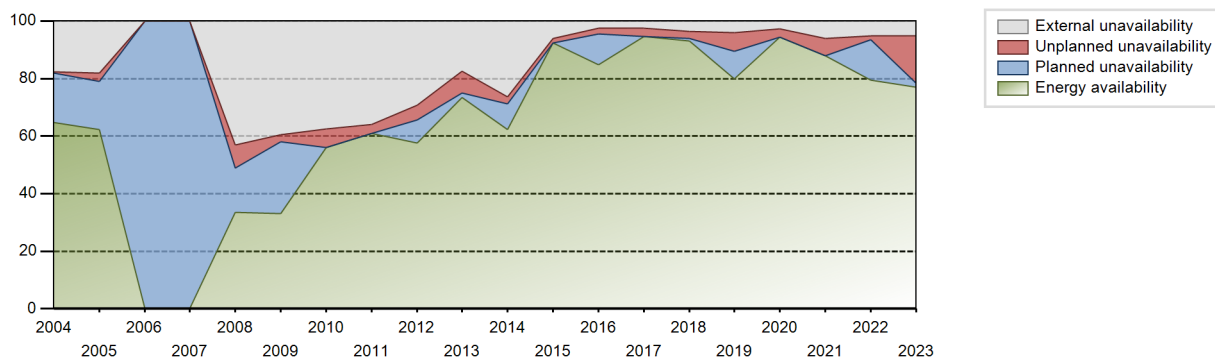
| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 36416.04 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.89 % |
| Cumulative Energy Availability Factor (EAF) | : 64.24 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.56 % |
| Cumulative Unit Capability Factor (UCF) | : 74.7 % | Cumulative Planned Unavailability Factor (PUF) | : 17.74 % |
| Cumulative Load Factor (LF) | : 62.03 % | Cumulative Externally cause unavailability (XUF) | : 10.46 % |
| Cumulative Operating Factor (OF) | : 74.84 % | | |

Electricity Production (net) [GWh]

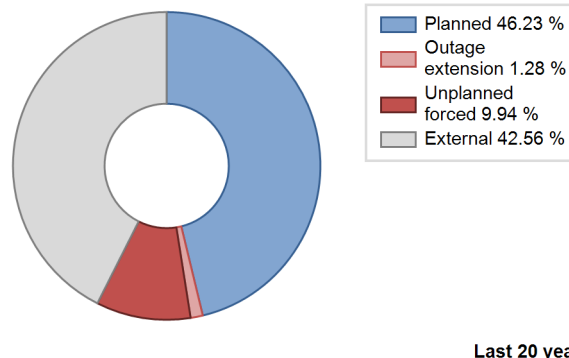
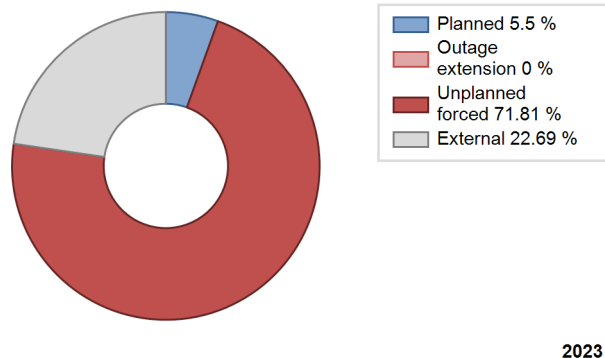


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|-------|-------|-------|-------|-------|--------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1991 | 449.26 | 4331 | 210 | 42.32 | 42.80 | 24.42 | 49.44 | 36.61 | 24.72 | 32.49 | 0.48 |
| 1992 | 742.66 | 5514 | 200 | 42.27 | 42.77 | 42.27 | 62.77 | 57.23 | 57.23 | 0.00 | 0.50 |
| 1993 | 339.57 | 2032 | 200 | 19.38 | 19.38 | 19.38 | 23.20 | 40.05 | 12.95 | 67.67 | 0.00 |
| 1994 | 0.00 | 0 | 200 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1995 | 944.42 | 5740 | 200 | 65.98 | 68.31 | 53.91 | 65.53 | 19.31 | 16.35 | 15.34 | 2.32 |
| 1996 | 1162.26 | 6407 | 200 | 66.16 | 76.93 | 66.16 | 72.94 | 14.44 | 12.98 | 10.08 | 10.78 |
| 1997 | 1585.20 | 8128 | 200 | 89.28 | 92.83 | 90.48 | 92.79 | 5.35 | 5.25 | 1.93 | 3.55 |
| 1998 | 1485.61 | 7986 | 200 | 83.85 | 90.84 | 84.79 | 91.16 | 7.01 | 6.84 | 2.32 | 6.98 |
| 1999 | 1128.61 | 6703 | 200 | 76.54 | 76.84 | 64.42 | 76.52 | 13.32 | 11.81 | 11.35 | 0.30 |
| 2000 | 1386.34 | 7452 | 200 | 83.36 | 87.21 | 78.91 | 84.84 | 8.32 | 7.92 | 4.88 | 3.85 |
| 2001 | 1562.99 | 8157 | 200 | 89.21 | 91.94 | 89.21 | 93.12 | 8.06 | 8.06 | 0.00 | 2.73 |
| 2002 | 1574.49 | 7912 | 202 | 87.98 | 89.30 | 88.98 | 90.32 | 2.92 | 2.73 | 7.97 | 1.32 |
| 2003 | 1528.24 | 8254 | 202 | 85.99 | 95.12 | 86.36 | 94.22 | 2.88 | 2.82 | 2.06 | 9.13 |
| 2004 | 1120.61 | 6860 | 202 | 64.80 | 82.54 | 63.16 | 78.10 | 0.34 | 0.28 | 17.18 | 17.74 |
| 2005 | 1064.75 | 6924 | 202 | 62.38 | 80.52 | 60.17 | 79.04 | 3.32 | 2.77 | 16.71 | 18.14 |
| 2006 | 0.00 | 0 | 202 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2007 | 0.00 | 0 | 202 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2008 | 567.17 | 5963 | 202 | 33.64 | 76.77 | 31.96 | 67.88 | 9.46 | 8.02 | 15.21 | 43.13 |
| 2009 | 551.08 | 6298 | 202 | 33.12 | 72.53 | 31.14 | 71.89 | 3.41 | 2.56 | 24.91 | 39.41 |
| 2010 | 956.95 | 8191 | 202 | 56.06 | 93.63 | 54.08 | 93.50 | 6.37 | 6.37 | 0.00 | 37.57 |
| 2011 | 1044.57 | 8494 | 202 | 61.01 | 97.04 | 59.03 | 96.96 | 2.96 | 2.96 | 0.00 | 36.02 |
| 2012 | 987.24 | 7611 | 202 | 57.62 | 86.90 | 55.64 | 86.65 | 3.27 | 5.07 | 8.03 | 29.28 |
| 2013 | 1223.62 | 7739 | 202 | 73.39 | 90.84 | 69.15 | 88.34 | 7.67 | 7.55 | 1.61 | 17.45 |
| 2014 | 1067.58 | 7750 | 202 | 62.31 | 88.69 | 60.33 | 88.47 | 2.58 | 2.35 | 8.96 | 26.38 |
| 2015 | 1568.35 | 8449 | 202 | 92.30 | 98.33 | 88.63 | 96.45 | 1.67 | 1.67 | 0.00 | 6.02 |
| 2016 | 1479.92 | 7649 | 202 | 84.76 | 87.24 | 83.41 | 87.08 | 0.00 | 2.07 | 10.70 | 2.48 |
| 2017 | 1658.28 | 8520 | 202 | 94.72 | 97.30 | 93.71 | 97.26 | 2.70 | 2.70 | 0.00 | 2.58 |
| 2018 | 1624.80 | 8462 | 202 | 93.06 | 96.66 | 91.82 | 96.60 | 2.53 | 2.51 | 0.83 | 3.60 |
| 2019 | 1411.63 | 7459 | 202 | 79.88 | 83.91 | 79.77 | 85.15 | 1.80 | 6.45 | 9.65 | 4.02 |
| 2020 | 1655.65 | 8543 | 202 | 94.46 | 97.23 | 93.31 | 97.26 | 2.77 | 2.77 | 0.00 | 2.78 |
| 2021 | 1556.37 | 8269 | 202 | 87.95 | 94.02 | 87.95 | 94.39 | 5.98 | 5.98 | 0.00 | 6.07 |
| 2022 | 1394.87 | 7444 | 202 | 79.44 | 84.51 | 78.83 | 84.98 | 1.57 | 1.35 | 14.15 | 5.07 |
| 2023 | 1355.97 | 7241 | 202 | 77.11 | 82.30 | 76.63 | 82.66 | 16.65 | 16.44 | 1.26 | 5.19 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1991 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1305 | | | 684 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 60 | | |
| D. Inspection, maintenance or repair without refuelling | 105 | | | 578 | 19 | |
| E. Testing of plant systems or components | | | | 14 | 25 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 85 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 531 | | |
| H. Nuclear regulatory requirements | | | | 62 | 6 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 52 |
| L. Human factor related | | | | | 5 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 7 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 19 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 26 | 11 | |
| Z. Other | | 108 | | | 9 | 2 |
| Subtotal | 105 | 1413 | | 1356 | 759 | 80 |
| Total | | 1518 | | | 2195 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1991 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 39 |
| 12. Reactor I&C Systems | | 50 |
| 13. Reactor Auxiliary Systems | | 18 |
| 15. Reactor Cooling Systems | | 98 |
| 16. Steam generation systems | 108 | 11 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 18 |
| 21. Fuel Handling and Storage Facilities | | 28 |
| 31. Turbine and auxiliaries | | 276 |
| 32. Feedwater and Main Steam System | | 13 |
| 33. Circulating Water System | | 9 |
| 34. Miscellaneous Systems | | 8 |
| 41. Main Generator Systems | 1305 | 107 |
| 42. Electrical Power Supply Systems | | 93 |
| Total | 1413 | 768 |

Highlights (2023)

Unit registered 100% Availability Factors in eight months during calendar year.

2023 Operating Experience

IN-8 **NARORA-2** **INDIA**

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 1977-11-01 |
| Thermal power | : 801 MWth | Grid Date | : 1992-01-05 |
| Gross electrical power | : 220 MWe | Commercial Date | : 1992-07-01 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 31 years |

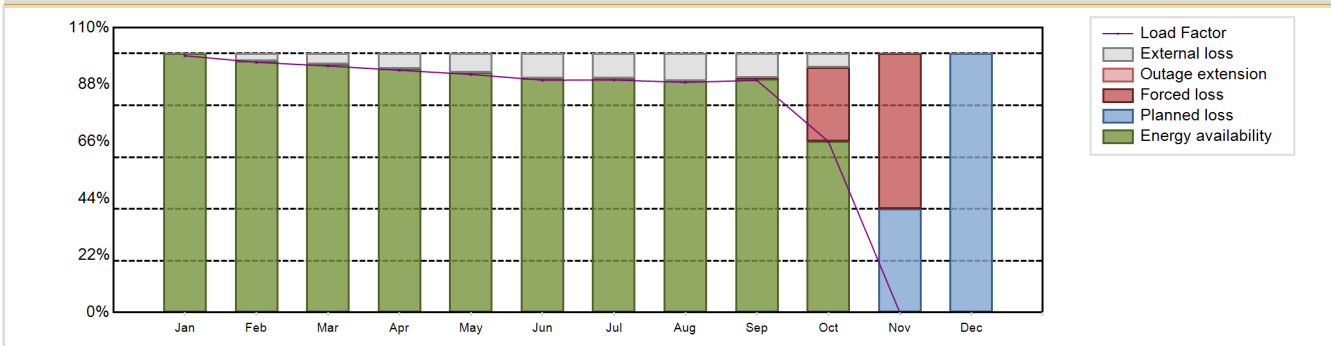
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|----------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 8.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 293.4 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : D2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 1.25 |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 15000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 4.5 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 5 | HP cylinder inlet steam pressure [MPa] | : 3.972 |
| Number of fissile fuel assemblies/bundles | : 3672 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 35.3 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : 4 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 1326.28 GW(e).h | Forced Loss Rate (FLR) | : 8.36 % |
| Energy Availability Factor (EAF) | : 75.44 % | Unplanned Capability Loss Factor (UCL) | : 7.37 % |
| Unit Capability Factor (UCF) | : 80.85 % | Planned Unavailability Factor (PUF) | : 11.78 % |
| Load Factor (LF) | : 74.95 % | Externally cause unavailability (XUF) | : 5.41 % |
| Operating Factor (OF) | : 80.88 % | Total off-line time | : 1675 hours |

Annual Summary

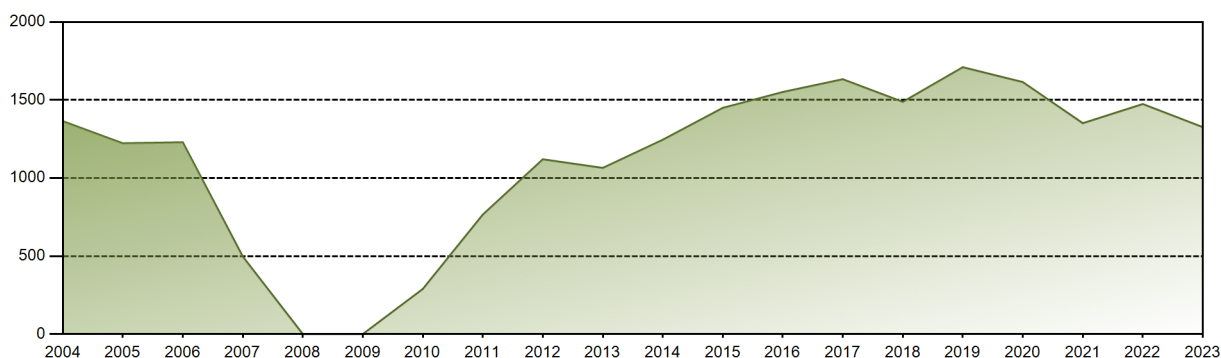


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 149.03 | 131.16 | 143.10 | 136.06 | 138.17 | 130.52 | 134.94 | 133.60 | 130.41 | 99.29 | 0.00 | 0.00 | 1326.28 |
| EAF [%] | 100.00 | 97.13 | 95.87 | 94.16 | 92.59 | 90.35 | 90.44 | 89.55 | 90.27 | 66.15 | 0.00 | 0.00 | 75.44 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.63 | 71.61 | 0.00 | 0.00 | 80.85 |
| LF [%] | 99.16 | 96.62 | 95.22 | 93.55 | 91.94 | 89.74 | 89.79 | 88.90 | 89.67 | 66.07 | 0.00 | 0.00 | 74.95 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 71.64 | 0.00 | 0.00 | 80.88 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 28.39 | 100.00 | 0.00 | 8.36 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 28.39 | 60.00 | 0.00 | 7.37 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 40.00 | 100.00 | 11.78 |
| XUF [%] | 0.00 | 2.87 | 4.13 | 5.84 | 7.41 | 9.65 | 9.56 | 10.45 | 9.36 | 5.45 | 0.00 | 0.00 | 5.41 |

Historical Summary

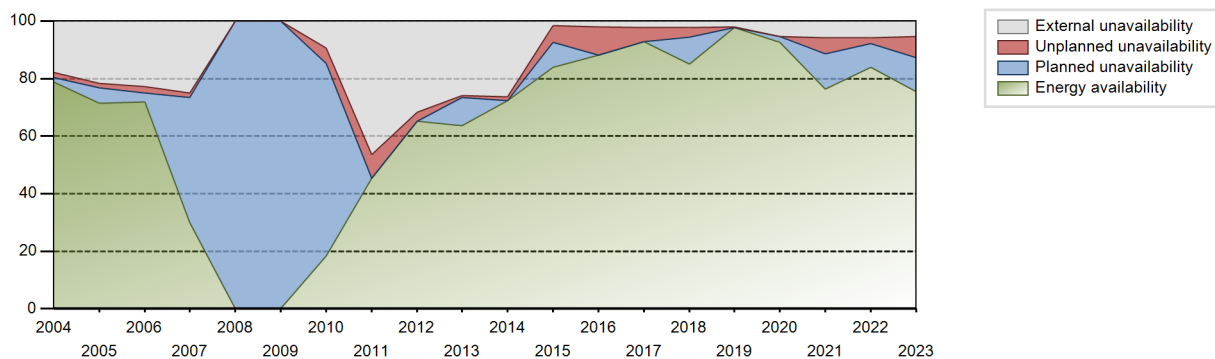
| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 36074.52 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.65 % |
| Cumulative Energy Availability Factor (EAF) | : 66.02 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.39 % |
| Cumulative Unit Capability Factor (UCF) | : 75.8 % | Cumulative Planned Unavailability Factor (PUF) | : 17.81 % |
| Cumulative Load Factor (LF) | : 64.85 % | Cumulative Externally cause unavailability (XUF) | : 9.79 % |
| Cumulative Operating Factor (OF) | : 76.08 % | | |

Electricity Production (net) [GWh]

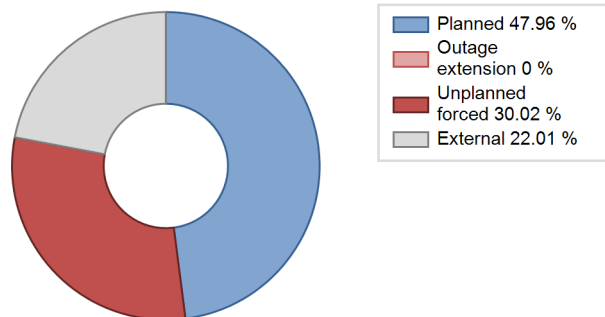


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|--------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1992 | 567.04 | 3553 | 201 | 64.20 | 65.16 | 64.20 | 80.46 | 34.83 | 34.83 | 0.00 | 0.96 |
| 1993 | 83.31 | 548 | 200 | 4.85 | 4.85 | 4.76 | 6.26 | 60.06 | 7.29 | 87.87 | 0.00 |
| 1994 | 761.66 | 5494 | 200 | 43.47 | 53.14 | 43.47 | 62.72 | 33.96 | 27.33 | 19.53 | 9.67 |
| 1995 | 1036.81 | 5798 | 200 | 66.13 | 68.60 | 59.18 | 66.19 | 31.40 | 31.40 | 0.00 | 2.46 |
| 1996 | 1227.52 | 6572 | 200 | 69.87 | 79.42 | 69.87 | 74.82 | 11.54 | 10.36 | 10.22 | 9.55 |
| 1997 | 1568.71 | 8121 | 200 | 89.22 | 91.43 | 89.54 | 92.71 | 5.51 | 5.33 | 3.24 | 2.21 |
| 1998 | 1333.24 | 6829 | 200 | 75.05 | 80.05 | 76.10 | 77.96 | 5.41 | 4.58 | 15.37 | 5.00 |
| 1999 | 1425.94 | 7468 | 200 | 85.78 | 86.98 | 81.39 | 85.25 | 5.44 | 5.01 | 8.01 | 1.19 |
| 2000 | 1340.76 | 7182 | 200 | 79.90 | 80.61 | 76.32 | 81.76 | 10.09 | 9.05 | 10.34 | 0.72 |
| 2001 | 1343.01 | 6897 | 200 | 74.53 | 75.39 | 76.66 | 78.73 | 13.51 | 11.78 | 12.84 | 0.86 |
| 2002 | 1692.79 | 8416 | 202 | 94.75 | 95.71 | 95.66 | 96.07 | 3.12 | 3.17 | 1.11 | 0.96 |
| 2003 | 1287.09 | 7458 | 202 | 70.67 | 85.43 | 72.74 | 85.14 | 4.68 | 4.20 | 10.38 | 14.75 |
| 2004 | 1364.55 | 8447 | 202 | 78.88 | 96.71 | 76.90 | 96.16 | 1.78 | 1.76 | 1.54 | 17.83 |
| 2005 | 1222.91 | 7907 | 202 | 71.49 | 93.25 | 69.11 | 90.26 | 1.63 | 1.55 | 5.21 | 21.75 |
| 2006 | 1229.43 | 8278 | 202 | 71.86 | 94.62 | 69.48 | 94.50 | 2.33 | 2.26 | 3.12 | 22.76 |
| 2007 | 496.85 | 4808 | 202 | 29.99 | 54.90 | 28.08 | 54.89 | 2.99 | 1.69 | 43.41 | 24.91 |
| 2008 | 0.00 | 0 | 202 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2009 | 0.00 | 0 | 202 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2010 | 289.19 | 2282 | 202 | 18.32 | 27.79 | 16.34 | 26.05 | 16.16 | 5.36 | 66.86 | 9.46 |
| 2011 | 765.97 | 8014 | 202 | 45.27 | 91.65 | 43.29 | 91.48 | 8.35 | 8.35 | 0.00 | 46.39 |
| 2012 | 1120.09 | 8495 | 202 | 65.11 | 96.77 | 63.13 | 96.71 | 3.23 | 3.23 | 0.00 | 31.66 |
| 2013 | 1064.99 | 7697 | 202 | 63.57 | 89.51 | 60.19 | 87.87 | 0.60 | 0.54 | 9.95 | 25.94 |
| 2014 | 1245.70 | 8646 | 202 | 72.38 | 98.73 | 70.40 | 98.70 | 1.27 | 1.27 | 0.00 | 26.35 |
| 2015 | 1449.83 | 7467 | 202 | 83.93 | 85.54 | 81.93 | 85.24 | 4.12 | 5.86 | 8.60 | 1.61 |
| 2016 | 1551.47 | 7906 | 202 | 88.09 | 90.19 | 87.44 | 90.00 | 9.81 | 9.81 | 0.00 | 2.10 |
| 2017 | 1633.27 | 8327 | 202 | 92.86 | 95.08 | 92.30 | 95.06 | 4.92 | 4.92 | 0.00 | 2.22 |
| 2018 | 1488.42 | 7629 | 202 | 85.01 | 87.34 | 84.11 | 87.09 | 2.44 | 3.26 | 9.40 | 2.33 |
| 2019 | 1710.41 | 8760 | 202 | 97.81 | 99.83 | 96.66 | 100.00 | 0.17 | 0.17 | 0.00 | 2.02 |
| 2020 | 1615.02 | 8613 | 202 | 92.68 | 97.97 | 91.02 | 98.05 | 0.12 | 0.12 | 1.91 | 5.29 |
| 2021 | 1351.53 | 7331 | 202 | 76.42 | 82.32 | 76.38 | 83.69 | 6.24 | 5.48 | 12.20 | 5.90 |
| 2022 | 1474.35 | 8063 | 202 | 83.95 | 89.83 | 83.32 | 92.04 | 2.03 | 1.86 | 8.31 | 5.88 |
| 2023 | 1326.28 | 7085 | 202 | 75.44 | 80.85 | 74.95 | 80.88 | 8.36 | 7.37 | 11.78 | 5.41 |

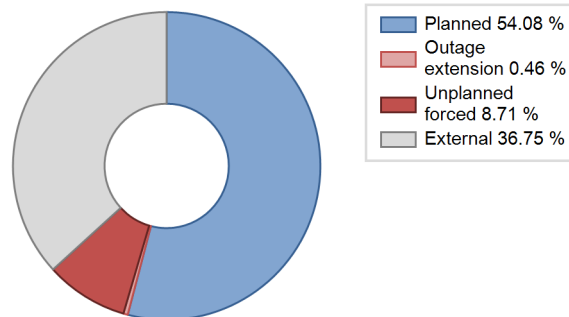
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1992 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 357 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 41 | | |
| D. Inspection, maintenance or repair without refuelling | 1032 | | | 712 | 9 | |
| E. Testing of plant systems or components | | 643 | | 14 | 33 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 757 | | |
| H. Nuclear regulatory requirements | | | | | 15 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 56 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 3 |
| L. Human factor related | | | | | 5 | |
| P. Fire | | | | | 14 | |
| Z. Other | | | | | 41 | |
| Subtotal | 1032 | 643 | | 1524 | 474 | 59 |
| Total | | 1675 | | | 2057 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1992 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 643 | 47 |
| 12. Reactor I&C Systems | | 45 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 31 |
| 16. Steam generation systems | | 20 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 8 |
| 21. Fuel Handling and Storage Facilities | | 18 |
| 31. Turbine and auxiliaries | | 115 |
| 32. Feedwater and Main Steam System | | 14 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 14 |
| 41. Main Generator Systems | | 21 |
| 42. Electrical Power Supply Systems | | 88 |
| Total | 643 | 428 |

Highlights (2023)

Unit registered 100% Availability factor in nine months during calendar year 2023.

2023 Operating Experience

IN-4

RAJASTHAN-2

INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : AECL/DAE (ATOMIC ENERGY OF CANADA Ltda AND DEPARTMENT OF ATOMIC ENERGY (INDIA))
 Turbine Supplier : EE (THE ENGLISH ELECTRIC CO., LTD.)

Reactor Unit Details

Reactor type and model : PHWR / Horizontal Pressure Tube type
 Thermal power : 693 MWth
 Gross electrical power : 200 MWe
 Reference unit power (net) : 187 MWe

Key Dates

Construction Date : 1968-04-01
 Grid Date : 1980-11-01
 Commercial Date : 1981-04-01
 Age at end of year : 43 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 6700
 Active core diameter [m] : 4.5
 Active core height/length [m] : 5
 Number of fissile fuel assemblies/bundles : 3672
 Fuel linear heat generation rate [kW/m] : 35.3
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 2
 Coolant type : D2O

Operating coolant pressure [MPa] : 11.6
 Reactor outlet temperature [°C] : 304
 Number of SG : 8
 Containment type : Confinement
 Containment design pressure [MPa] : 1.44

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 4.1
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

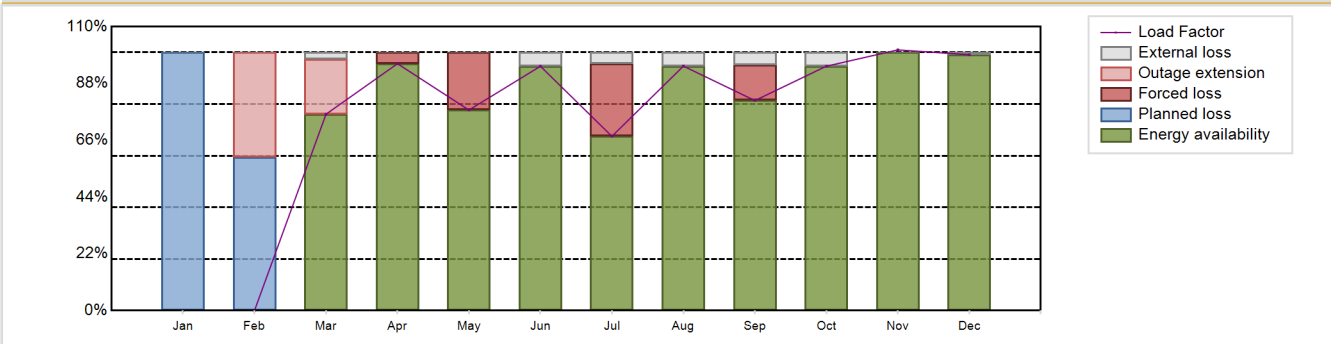
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Annual Production Results (2023)

Net Energy Production : 1211.09 GW(e).h
 Energy Availability Factor (EAF) : 73.85 %
 Unit Capability Factor (UCF) : 76.26 %
 Load Factor (LF) : 73.93 %
 Operating Factor (OF) : 77.21 %
 Equivalent non-electrical energy generated (NEG) : 1.83 GW(e).h

Forced Loss Rate (FLR) : 7.01 %
 Unplanned Capability Loss Factor (UCL) : 10.69 %
 Planned Unavailability Factor (PUF) : 13.04 %
 Externally cause unavailability (XUF) : 2.41 %
 Total off-line time : 1996 hours

Annual Summary

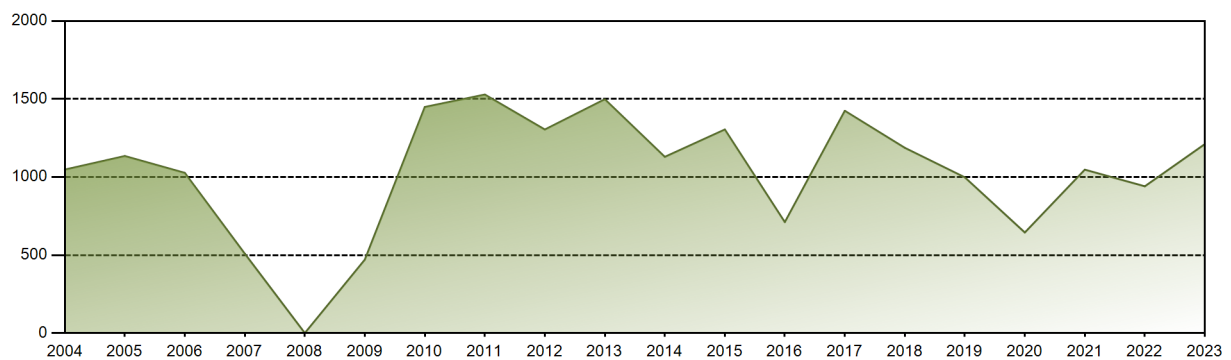


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|-------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 105.84 | 128.79 | 108.11 | 127.45 | 93.95 | 131.77 | 109.57 | 131.73 | 135.98 | 137.90 | 1211.09 |
| EAF [%] | 0.00 | 0.00 | 76.07 | 95.65 | 77.70 | 94.66 | 67.53 | 94.71 | 81.38 | 94.69 | 100.00 | 99.12 | 73.85 |
| UCF [%] | 0.00 | 0.00 | 78.57 | 95.65 | 77.70 | 100.00 | 72.00 | 100.00 | 86.34 | 100.00 | 100.00 | 100.00 | 76.26 |
| LF [%] | 0.00 | 0.00 | 76.07 | 95.65 | 77.70 | 94.66 | 67.53 | 94.71 | 81.38 | 94.69 | 100.99 | 99.12 | 73.93 |
| OF [%] | 0.00 | 0.00 | 78.63 | 100.00 | 84.54 | 100.00 | 72.04 | 100.00 | 86.39 | 100.00 | 100.00 | 100.00 | 77.21 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 4.35 | 22.30 | 0.00 | 28.00 | 0.00 | 13.66 | 0.00 | 0.00 | 0.00 | 7.01 |
| UCL [%] | 0.00 | 40.68 | 21.43 | 4.35 | 22.30 | 0.00 | 28.00 | 0.00 | 13.66 | 0.00 | 0.00 | 0.00 | 10.69 |
| PUF [%] | 100.00 | 59.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.04 |
| XUF [%] | 0.00 | 0.00 | 2.50 | 0.00 | 0.00 | 5.34 | 4.47 | 5.29 | 4.96 | 5.31 | 0.00 | 0.88 | 2.41 |

Historical Summary

| | | | | | |
|---|---|------------------|---|---|---------|
| Lifetime energy generation | : | 38850.96 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 18.06 % |
| Cumulative Energy Availability Factor (EAF) | : | 59.61 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 14.05 % |
| Cumulative Unit Capability Factor (UCF) | : | 63.1 % | Cumulative Planned Unavailability Factor (PUF) | : | 22.85 % |
| Cumulative Load Factor (LF) | : | 57.01 % | Cumulative Externally cause unavailability (XUF) | : | 3.48 % |
| Cumulative Operating Factor (OF) | : | 66.51 % | | | |

Electricity Production (net) [GWh]

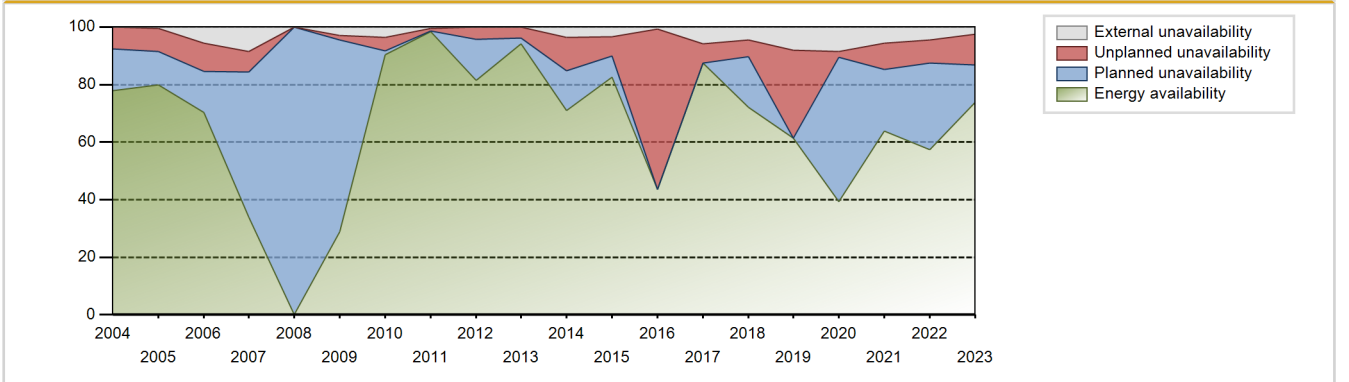


Performance for Years of Commercial Operation

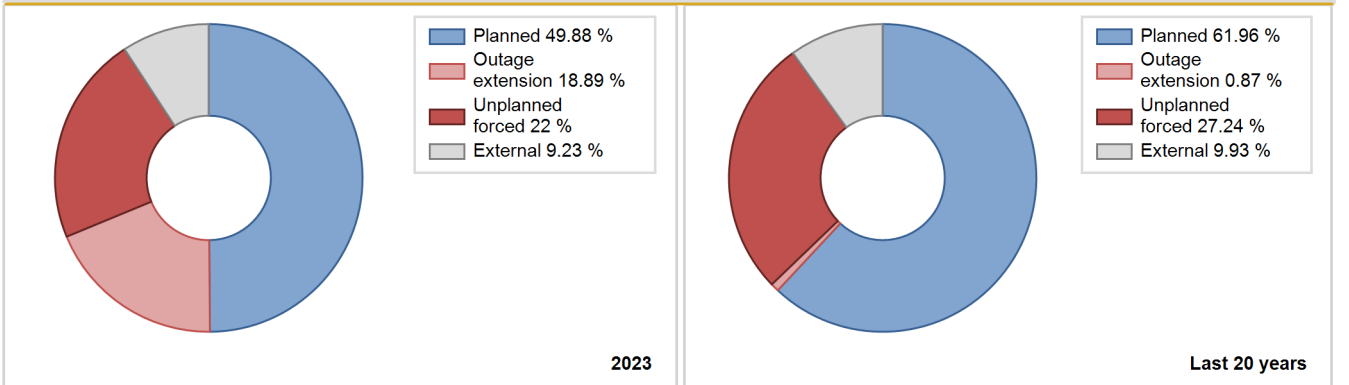
| Year | Energy | Time Online | Reference Unit Power | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------|-------------|----------------------|-------|-------|-------|-------|-------|-------|--------|-------|
| | [GW-h] | [Hours] | [MW] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 686.00 | 7068 | 220 | 38.37 | 38.37 | 38.01 | 80.55 | 33.17 | 19.05 | 42.58 | 0.00 |
| 1982 | 372.90 | 3651 | 206 | 20.67 | 20.67 | 20.66 | 41.68 | 79.33 | 79.33 | 0.00 | 0.00 |
| 1983 | 957.20 | 6673 | 202 | 54.11 | 54.11 | 54.09 | 76.18 | 45.89 | 45.89 | 0.00 | 0.00 |
| 1984 | 908.73 | 5870 | 185 | 49.14 | 56.12 | 55.92 | 66.83 | 35.88 | 31.40 | 12.48 | 6.98 |
| 1985 | 959.92 | 6243 | 184 | 71.30 | 73.35 | 59.55 | 71.27 | 26.65 | 26.65 | 0.00 | 2.05 |
| 1986 | 1080.48 | 6743 | 207 | 59.59 | 65.24 | 59.59 | 76.97 | 18.09 | 14.41 | 20.35 | 5.65 |
| 1987 | 1031.10 | 6277 | 207 | 56.86 | 63.17 | 56.86 | 71.66 | 19.33 | 15.14 | 21.69 | 6.31 |
| 1988 | 1233.98 | 7935 | 207 | 67.86 | 70.14 | 67.86 | 90.33 | 25.53 | 24.05 | 5.82 | 2.27 |
| 1989 | 1084.21 | 6980 | 207 | 59.79 | 60.49 | 59.79 | 79.68 | 33.04 | 29.85 | 9.66 | 0.70 |
| 1990 | 1173.83 | 7151 | 192 | 68.70 | 68.70 | 69.79 | 81.63 | 19.43 | 16.57 | 14.73 | 0.00 |
| 1991 | 895.11 | 5416 | 192 | 62.95 | 62.95 | 53.22 | 61.83 | 24.58 | 20.51 | 16.54 | 0.00 |
| 1992 | 874.35 | 5297 | 184 | 58.10 | 90.30 | 54.10 | 60.30 | 9.70 | 9.70 | 0.00 | 32.20 |
| 1993 | 1153.48 | 6983 | 184 | 71.15 | 74.22 | 71.56 | 79.71 | 25.78 | 25.78 | 0.00 | 3.08 |
| 1994 | 519.42 | 3244 | 184 | 32.23 | 39.37 | 32.23 | 37.03 | 11.39 | 5.06 | 55.58 | 7.14 |
| 1995 | 0.00 | 0 | 184 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1996 | 0.00 | 0 | 184 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1997 | 0.00 | 0 | 184 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1998 | 512.37 | 3728 | 184 | 49.60 | 49.60 | 31.79 | 42.56 | 10.00 | 5.51 | 44.89 | 0.00 |
| 1999 | 1162.33 | 7264 | 184 | 83.11 | 87.62 | 72.11 | 82.92 | 8.14 | 7.77 | 4.61 | 4.51 |
| 2000 | 1308.11 | 8104 | 184 | 92.26 | 92.26 | 80.93 | 92.26 | 7.74 | 7.74 | 0.00 | 0.00 |
| 2001 | 1348.28 | 7486 | 184 | 85.48 | 86.86 | 83.65 | 85.46 | 3.40 | 3.06 | 10.08 | 1.38 |
| 2002 | 1430.87 | 7768 | 187 | 88.99 | 90.67 | 87.35 | 88.68 | 5.26 | 5.03 | 4.30 | 1.68 |
| 2003 | 1391.45 | 8018 | 187 | 84.70 | 92.31 | 84.94 | 91.53 | 4.62 | 4.47 | 3.23 | 7.60 |
| 2004 | 1047.75 | 6806 | 187 | 77.84 | 77.84 | 63.79 | 77.48 | 8.89 | 7.60 | 14.56 | 0.00 |
| 2005 | 1134.78 | 7581 | 187 | 80.01 | 80.55 | 69.27 | 86.54 | 9.05 | 8.01 | 11.44 | 0.54 |
| 2006 | 1026.82 | 7207 | 187 | 70.37 | 75.92 | 62.68 | 82.27 | 10.32 | 9.85 | 14.23 | 5.55 |
| 2007 | 508.69 | 3758 | 187 | 33.98 | 42.38 | 31.05 | 42.90 | 14.53 | 7.21 | 50.41 | 8.40 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|--------|------|
| 2008 | 0.00 | 0 | 187 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2009 | 470.72 | 2795 | 187 | 28.74 | 31.73 | 28.74 | 31.91 | 4.49 | 1.49 | 66.77 | 3.00 |
| 2010 | 1449.01 | 8286 | 187 | 90.47 | 94.16 | 88.46 | 94.59 | 4.56 | 4.50 | 1.34 | 3.69 |
| 2011 | 1528.78 | 8518 | 187 | 98.34 | 98.92 | 93.33 | 97.24 | 0.75 | 0.75 | 0.33 | 0.58 |
| 2012 | 1304.66 | 7265 | 187 | 81.50 | 81.50 | 79.43 | 82.71 | 5.07 | 4.36 | 14.14 | 0.00 |
| 2013 | 1498.71 | 8327 | 187 | 94.13 | 94.13 | 91.49 | 95.06 | 4.01 | 3.93 | 1.94 | 0.00 |
| 2014 | 1129.42 | 6534 | 187 | 70.92 | 74.59 | 68.95 | 74.59 | 13.48 | 11.62 | 13.79 | 3.67 |
| 2015 | 1304.85 | 8067 | 187 | 82.55 | 85.91 | 79.66 | 92.09 | 7.23 | 6.70 | 7.39 | 3.36 |
| 2016 | 711.15 | 4360 | 187 | 43.57 | 44.22 | 43.29 | 49.64 | 55.78 | 55.78 | 0.00 | 0.65 |
| 2017 | 1424.74 | 8171 | 187 | 87.51 | 93.32 | 86.97 | 93.28 | 6.68 | 6.68 | 0.00 | 5.81 |
| 2018 | 1187.27 | 6734 | 187 | 72.06 | 76.45 | 72.48 | 76.87 | 7.19 | 5.92 | 17.63 | 4.38 |
| 2019 | 998.12 | 6208 | 187 | 61.40 | 69.38 | 60.93 | 70.87 | 30.62 | 30.62 | 0.00 | 7.98 |
| 2020 | 644.59 | 4201 | 187 | 39.24 | 47.83 | 39.24 | 47.83 | 3.83 | 1.90 | 50.27 | 8.58 |
| 2021 | 1047.41 | 6093 | 187 | 63.94 | 69.57 | 63.94 | 69.55 | 11.52 | 9.06 | 21.38 | 5.63 |
| 2022 | 940.72 | 5424 | 187 | 57.39 | 61.93 | 57.43 | 61.92 | 11.39 | 7.96 | 30.12 | 4.54 |
| 2023 | 1211.09 | 6764 | 187 | 73.85 | 76.26 | 73.93 | 77.21 | 7.01 | 10.69 | 13.04 | 2.41 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 854 | | | 849 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 104 | | |
| D. Inspection, maintenance or repair without refuelling | 1143 | | | 1348 | 2 | |
| E. Testing of plant systems or components | | | | | 9 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 445 | | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 125 |
| L. Human factor related | | | | | 8 | |
| P. Fire | | | | | 8 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 10 |
| Z. Other | | | | 31 | 27 | 1 |
| Subtotal | 1143 | 854 | | 1928 | 906 | 136 |
| Total | | 1997 | | | 2970 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1981 to 2023 | |
|--|------------|------------|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 56 |
| 12. Reactor I&C Systems | | 98 | | 126 |
| 13. Reactor Auxiliary Systems | | | | 24 |
| 14. Safety Systems | | | | 18 |
| 15. Reactor Cooling Systems | | 230 | | 145 |
| 16. Steam generation systems | | 93 | | 108 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 1 |
| 21. Fuel Handling and Storage Facilities | | | | 22 |
| 31. Turbine and auxiliaries | | 433 | | 188 |
| 32. Feedwater and Main Steam System | | | | 66 |
| 33. Circulating Water System | | | | 2 |
| 34. Miscellaneous Systems | | | | 7 |
| 35. All other I&C Systems | | | | 11 |
| 41. Main Generator Systems | | | | 47 |
| 42. Electrical Power Supply Systems | | | | 53 |
| Total | | 854 | | 874 |

Highlights (2023)

RAPS-2 operated with a Capacity factor of 76.26% and Availability factor of 77.21% during the year.

2023 Operating Experience

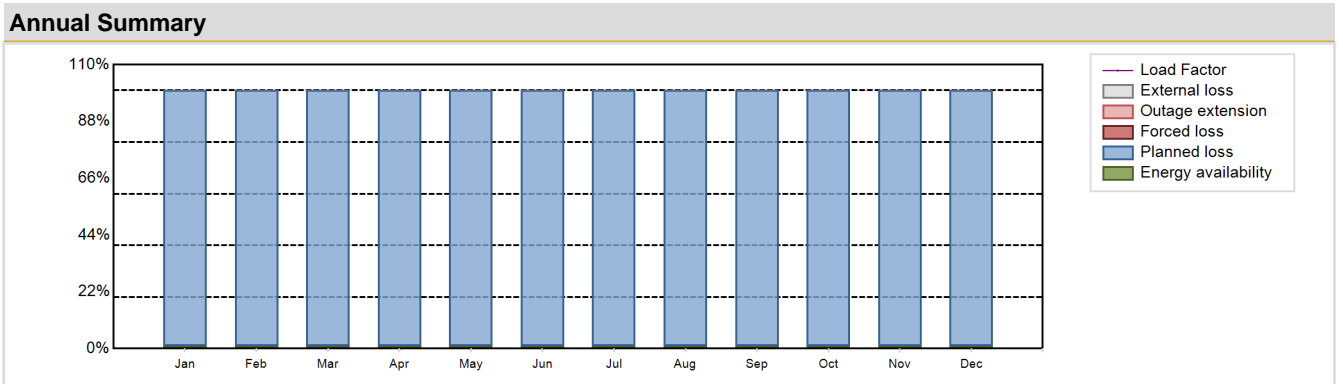
IN-11 RAJASTHAN-3 INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 1990-02-01 |
| Thermal power | : 801 MWth | Grid Date | : 2000-03-10 |
| Gross electrical power | : 220 MWe | Commercial Date | : 2000-06-01 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 23 years |

| Design Characteristics | | | |
|---|--------------|--|----------|
| Primary Systems | | Operating coolant pressure [MPa] | : 8.7 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 293 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : Double |
| Moderator material | : D2O | Containment design pressure [MPa] | : 0.42 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 6700 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.5 | HP cylinder inlet steam pressure [MPa] | : 3.972 |
| Active core height/length [m] | : 5 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 3672 | Primary means of condenser cooling | : - |
| Fuel linear heat generation rate [kW/m] | : 35.3 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 4 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 1 | Number of on-site safety related diesel generators | : - |
| Coolant type | : D2O | Non-electrical applications | : PH |

| Annual Production Results (2023) | | | |
|--|-------------|--|--------------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0.99 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0.99 % | Planned Unavailability Factor (PUF) | : 99.01 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : 8760 hours |
| Equivalent non-electrical energy generated (NEG) | : 0 GW(e).h | | |

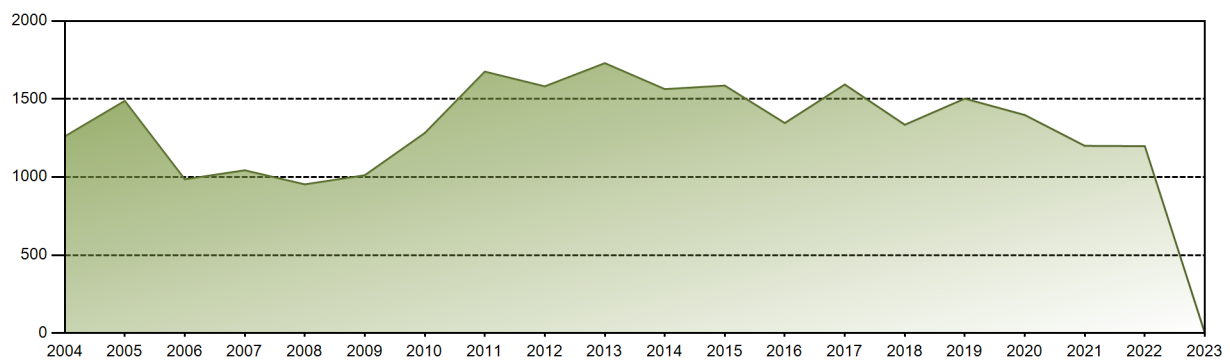


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EAF [%] | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| UCF [%] | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 99.01 | 99.01 | 99.01 | 99.01 | 99.01 | 99.01 | 99.01 | 99.01 | 99.01 | 99.01 | 99.01 | 99.01 | 99.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | | | |
|---|---|------------------|---|---|--------|
| Lifetime energy generation | : | 31026.25 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 4.46 % |
| Cumulative Energy Availability Factor (EAF) | : | 76.84 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 4.03 % |
| Cumulative Unit Capability Factor (UCF) | : | 86.29 % | Cumulative Planned Unavailability Factor (PUF) | : | 9.68 % |
| Cumulative Load Factor (LF) | : | 73.45 % | Cumulative Externally cause unavailability (XUF) | : | 9.45 % |
| Cumulative Operating Factor (OF) | : | 86.27 % | | | |

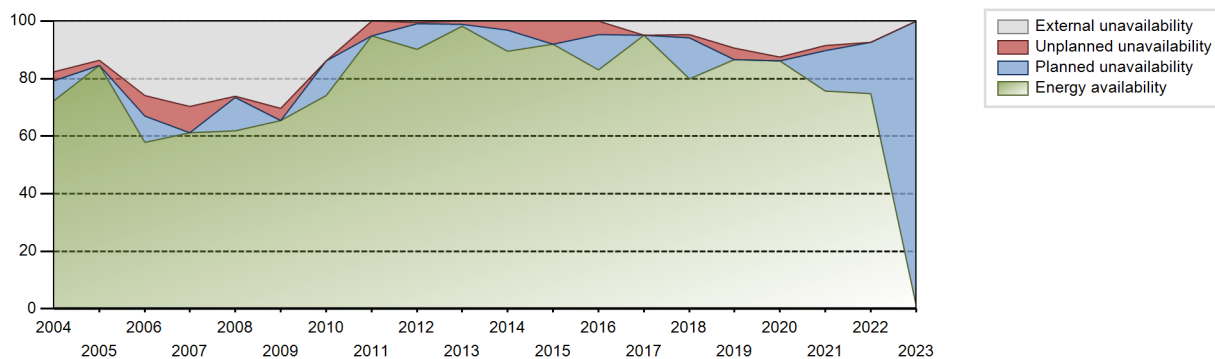
Electricity Production (net) [GWh]



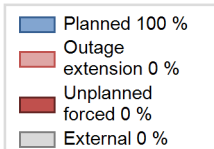
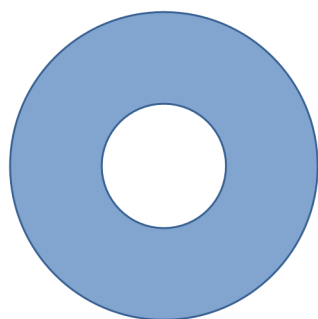
Performance for Years of Commercial Operation

| Year | Energy | Time Online | Reference Unit Power | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------|-------------|----------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| | [GW-h] | [Hours] | [MW] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2000 | 893.76 | 4794 | 200 | 76.36 | 76.36 | 77.64 | 77.59 | 23.64 | 23.64 | 0.00 | 0.00 |
| 2001 | 1366.08 | 7317 | 200 | 83.58 | 84.85 | 77.97 | 83.53 | 15.15 | 15.15 | 0.00 | 1.27 |
| 2002 | 1317.95 | 6715 | 202 | 75.54 | 81.17 | 74.48 | 76.66 | 5.31 | 4.55 | 14.28 | 5.63 |
| 2003 | 1442.06 | 8285 | 202 | 84.53 | 95.29 | 81.49 | 94.58 | 4.71 | 4.71 | 0.00 | 10.77 |
| 2004 | 1260.33 | 7711 | 202 | 72.28 | 90.02 | 71.03 | 87.78 | 3.17 | 2.94 | 7.04 | 17.74 |
| 2005 | 1487.92 | 8581 | 202 | 84.56 | 98.27 | 84.09 | 97.96 | 1.73 | 1.73 | 0.00 | 13.71 |
| 2006 | 985.60 | 7323 | 202 | 57.83 | 83.76 | 55.70 | 83.60 | 7.87 | 7.15 | 9.09 | 25.93 |
| 2007 | 1043.01 | 7934 | 202 | 61.07 | 90.67 | 58.94 | 90.57 | 9.33 | 9.33 | 0.00 | 29.59 |
| 2008 | 952.90 | 7707 | 202 | 61.80 | 87.86 | 53.70 | 87.74 | 0.60 | 0.53 | 11.61 | 26.06 |
| 2009 | 1011.51 | 8338 | 202 | 65.49 | 95.78 | 57.16 | 95.18 | 4.22 | 4.22 | 0.00 | 30.29 |
| 2010 | 1282.09 | 7699 | 202 | 74.20 | 88.01 | 72.45 | 87.89 | 0.00 | 0.00 | 11.99 | 13.80 |
| 2011 | 1675.45 | 8307 | 202 | 94.89 | 94.89 | 94.68 | 94.83 | 5.11 | 5.11 | 0.00 | 0.00 |
| 2012 | 1581.04 | 7932 | 202 | 90.23 | 90.77 | 89.10 | 90.30 | 0.45 | 0.41 | 8.82 | 0.54 |
| 2013 | 1729.79 | 8603 | 202 | 98.23 | 98.23 | 97.75 | 98.21 | 1.23 | 1.23 | 0.55 | 0.00 |
| 2014 | 1563.28 | 7991 | 202 | 89.54 | 89.54 | 88.35 | 91.22 | 3.38 | 3.13 | 7.33 | 0.00 |
| 2015 | 1585.87 | 8431 | 202 | 92.04 | 92.04 | 89.62 | 96.24 | 7.96 | 7.96 | 0.00 | 0.00 |
| 2016 | 1345.94 | 7519 | 202 | 82.99 | 82.99 | 75.85 | 85.60 | 5.36 | 4.70 | 12.31 | 0.00 |
| 2017 | 1592.74 | 8758 | 202 | 95.03 | 99.98 | 90.01 | 99.98 | 0.02 | 0.02 | 0.00 | 4.95 |
| 2018 | 1335.05 | 7489 | 202 | 79.86 | 84.52 | 75.45 | 85.49 | 1.47 | 1.26 | 14.22 | 4.66 |
| 2019 | 1502.33 | 8514 | 202 | 86.53 | 95.93 | 84.90 | 97.19 | 4.07 | 4.07 | 0.00 | 9.40 |
| 2020 | 1397.32 | 8662 | 202 | 86.17 | 98.63 | 78.75 | 98.61 | 1.37 | 1.37 | 0.00 | 12.46 |
| 2021 | 1199.71 | 7362 | 202 | 75.60 | 84.04 | 67.80 | 84.04 | 2.15 | 1.85 | 14.11 | 8.45 |
| 2022 | 1197.78 | 7198 | 202 | 74.75 | 82.17 | 67.69 | 82.17 | 0.00 | 0.00 | 17.83 | 7.42 |
| 2023 | 0.00 | 0 | 202 | 0.99 | 0.99 | 0.00 | 0.00 | 0.00 | 0.00 | 99.01 | 0.00 |

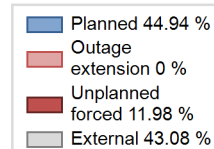
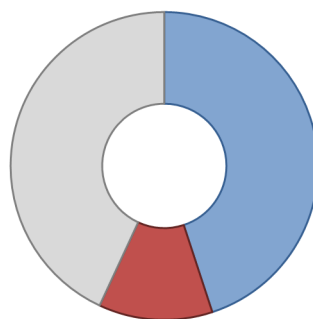
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2000 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 308 | |
| D. Inspection, maintenance or repair without refuelling | | | | 425 | | |
| E. Testing of plant systems or components | | | | | 15 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | 8760 | | | 438 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 31 |
| L. Human factor related | | | | | 5 | |
| Subtotal | 8760 | | | 863 | 328 | 31 |
| Total | | 8760 | | | 1222 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2000 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 12 |
| 12. Reactor I&C Systems | | 70 |
| 13. Reactor Auxiliary Systems | | 21 |
| 15. Reactor Cooling Systems | | 28 |
| 16. Steam generation systems | | 17 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 21. Fuel Handling and Storage Facilities | | 16 |
| 31. Turbine and auxiliaries | | 47 |
| 32. Feedwater and Main Steam System | | 38 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 2 |
| 41. Main Generator Systems | | 33 |
| 42. Electrical Power Supply Systems | | 39 |
| Total | | 327 |

Highlights (2023)

Unit was under shutdown during the year 2023 since 27/10/2022 for carrying out En Mass Coolant Channel Replacement and En Mass Feeder Replacement.

2023 Operating Experience

IN-12 RAJASTHAN-4 INDIA

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 1990-10-01 |
| Thermal power | : 801 MWth | Grid Date | : 2000-11-17 |
| Gross electrical power | : 220 MWe | Commercial Date | : 2000-12-23 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 23 years |

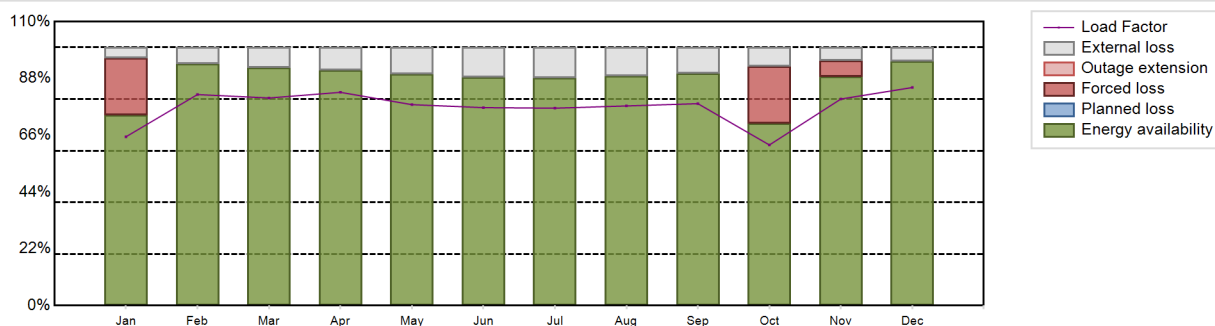
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|----------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 8.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 293 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : D2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 0.42 |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 6700 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 4.5 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 5 | HP cylinder inlet steam pressure [MPa] | : 3.972 |
| Number of fissile fuel assemblies/bundles | : 3672 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 20.6 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : 4 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 1 | Number of FW pumps for full power operation | : - |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : PH |

Annual Production Results (2023)

| | | | |
|--|-------------------|--|-------------|
| Net Energy Production | : 1360.73 GW(e).h | Forced Loss Rate (FLR) | : 4.26 % |
| Energy Availability Factor (EAF) | : 87.42 % | Unplanned Capability Loss Factor (UCL) | : 4.26 % |
| Unit Capability Factor (UCF) | : 95.74 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 76.9 % | Externally cause unavailability (XUF) | : 8.32 % |
| Operating Factor (OF) | : 95.78 % | Total off-line time | : 370 hours |
| Equivalent non-electrical energy generated (NEG) | : 187.21 GW(e).h | | |

Annual Summary

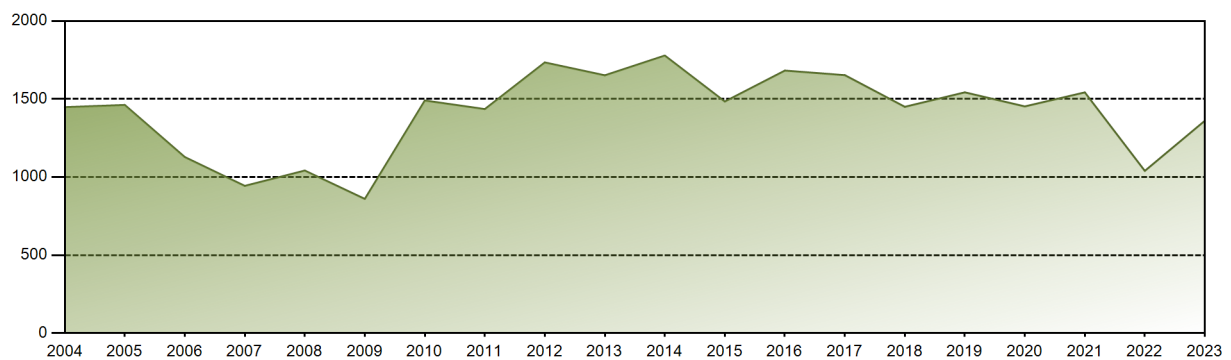


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 98.31 | 110.98 | 120.87 | 120.16 | 117.00 | 111.55 | 114.93 | 116.25 | 113.77 | 93.53 | 116.39 | 126.97 | 1360.73 |
| EAF [%] | 73.85 | 93.72 | 92.23 | 91.10 | 89.63 | 88.49 | 88.12 | 88.93 | 89.97 | 70.57 | 88.67 | 94.65 | 87.42 |
| UCF [%] | 78.04 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 77.96 | 93.68 | 100.00 | 95.74 |
| LF [%] | 65.41 | 81.76 | 80.43 | 82.62 | 77.85 | 76.70 | 76.47 | 77.35 | 78.23 | 62.24 | 80.03 | 84.48 | 76.90 |
| OF [%] | 78.36 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 77.96 | 93.75 | 100.00 | 95.78 |
| FLR [%] | 21.96 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.04 | 6.32 | 0.00 | 4.26 |
| UCL [%] | 21.96 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.04 | 6.32 | 0.00 | 4.26 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 4.19 | 6.28 | 7.77 | 8.90 | 10.37 | 11.51 | 11.88 | 11.07 | 10.03 | 7.39 | 5.01 | 5.35 | 8.32 |

Historical Summary

| | | | | | |
|---|---|------------------|---|---|--------|
| Lifetime energy generation | : | 32739.17 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 3.82 % |
| Cumulative Energy Availability Factor (EAF) | : | 81.86 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 3.99 % |
| Cumulative Unit Capability Factor (UCF) | : | 91.02 % | Cumulative Planned Unavailability Factor (PUF) | : | 4.99 % |
| Cumulative Load Factor (LF) | : | 79.53 % | Cumulative Externally cause unavailability (XUF) | : | 9.16 % |
| Cumulative Operating Factor (OF) | : | 90.43 % | | | |

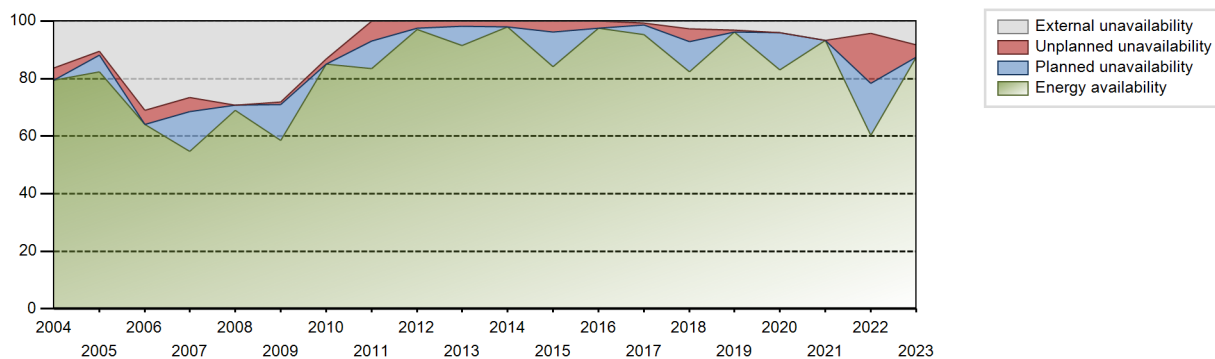
Electricity Production (net) [GWh]



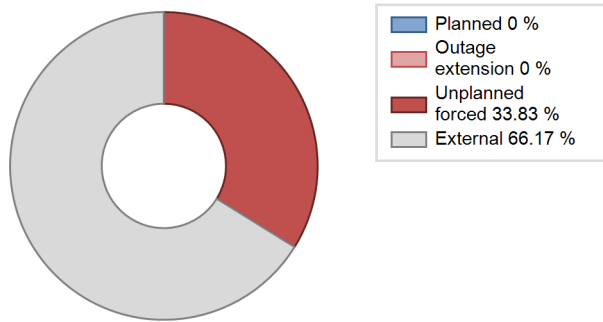
Performance for Years of Commercial Operation

| Year | Energy | Time Online | Reference Unit Power | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------|-------------|----------------------|-------|--------|--------|--------|-------|-------|-------|-------|
| | [GW-h] | [Hours] | [MW] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2000 | 57.46 | 518 | 200 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 1200.83 | 6214 | 200 | 71.01 | 81.99 | 68.54 | 70.94 | 18.01 | 18.01 | 0.00 | 10.98 |
| 2002 | 1671.49 | 8255 | 202 | 94.30 | 96.52 | 94.46 | 94.24 | 3.48 | 3.48 | 0.00 | 2.22 |
| 2003 | 1318.22 | 7633 | 202 | 74.78 | 87.55 | 74.50 | 87.13 | 5.77 | 5.36 | 7.09 | 12.77 |
| 2004 | 1447.74 | 8329 | 202 | 79.49 | 95.78 | 81.59 | 94.82 | 4.22 | 4.22 | 0.00 | 16.29 |
| 2005 | 1461.94 | 8074 | 202 | 82.29 | 92.77 | 82.62 | 92.17 | 1.52 | 1.43 | 5.80 | 10.49 |
| 2006 | 1128.13 | 8334 | 202 | 64.10 | 95.18 | 63.75 | 95.14 | 4.82 | 4.82 | 0.00 | 31.08 |
| 2007 | 943.36 | 7101 | 202 | 54.68 | 81.17 | 53.31 | 81.06 | 5.74 | 4.94 | 13.89 | 26.49 |
| 2008 | 1041.60 | 8626 | 202 | 69.05 | 98.21 | 58.70 | 98.20 | 0.00 | 0.00 | 1.79 | 29.17 |
| 2009 | 859.80 | 7542 | 202 | 58.54 | 86.76 | 48.59 | 86.10 | 0.83 | 0.72 | 12.52 | 28.22 |
| 2010 | 1490.50 | 8598 | 202 | 84.93 | 98.17 | 84.23 | 98.15 | 1.83 | 1.83 | 0.00 | 13.24 |
| 2011 | 1435.59 | 7299 | 202 | 83.49 | 83.49 | 81.13 | 83.32 | 7.68 | 6.94 | 9.57 | 0.00 |
| 2012 | 1734.64 | 8512 | 202 | 97.09 | 97.09 | 97.76 | 96.90 | 2.51 | 2.50 | 0.42 | 0.00 |
| 2013 | 1651.99 | 7999 | 202 | 91.40 | 91.40 | 93.36 | 91.31 | 1.90 | 1.77 | 6.83 | 0.00 |
| 2014 | 1778.77 | 8575 | 202 | 97.91 | 97.91 | 100.52 | 97.89 | 2.09 | 2.09 | 0.00 | 0.00 |
| 2015 | 1484.17 | 7362 | 202 | 84.20 | 84.20 | 83.87 | 84.04 | 4.38 | 3.85 | 11.95 | 0.00 |
| 2016 | 1682.21 | 8559 | 202 | 97.46 | 97.46 | 94.81 | 97.44 | 2.54 | 2.54 | 0.00 | 0.00 |
| 2017 | 1653.11 | 8399 | 202 | 95.19 | 95.93 | 93.42 | 95.88 | 0.57 | 0.55 | 3.53 | 0.74 |
| 2018 | 1450.03 | 7441 | 202 | 82.41 | 85.03 | 81.94 | 84.94 | 5.02 | 4.49 | 10.48 | 2.61 |
| 2019 | 1542.80 | 8701 | 202 | 96.26 | 99.33 | 87.19 | 99.33 | 0.67 | 0.67 | 0.00 | 3.07 |
| 2020 | 1452.54 | 7641 | 202 | 83.07 | 87.12 | 81.86 | 86.99 | 0.00 | 0.00 | 12.88 | 4.05 |
| 2021 | 1542.54 | 8760 | 202 | 93.18 | 100.00 | 87.17 | 100.00 | 0.00 | 0.00 | 0.00 | 6.82 |
| 2022 | 1039.61 | 5959 | 202 | 60.33 | 64.55 | 58.75 | 68.03 | 12.01 | 17.49 | 17.96 | 4.22 |
| 2023 | 1360.73 | 8390 | 202 | 87.42 | 95.74 | 76.90 | 95.78 | 4.26 | 4.26 | 0.00 | 8.32 |

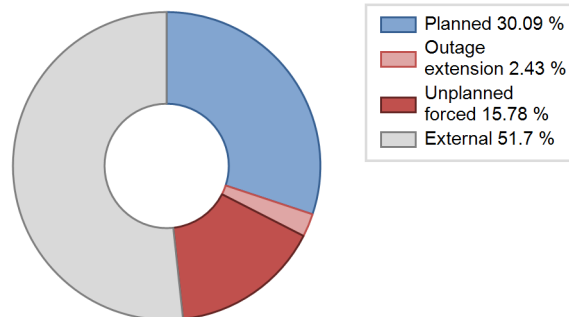
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2000 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 370 | | | 252 | |
| D. Inspection, maintenance or repair without refuelling | | | | 439 | | |
| E. Testing of plant systems or components | | | | | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 50 |
| L. Human factor related | | | | | 8 | |
| Z. Other | | | | | 33 | |
| Subtotal | | 370 | | 439 | 293 | 50 |
| Total | | 370 | | | 782 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2000 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 8 |
| 12. Reactor I&C Systems | | 25 |
| 13. Reactor Auxiliary Systems | 161 | 7 |
| 14. Safety Systems | | 13 |
| 15. Reactor Cooling Systems | | 46 |
| 16. Steam generation systems | 209 | 44 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | | 13 |
| 32. Feedwater and Main Steam System | | 28 |
| 34. Miscellaneous Systems | | 4 |
| 41. Main Generator Systems | | 20 |
| 42. Electrical Power Supply Systems | | 42 |
| Total | 370 | 258 |

Highlights (2023)

Annual Availability factor for RAPS-4 was 95.77%.
Annual Capacity factor for RAPS-4 was 88.71%.

2023 Operating Experience

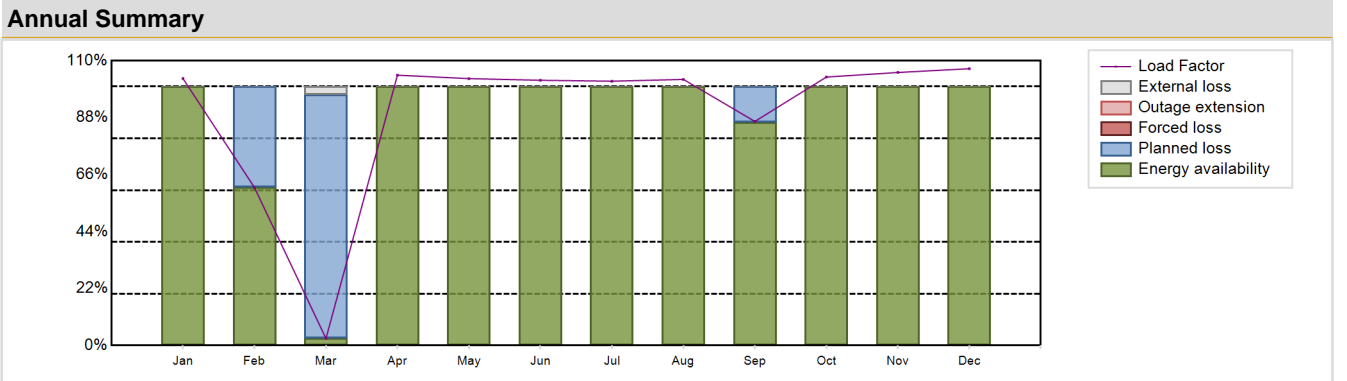
IN-19 **RAJASTHAN-5** **INDIA**

Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : TURBOATO (TURBOATOM Kharkiv Turbine Manufacture Plant)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--|--------------------|--------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube type | Construction Date | : 2002-09-18 |
| Thermal power | : 801 MWth | Grid Date | : 2009-12-22 |
| Gross electrical power | : 220 MWe | Commercial Date | : 2010-02-04 |
| Reference unit power (net) | : 202 MWe | Age at end of year | : 14 years |

| Design Characteristics | | | |
|---|--------------|--|----------|
| Primary Systems | | Operating coolant pressure [MPa] | : 1.034 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 293 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : Double |
| Moderator material | : D2O | Containment design pressure [MPa] | : 1.73 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 7000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 6.38 | HP cylinder inlet steam pressure [MPa] | : 3.972 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 5096 | Primary means of condenser cooling | : - |
| Fuel linear heat generation rate [kW/m] | : 20.18 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 4 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 1 | Number of on-site safety related diesel generators | : - |
| Coolant type | : D2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 1601.27 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 87.64 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 87.91 % | Planned Unavailability Factor (PUF) | : 12.09 % |
| Load Factor (LF) | : 90.49 % | Externally cause unavailability (XUF) | : 0.27 % |
| Operating Factor (OF) | : 87.8 % | Total off-line time | : 1069 hours |

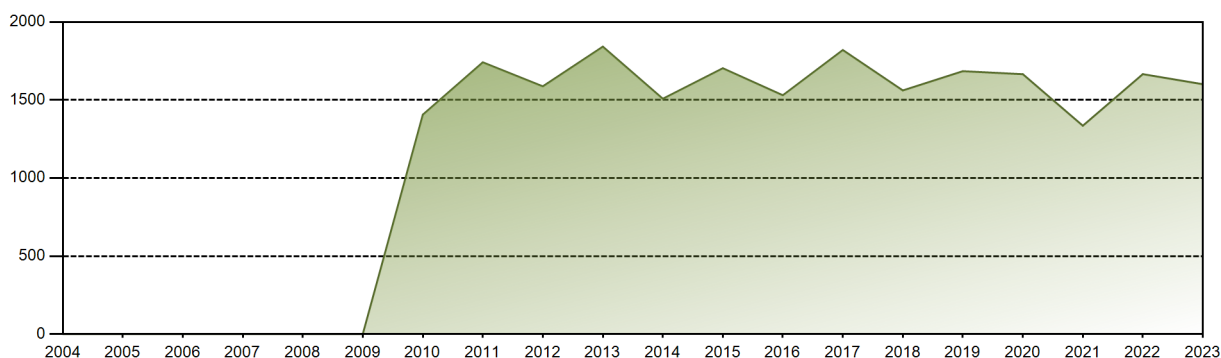


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 154.97 | 82.82 | 4.08 | 151.85 | 154.91 | 149.00 | 153.43 | 154.46 | 125.88 | 155.83 | 153.37 | 160.67 | 1601.27 |
| EAF [%] | 100.00 | 61.06 | 2.82 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.33 | 100.00 | 100.00 | 100.00 | 87.64 |
| UCF [%] | 100.00 | 61.06 | 6.01 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.33 | 100.00 | 100.00 | 100.00 | 87.91 |
| LF [%] | 103.11 | 61.01 | 2.72 | 104.41 | 103.07 | 102.44 | 102.09 | 102.78 | 86.55 | 103.69 | 105.45 | 106.91 | 90.49 |
| OF [%] | 100.00 | 60.71 | 5.11 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.25 | 100.00 | 100.00 | 100.00 | 87.80 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 38.94 | 93.99 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.67 | 0.00 | 0.00 | 0.00 | 12.09 |
| XUF [%] | 0.00 | 0.00 | 3.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 22655.93 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.62 % |
| Cumulative Energy Availability Factor (EAF) | : 90.36 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.41 % |
| Cumulative Unit Capability Factor (UCF) | : 90.65 % | Cumulative Planned Unavailability Factor (PUF) | : 5.94 % |
| Cumulative Load Factor (LF) | : 91.96 % | Cumulative Externally cause unavailability (XUF) | : 0.29 % |
| Cumulative Operating Factor (OF) | : 90.59 % | | |

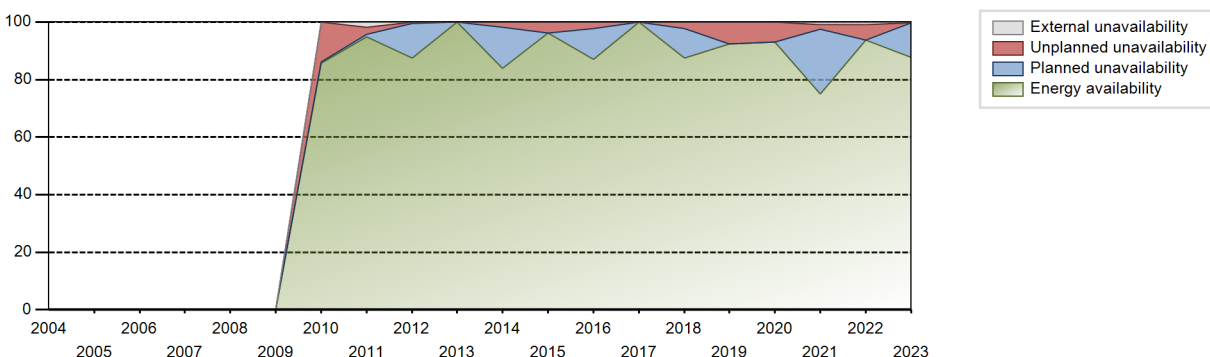
Electricity Production (net) [GWh]



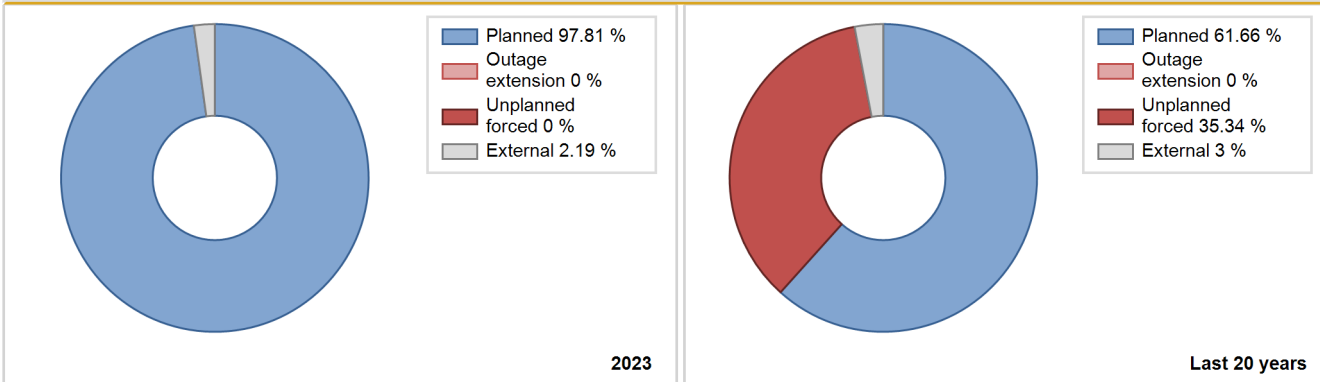
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|--------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2010 | 1406.17 | 7158 | 202 | 85.72 | 85.72 | 86.84 | 89.30 | 14.00 | 13.95 | 0.32 | 0.00 |
| 2011 | 1741.80 | 8325 | 202 | 94.91 | 96.66 | 98.43 | 95.03 | 2.56 | 2.54 | 0.80 | 1.75 |
| 2012 | 1587.81 | 7590 | 202 | 87.49 | 87.49 | 89.49 | 86.41 | 0.63 | 0.55 | 11.95 | 0.00 |
| 2013 | 1842.26 | 8760 | 202 | 100.00 | 100.00 | 104.11 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 1508.24 | 7329 | 202 | 83.83 | 83.83 | 85.23 | 83.66 | 2.06 | 1.76 | 14.40 | 0.00 |
| 2015 | 1703.88 | 8429 | 202 | 96.28 | 96.28 | 96.29 | 96.22 | 3.72 | 3.72 | 0.00 | 0.00 |
| 2016 | 1530.66 | 7643 | 202 | 87.14 | 87.14 | 86.27 | 87.01 | 2.61 | 2.34 | 10.52 | 0.00 |
| 2017 | 1820.58 | 8760 | 202 | 100.00 | 100.00 | 102.89 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 1561.42 | 7654 | 202 | 87.51 | 87.51 | 88.24 | 87.37 | 2.51 | 2.25 | 10.24 | 0.00 |
| 2019 | 1684.90 | 8087 | 202 | 92.41 | 92.41 | 95.22 | 92.32 | 7.59 | 7.59 | 0.00 | 0.00 |
| 2020 | 1665.65 | 8159 | 202 | 92.98 | 92.98 | 93.87 | 92.88 | 7.02 | 7.02 | 0.00 | 0.00 |
| 2021 | 1335.29 | 6610 | 202 | 75.09 | 76.08 | 75.46 | 75.46 | 2.00 | 1.55 | 22.36 | 0.99 |
| 2022 | 1665.99 | 8293 | 202 | 93.70 | 94.72 | 94.15 | 94.67 | 5.28 | 5.28 | 0.00 | 1.02 |
| 2023 | 1601.27 | 7691 | 202 | 87.64 | 87.91 | 90.49 | 87.80 | 0.00 | 0.00 | 12.09 | 0.27 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2010 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 264 | |
| D. Inspection, maintenance or repair without refuelling | 971 | | | 515 | | |
| E. Testing of plant systems or components | | | | 2 | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 17 |
| L. Human factor related | | | | | 4 | |
| Z. Other | 99 | | | 7 | 12 | 4 |
| Subtotal | 1070 | | | 524 | 280 | 21 |
| Total | | 1070 | | | 825 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2010 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 77 |
| 12. Reactor I&C Systems | | 37 |
| 15. Reactor Cooling Systems | | 44 |
| 16. Steam generation systems | | 4 |
| 21. Fuel Handling and Storage Facilities | | 0 |
| 31. Turbine and auxiliaries | | 17 |
| 33. Circulating Water System | | 10 |
| 34. Miscellaneous Systems | | 3 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 93 |
| 42. Electrical Power Supply Systems | | 8 |
| Total | | 293 |

Highlights (2023)

1. RAPS-5 was under biennial shut down from 17th February to 30th March 2023.
2. RAPS-5 was planned shutdown from 13th Sept. to 17th Sept. 2023 for rectification of coolant channel G-02(S) seal plug leak.

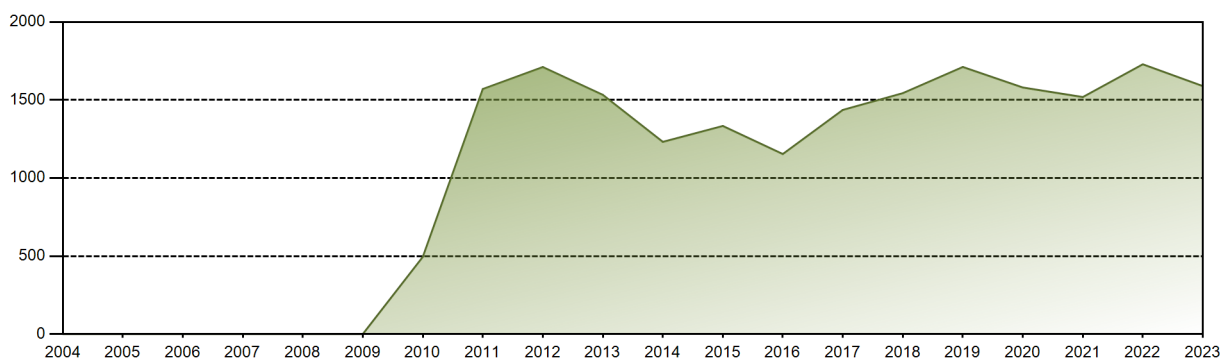
2023 Operating Experience

| IN-20 | | RAJASTHAN-6 | | INDIA | | | | | | | | | |
|---|---|--------------------------------------|--|--------|------------|--------|--------|--------|--------|-------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.) | | | | | | | | | | | | |
| Owner | : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.) | | | | | | | | | | | | |
| Reactor Supplier | : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.) | | | | | | | | | | | | |
| Turbine Supplier | : TURBOATO (TURBOATOM Kharkiv Turbine Manufacture Plant) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : | PHWR / Horizontal Pressure Tube type | Construction Date | : | 2003-01-20 | | | | | | | | |
| Thermal power | : | 801 MWth | Grid Date | : | 2010-03-28 | | | | | | | | |
| Gross electrical power | : | 220 MWe | Commercial Date | : | 2010-03-31 | | | | | | | | |
| Reference unit power (net) | : | 202 MWe | Age at end of year | : | 13 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Secondary systems | | | | | | | | | | |
| Reactor vessel centreline orientation | : | Horizontal | Operating coolant pressure [MPa] | : | 0.991 | | | | | | | | |
| Fuel material | : | UO2 | Reactor outlet temperature [°C] | : | 293 | | | | | | | | |
| Refuelling type | : | ON-line | Number of SG | : | 4 | | | | | | | | |
| Moderator material | : | D2O | Containment type | : | Double | | | | | | | | |
| Average fuel enrichment [% of U235] | : | - | Containment design pressure [MPa] | : | 1.73 | | | | | | | | |
| Refuelling frequency [month] | : | - | Secondary systems | | | | | | | | | | |
| Part of the core refuelled [%] | : | - | Number of turbine-generators per unit/reactor | : | 1 | | | | | | | | |
| Average discharge burnup [MWd/t] | : | 7000 | Turbine speed [rpm] | : | 3000 | | | | | | | | |
| Active core diameter [m] | : | 6.38 | Number of LP cylinders per turbine | : | - | | | | | | | | |
| Active core height/length [m] | : | 5.94 | HP cylinder inlet steam pressure [MPa] | : | 3.972 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 5096 | Output voltage [kV] | : | - | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 20.18 | Primary means of condenser cooling | : | - | | | | | | | | |
| Number of control rod assemblies | : | 4 | Number of main condensate pumps | : | - | | | | | | | | |
| Number of external reactor coolant loops | : | 1 | Number of FW pumps for full power operation | : | - | | | | | | | | |
| Coolant type | : | D2O | Number of on-site safety related diesel generators | : | - | | | | | | | | |
| | | | Non-electrical applications | | | | | | | | | | |
| | | | | : | none | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : | 1589.28 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | |
| Energy Availability Factor (EAF) | : | 88.85 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | |
| Unit Capability Factor (UCF) | : | 90.16 % | Planned Unavailability Factor (PUF) | : | 9.84 % | | | | | | | | |
| Load Factor (LF) | : | 89.81 % | Externally cause unavailability (XUF) | : | 1.31 % | | | | | | | | |
| Operating Factor (OF) | : | 90.07 % | Total off-line time | : | 870 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 155.41 | 138.29 | 151.37 | 144.28 | 147.65 | 141.75 | 145.35 | 145.71 | 140.63 | 2.12 | 118.24 | 158.49 | 1589.28 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 98.25 | 97.46 | 96.72 | 96.95 | 96.69 | 2.46 | 79.35 | 100.00 | 88.85 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 4.15 | 79.35 | 100.00 | 90.16 |
| LF [%] | 103.41 | 101.87 | 100.72 | 99.20 | 98.25 | 97.46 | 96.72 | 96.95 | 96.69 | 1.41 | 81.30 | 105.46 | 89.81 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 3.23 | 79.17 | 100.00 | 90.07 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 95.85 | 20.65 | 0.00 | 9.84 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.75 | 2.54 | 3.28 | 3.05 | 3.31 | 1.68 | 0.00 | 0.00 | 1.31 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 20139.25 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 13.18 % |
| Cumulative Energy Availability Factor (EAF) | : 82.06 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 12.62 % |
| Cumulative Unit Capability Factor (UCF) | : 82.5 % | Cumulative Planned Unavailability Factor (PUF) | : 4.88 % |
| Cumulative Load Factor (LF) | : 82.7 % | Cumulative Externally cause unavailability (XUF) | : 0.44 % |
| Cumulative Operating Factor (OF) | : 83.25 % | | |

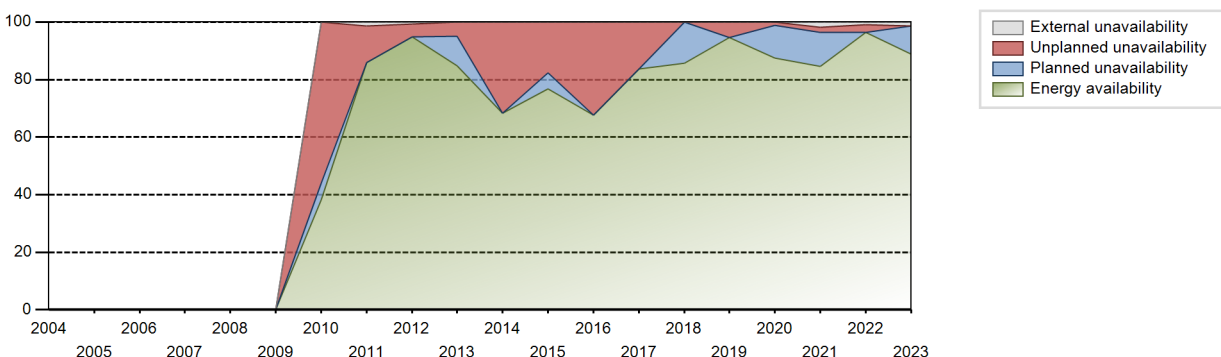
Electricity Production (net) [GWh]



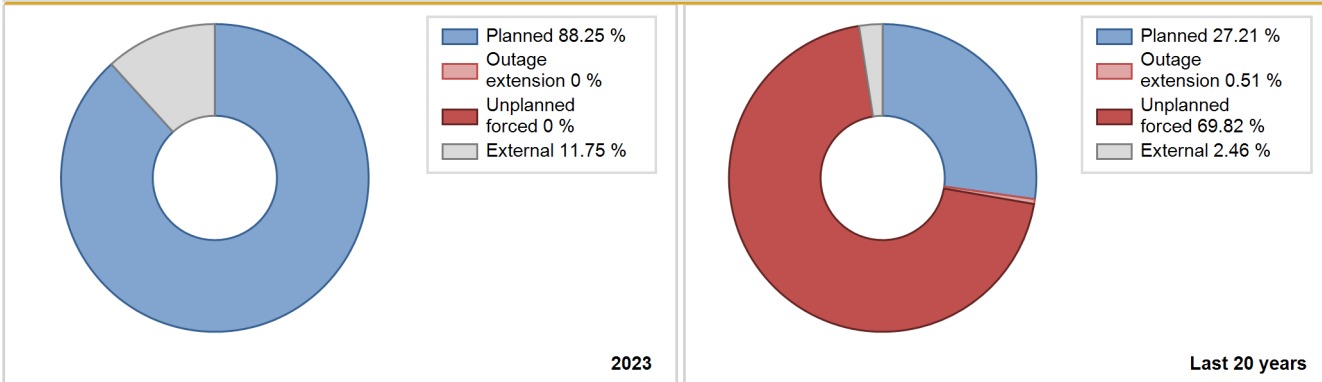
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2010 | 494.85 | 3041 | 202 | 38.11 | 38.11 | 37.12 | 46.08 | 59.53 | 56.06 | 5.83 | 0.00 |
| 2011 | 1570.55 | 7506 | 202 | 85.84 | 87.27 | 88.76 | 85.68 | 12.73 | 12.73 | 0.00 | 1.43 |
| 2012 | 1711.31 | 8317 | 202 | 94.75 | 95.52 | 96.45 | 94.68 | 4.48 | 4.48 | 0.00 | 0.76 |
| 2013 | 1533.21 | 7420 | 202 | 84.87 | 84.87 | 86.65 | 84.70 | 5.38 | 4.83 | 10.30 | 0.00 |
| 2014 | 1231.86 | 6514 | 202 | 68.36 | 68.36 | 69.62 | 74.36 | 31.64 | 31.64 | 0.00 | 0.00 |
| 2015 | 1333.69 | 7042 | 202 | 76.86 | 76.86 | 75.37 | 80.39 | 18.72 | 17.70 | 5.44 | 0.00 |
| 2016 | 1153.85 | 5921 | 202 | 67.75 | 67.75 | 65.03 | 67.41 | 32.25 | 32.25 | 0.00 | 0.00 |
| 2017 | 1436.62 | 7321 | 202 | 83.74 | 83.74 | 81.19 | 83.57 | 16.26 | 16.26 | 0.00 | 0.00 |
| 2018 | 1543.92 | 7489 | 202 | 85.64 | 85.64 | 87.25 | 85.49 | 0.01 | 0.01 | 14.35 | 0.00 |
| 2019 | 1711.86 | 8281 | 202 | 94.59 | 94.59 | 96.74 | 94.53 | 5.41 | 5.41 | 0.00 | 0.00 |
| 2020 | 1580.21 | 7680 | 202 | 87.56 | 87.56 | 89.06 | 87.43 | 0.00 | 1.26 | 11.19 | 0.00 |
| 2021 | 1519.08 | 7429 | 202 | 84.67 | 86.42 | 85.85 | 84.81 | 2.18 | 1.93 | 11.65 | 1.75 |
| 2022 | 1728.96 | 8513 | 202 | 96.38 | 97.20 | 97.71 | 97.18 | 2.80 | 2.80 | 0.00 | 0.82 |
| 2023 | 1589.28 | 7890 | 202 | 88.85 | 90.16 | 89.81 | 90.07 | 0.00 | 0.00 | 9.84 | 1.31 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2010 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 987 | |
| D. Inspection, maintenance or repair without refuelling | 870 | | | 430 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 14 |
| L. Human factor related | | | | | 17 | |
| P. Fire | | | | | 6 | |
| Z. Other | | | | | | 9 |
| Subtotal | 870 | | | 430 | 1010 | 23 |
| Total | | 870 | | | 1463 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2010 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|-------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 43 |
| 12. Reactor I&C Systems | | | | 25 |
| 13. Reactor Auxiliary Systems | | | | 6 |
| 14. Safety Systems | | | | 8 |
| 15. Reactor Cooling Systems | | | | 4 |
| 16. Steam generation systems | | | | 29 |
| 31. Turbine and auxiliaries | | | | 154 |
| 32. Feedwater and Main Steam System | | | | 7 |
| 33. Circulating Water System | | | | 14 |
| 35. All other I&C Systems | | | | 5 |
| 41. Main Generator Systems | | | | 457 |
| 42. Electrical Power Supply Systems | | | | 267 |
| Total | | | | 1019 |

Highlights (2023)

RAPS-6 was under biennial shutdown from 01/10/2023 to 07/11/2023.

2023 Operating Experience

IN-23 **TARAPUR-3** **INDIA**

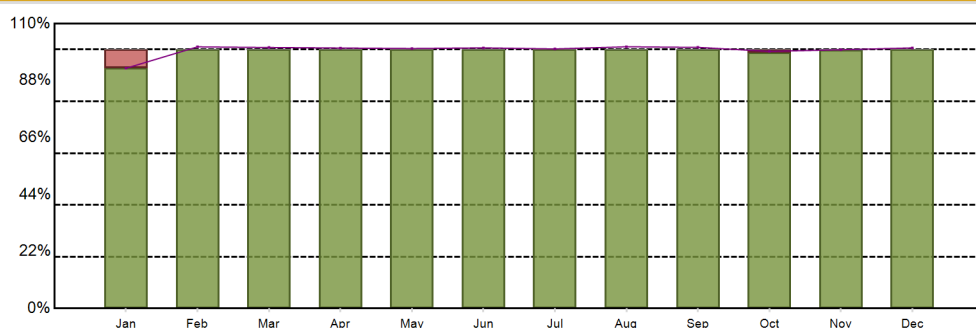
Status at end of year : **Operational**
 Operator : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Owner : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.)
 Reactor Supplier : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.)
 Turbine Supplier : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com)

| Reactor Unit Details | | | Key Dates | | |
|----------------------------|--|--|--------------------|---|------------|
| Reactor type and model | : PHWR / Horizontal Pressure Tube Type | | Construction Date | : | 2000-05-12 |
| Thermal power | : 1730 MWth | | Grid Date | : | 2006-06-15 |
| Gross electrical power | : 540 MWe | | Commercial Date | : | 2006-08-18 |
| Reference unit power (net) | : 490 MWe | | Age at end of year | : | 17 years |

| Design Characteristics | | | |
|---|--------------|--|----------------------|
| Primary Systems | | | |
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 0.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 304 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : D2O | Containment type | : - |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 1.44 |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 7000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 6.38 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 5.94 | HP cylinder inlet steam pressure [MPa] | : 4.1 |
| Number of fissile fuel assemblies/bundles | : 5096 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 20.18 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 4 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

| Annual Production Results (2023) | | | | | |
|----------------------------------|-------------------|--|---|----------|--|
| Net Energy Production | : 4286.26 GW(e).h | Forced Loss Rate (FLR) | : | 0.71 % | |
| Energy Availability Factor (EAF) | : 99.28 % | Unplanned Capability Loss Factor (UCL) | : | 0.71 % | |
| Unit Capability Factor (UCF) | : 99.28 % | Planned Unavailability Factor (PUF) | : | 0 % | |
| Load Factor (LF) | : 99.86 % | Externally cause unavailability (XUF) | : | 0 % | |
| Operating Factor (OF) | : 99.35 % | Total off-line time | : | 57 hours | |

Annual Summary

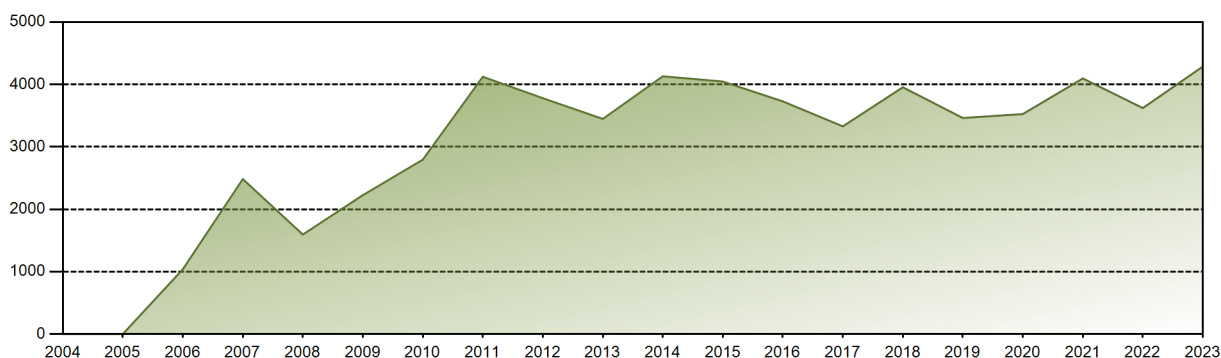


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 338.27 | 332.78 | 367.56 | 354.91 | 366.09 | 355.15 | 365.51 | 368.57 | 355.85 | 362.04 | 352.63 | 366.91 | 4286.26 |
| EAF [%] | 92.79 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.82 | 99.95 | 100.00 | 99.28 |
| UCF [%] | 92.79 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.82 | 99.95 | 100.00 | 99.28 |
| LF [%] | 92.79 | 101.06 | 100.82 | 100.60 | 100.42 | 100.67 | 100.26 | 101.10 | 100.86 | 99.31 | 99.95 | 100.64 | 99.86 |
| OF [%] | 93.55 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.79 | 100.00 | 100.00 | 99.35 |
| FLR [%] | 7.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.18 | 0.00 | 0.00 | 0.71 |
| UCL [%] | 7.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.18 | 0.00 | 0.00 | 0.71 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 59646.12 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.03 % |
| Cumulative Energy Availability Factor (EAF) | : 80.84 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.93 % |
| Cumulative Unit Capability Factor (UCF) | : 89.12 % | Cumulative Planned Unavailability Factor (PUF) | : 5.95 % |
| Cumulative Load Factor (LF) | : 79.91 % | Cumulative Externally cause unavailability (XUF) | : 8.28 % |
| Cumulative Operating Factor (OF) | : 89.19 % | | |

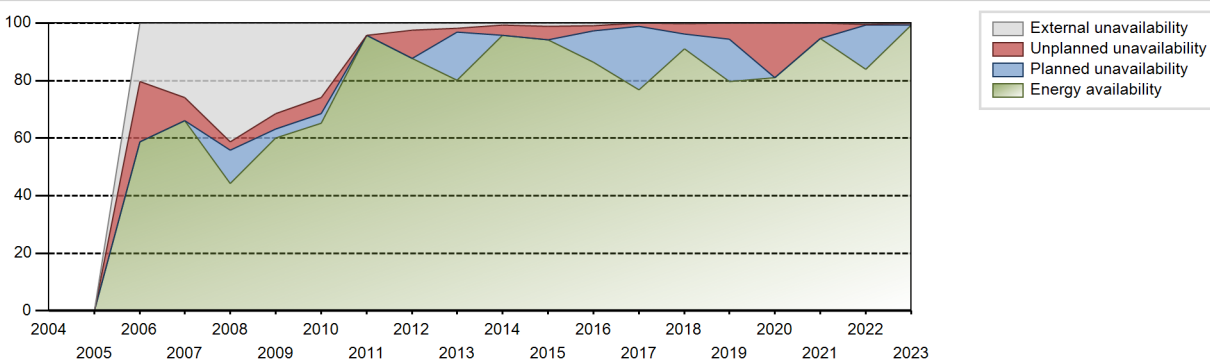
Electricity Production (net) [GWh]



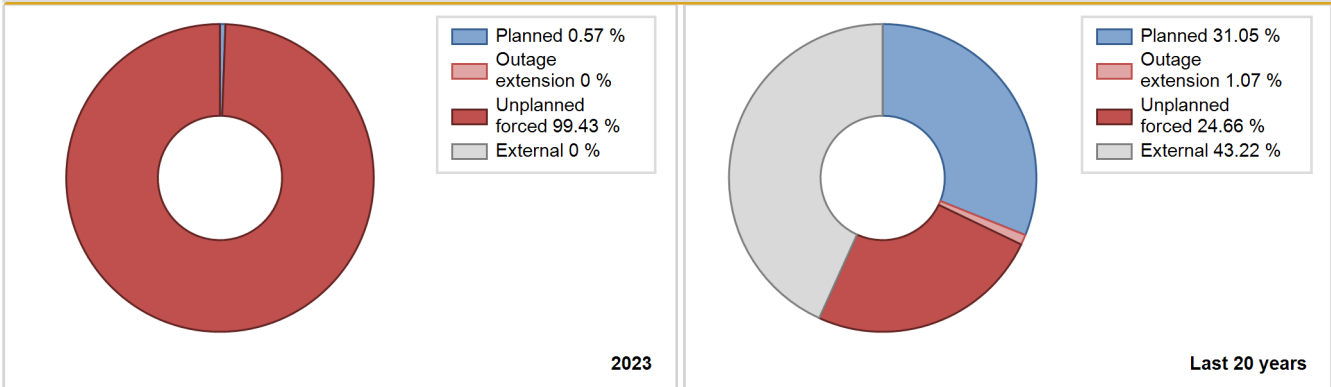
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|-------|--------|-------|-------|-------|-------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2006 | 1037.77 | 3599 | 490 | 58.83 | 79.15 | 61.08 | 80.50 | 20.85 | 20.85 | 0.00 | 20.32 |
| 2007 | 2482.81 | 7967 | 490 | 66.18 | 92.12 | 57.84 | 90.95 | 7.88 | 7.88 | 0.00 | 25.93 |
| 2008 | 1594.38 | 7465 | 490 | 44.33 | 85.57 | 37.04 | 84.98 | 3.24 | 2.86 | 11.56 | 41.25 |
| 2009 | 2225.01 | 8022 | 490 | 60.11 | 91.58 | 51.84 | 91.58 | 5.45 | 5.27 | 3.15 | 31.47 |
| 2010 | 2794.03 | 7972 | 490 | 65.09 | 91.01 | 65.09 | 91.00 | 4.64 | 5.50 | 3.49 | 25.92 |
| 2011 | 4122.20 | 8760 | 490 | 95.78 | 100.00 | 96.03 | 100.00 | 0.00 | 0.00 | 0.00 | 4.22 |
| 2012 | 3779.47 | 7923 | 490 | 87.67 | 90.20 | 87.81 | 90.20 | 9.80 | 9.80 | 0.00 | 2.53 |
| 2013 | 3447.26 | 7200 | 490 | 80.22 | 82.08 | 80.31 | 82.19 | 1.53 | 1.28 | 16.65 | 1.86 |
| 2014 | 4129.97 | 8463 | 490 | 95.79 | 96.51 | 96.22 | 96.61 | 3.49 | 3.49 | 0.00 | 0.72 |
| 2015 | 4046.11 | 8352 | 490 | 94.07 | 95.17 | 94.26 | 95.34 | 4.83 | 4.83 | 0.00 | 1.10 |
| 2016 | 3728.32 | 7688 | 490 | 86.42 | 87.34 | 86.62 | 87.52 | 2.12 | 1.89 | 10.77 | 0.93 |
| 2017 | 3328.06 | 6785 | 490 | 76.89 | 76.89 | 77.53 | 77.45 | 1.34 | 1.05 | 22.07 | 0.00 |
| 2018 | 3954.15 | 7992 | 490 | 90.95 | 91.24 | 92.12 | 91.23 | 3.15 | 3.56 | 5.21 | 0.29 |
| 2019 | 3461.87 | 7054 | 490 | 79.57 | 79.57 | 80.65 | 80.53 | 4.46 | 5.62 | 14.81 | 0.00 |
| 2020 | 3525.17 | 7140 | 490 | 81.06 | 81.06 | 81.90 | 81.28 | 18.94 | 18.94 | 0.00 | 0.00 |
| 2021 | 4095.66 | 8302 | 490 | 94.51 | 94.51 | 95.42 | 94.77 | 5.49 | 5.49 | 0.00 | 0.00 |
| 2022 | 3621.42 | 7381 | 490 | 83.87 | 84.35 | 84.37 | 84.26 | 0.30 | 0.26 | 15.39 | 0.49 |
| 2023 | 4286.26 | 8703 | 490 | 99.28 | 99.28 | 99.86 | 99.35 | 0.71 | 0.71 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2006 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 48 | | | 407 | |
| D. Inspection, maintenance or repair without refuelling | | | | 507 | 13 | |
| E. Testing of plant systems or components | | | | 10 | 9 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 9 |
| L. Human factor related | | | | | 24 | |
| P. Fire | | | | | 1 | |
| Z. Other | | | | | | 2 |
| Subtotal | | 48 | | 517 | 454 | 11 |
| Total | | 48 | | | 982 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2006 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 105 |
| 12. Reactor I&C Systems | | | | 111 |
| 14. Safety Systems | | | | 11 |
| 15. Reactor Cooling Systems | | | | 91 |
| 31. Turbine and auxiliaries | | | | 68 |
| 32. Feedwater and Main Steam System | | | | 16 |
| 33. Circulating Water System | | | | 5 |
| 34. Miscellaneous Systems | | | | 4 |
| 41. Main Generator Systems | | | | 13 |
| 42. Electrical Power Supply Systems | | 48 | | 23 |
| Total | | 48 | | 447 |

Highlights (2023)

TAPS-3 had Availability factor of 99.35% during the year.
 TAPS-3 operated with a Capacity factor of 99.65% during the year.

2023 Operating Experience

IN-24

TARAPUR-4

INDIA

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.) |
| Owner | : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD.) |
| Reactor Supplier | : NPCIL (NUCLEAR POWER CORPORATION OF INDIA, LTD. Vikram Sarabhai Bhavan, Anushakti Nagar, Mumbai - 400 094.) |
| Turbine Supplier | : BHEL (Bharat Heavy Electricals Ltd (BHEL) www.bhel.com) |

Reactor Unit Details

| | |
|----------------------------|--|
| Reactor type and model | : PHWR / Horizontal Pressure Tube Type |
| Thermal power | : 1730 MWth |
| Gross electrical power | : 540 MWe |
| Reference unit power (net) | : 490 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 2000-03-08 |
| Grid Date | : 2005-06-04 |
| Commercial Date | : 2005-09-12 |
| Age at end of year | : 18 years |

Design Characteristics

Primary Systems

| | |
|---|--------------|
| Reactor vessel centreline orientation | : Horizontal |
| Fuel material | : UO2 |
| Refuelling type | : ON-line |
| Moderator material | : D2O |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : - |
| Part of the core refuelled [%] | : - |
| Average discharge burnup [MWd/t] | : 7000 |
| Active core diameter [m] | : 6.38 |
| Active core height/length [m] | : 5.94 |
| Number of fissile fuel assemblies/bundles | : 5096 |
| Fuel linear heat generation rate [kW/m] | : 20.18 |
| Number of control rod assemblies | : 4 |
| Number of external reactor coolant loops | : 2 |
| Coolant type | : H2O |

| | |
|-----------------------------------|--------|
| Operating coolant pressure [MPa] | : 11.6 |
| Reactor outlet temperature [°C] | : 304 |
| Number of SG | : 4 |
| Containment type | : - |
| Containment design pressure [MPa] | : 1.44 |

Secondary systems

| | |
|--|----------------------|
| Number of turbine-generators per unit/reactor | : 1 |
| Turbine speed [rpm] | : 3000 |
| Number of LP cylinders per turbine | : - |
| HP cylinder inlet steam pressure [MPa] | : 4.1 |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : Sea (once-through) |
| Number of main condensate pumps | : - |
| Number of FW pumps for full power operation | : - |
| Number of on-site safety related diesel generators | : - |

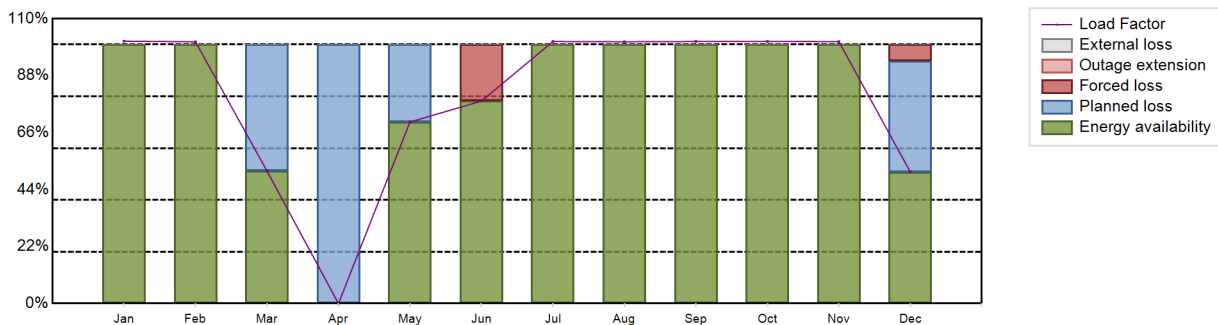
Non-electrical applications

| | |
|--|--------|
| | : none |
|--|--------|

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 3425.53 GW(e).h | Forced Loss Rate (FLR) | : 2.86 % |
| Energy Availability Factor (EAF) | : 79.12 % | Unplanned Capability Loss Factor (UCL) | : 2.33 % |
| Unit Capability Factor (UCF) | : 79.12 % | Planned Unavailability Factor (PUF) | : 18.55 % |
| Load Factor (LF) | : 79.8 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 79.5 % | Total off-line time | : 1796 hours |

Annual Summary

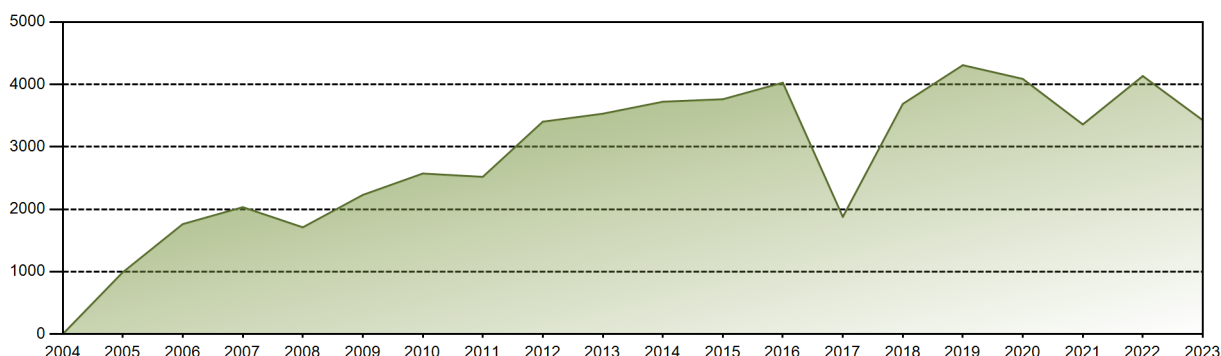


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 369.35 | 332.82 | 186.62 | 0.00 | 255.55 | 275.82 | 368.90 | 368.53 | 356.98 | 368.96 | 356.86 | 185.16 | 3425.53 |
| EAF [%] | 100.00 | 100.00 | 51.19 | 0.00 | 70.10 | 78.18 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 50.79 | 79.12 |
| UCF [%] | 100.00 | 100.00 | 51.19 | 0.00 | 70.10 | 78.18 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 50.79 | 79.12 |
| LF [%] | 101.31 | 101.07 | 51.19 | 0.00 | 70.10 | 78.18 | 101.19 | 101.09 | 101.18 | 101.21 | 101.15 | 50.79 | 79.80 |
| OF [%] | 100.00 | 100.00 | 51.34 | 0.00 | 71.10 | 79.17 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 53.09 | 79.50 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.06 | 2.86 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.31 | 2.33 |
| PUF [%] | 0.00 | 0.00 | 48.81 | 100.00 | 29.90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 42.90 | 18.55 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 57151.22 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.51 % |
| Cumulative Energy Availability Factor (EAF) | : 73.56 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.99 % |
| Cumulative Unit Capability Factor (UCF) | : 84.79 % | Cumulative Planned Unavailability Factor (PUF) | : 7.22 % |
| Cumulative Load Factor (LF) | : 72.5 % | Cumulative Externally cause unavailability (XUF) | : 11.23 % |
| Cumulative Operating Factor (OF) | : 84.78 % | | |

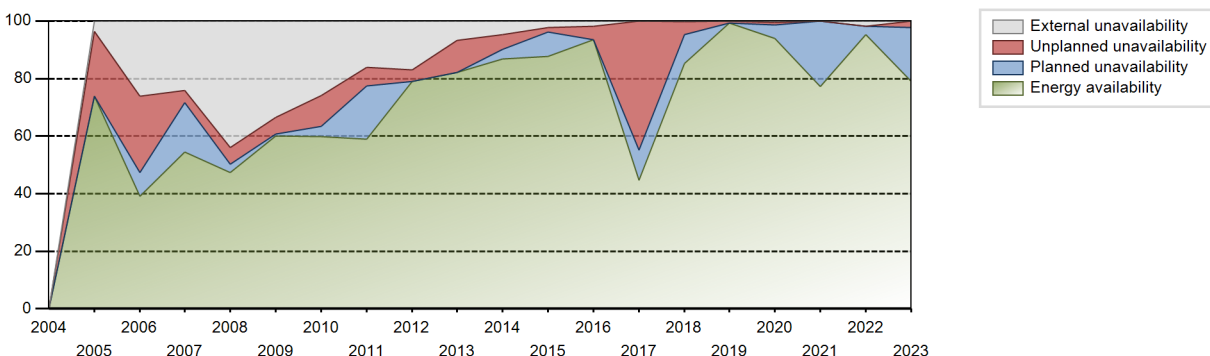
Electricity Production (net) [GWh]



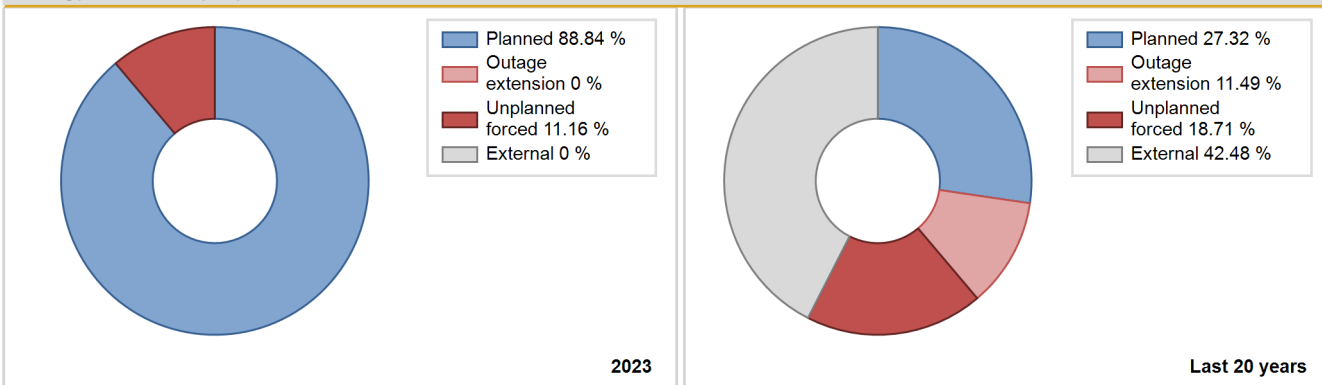
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|-------|-------|-------|-------|-------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2005 | 990.44 | 2770 | 490 | 73.84 | 77.37 | 65.69 | 76.03 | 22.63 | 22.63 | 0.00 | 3.54 |
| 2006 | 1762.12 | 5454 | 490 | 39.01 | 65.22 | 41.05 | 62.26 | 28.87 | 26.47 | 8.30 | 26.21 |
| 2007 | 2032.97 | 6797 | 490 | 54.43 | 78.54 | 47.36 | 77.59 | 5.22 | 4.32 | 17.13 | 24.11 |
| 2008 | 1709.82 | 8022 | 490 | 47.37 | 91.33 | 39.72 | 91.33 | 5.98 | 5.81 | 2.86 | 43.97 |
| 2009 | 2229.28 | 8187 | 490 | 59.98 | 93.47 | 51.94 | 93.46 | 5.76 | 5.71 | 0.82 | 33.49 |
| 2010 | 2571.83 | 7526 | 490 | 59.92 | 85.91 | 59.92 | 85.91 | 10.94 | 10.55 | 3.54 | 25.99 |
| 2011 | 2518.86 | 6568 | 490 | 58.84 | 74.99 | 58.68 | 74.98 | 0.13 | 6.41 | 18.61 | 16.15 |
| 2012 | 3402.67 | 8440 | 490 | 79.06 | 96.08 | 79.06 | 96.08 | 3.92 | 3.92 | 0.00 | 17.02 |
| 2013 | 3530.42 | 7779 | 490 | 82.16 | 88.80 | 82.25 | 88.80 | 11.20 | 11.20 | 0.00 | 6.64 |
| 2014 | 3722.25 | 8409 | 490 | 86.72 | 91.35 | 86.72 | 95.99 | 5.49 | 5.30 | 3.34 | 4.64 |
| 2015 | 3762.17 | 7881 | 490 | 87.75 | 89.97 | 87.65 | 89.97 | 1.69 | 1.54 | 8.48 | 2.22 |
| 2016 | 4027.88 | 8381 | 490 | 93.58 | 95.41 | 93.58 | 95.41 | 4.59 | 4.59 | 0.00 | 1.83 |
| 2017 | 1876.84 | 3951 | 490 | 44.67 | 44.67 | 43.72 | 45.10 | 0.21 | 44.81 | 10.52 | 0.00 |
| 2018 | 3687.88 | 7494 | 490 | 85.33 | 85.55 | 85.92 | 85.55 | 0.56 | 4.41 | 10.04 | 0.22 |
| 2019 | 4308.00 | 8717 | 490 | 99.40 | 99.40 | 100.36 | 99.51 | 0.11 | 0.60 | 0.00 | 0.00 |
| 2020 | 4088.13 | 8280 | 490 | 94.03 | 94.49 | 94.98 | 94.26 | 0.63 | 0.89 | 4.62 | 0.47 |
| 2021 | 3358.57 | 6806 | 490 | 77.23 | 77.23 | 78.24 | 77.69 | 0.00 | 0.00 | 22.77 | 0.00 |
| 2022 | 4133.62 | 8364 | 490 | 95.35 | 97.08 | 96.30 | 95.48 | 0.03 | 0.03 | 2.89 | 1.74 |
| 2023 | 3425.53 | 6964 | 490 | 79.12 | 79.12 | 79.80 | 79.50 | 2.86 | 2.33 | 18.55 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2005 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 190 | | | 480 | |
| D. Inspection, maintenance or repair without refuelling | 1606 | | | 570 | 229 | |
| E. Testing of plant systems or components | | | | 17 | 1 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 39 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 26 |
| L. Human factor related | | | | | 19 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 23 |
| Z. Other | | | | | 4 | 10 |
| Subtotal | 1606 | 190 | | 626 | 733 | 59 |
| Total | | 1796 | | | 1418 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2005 to 2023 | |
|--|------------|-------------------------------------|--------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | | | 60 |
| 12. Reactor I&C Systems | | | 40 | 134 |
| 13. Reactor Auxiliary Systems | | | | 33 |
| 14. Safety Systems | | | | 14 |
| 15. Reactor Cooling Systems | | | | 16 |
| 16. Steam generation systems | | | | 5 |
| 21. Fuel Handling and Storage Facilities | | | | 53 |
| 31. Turbine and auxiliaries | | | | 19 |
| 32. Feedwater and Main Steam System | | | | 6 |
| 33. Circulating Water System | | | | 14 |
| 34. Miscellaneous Systems | | | | 7 |
| 35. All other I&C Systems | | | | 0 |
| 41. Main Generator Systems | | | | 80 |
| 42. Electrical Power Supply Systems | | | 150 | 83 |
| Total | | | 190 | 524 |

Highlights (2023)

TAPS-4 had Availability factor of 79.5% during the year.
Capacity factor for TAPS-4 during the year was 79.85%.

2023 Operating Experience

IR-1 **BUSHEHR-1** **IRAN, ISLAMIC REPUBLIC OF**

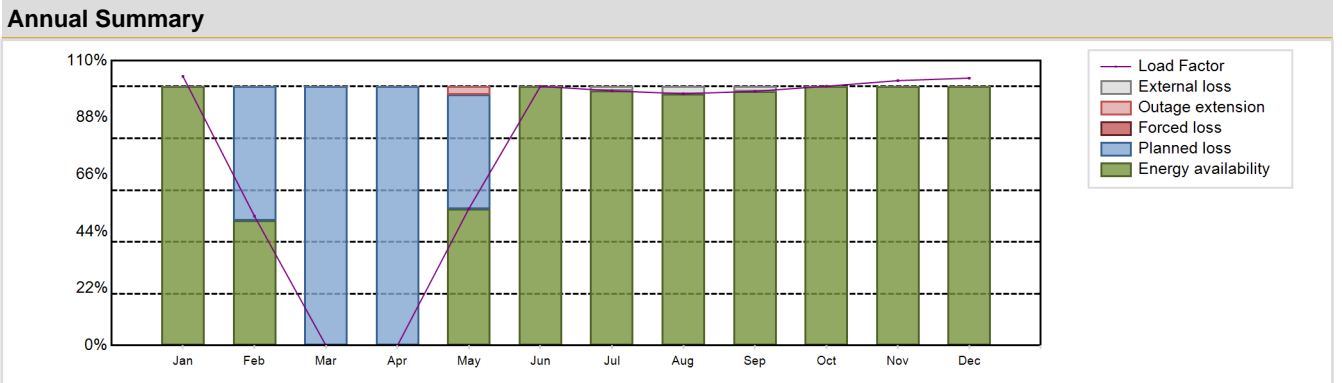
Status at end of year : **Operational**
 Operator : NPPDCO (Nuclear Power Production and Development Co. of Iran)
 Owner : NPPDCO (Nuclear Power Production and Development Co. of Iran)
 Reactor Supplier : JSC ASE (JSC "Atomstroyexport")
 Turbine Supplier : JSC ASE (JSC "Atomstroyexport")



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-446 | Construction Date | : 1975-05-01 |
| Thermal power | : 3000 MWth | Grid Date | : 2011-09-03 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 2013-09-23 |
| Reference unit power (net) | : 915 MWe | Age at end of year | : 12 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.7 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 321 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.46 |
| Average fuel enrichment [% of U235] | : 2.45 | Secondary systems | |
| Refuelling frequency [month] | : 10 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 43000 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 5.88 |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : 27 |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 16.67 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 103 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 8 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 6071.16 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 74.77 % | Unplanned Capability Loss Factor (UCL) | : 0.26 % |
| Unit Capability Factor (UCF) | : 75.29 % | Planned Unavailability Factor (PUF) | : 24.44 % |
| Load Factor (LF) | : 75.74 % | Externally cause unavailability (XUF) | : 0.52 % |
| Operating Factor (OF) | : 75.4 % | Total off-line time | : 2155 hours |

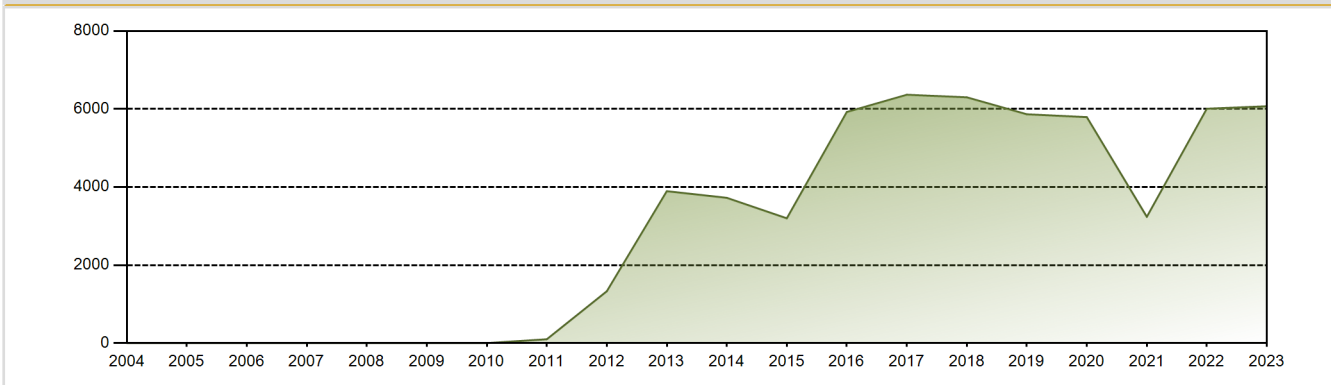


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 707.53 | 307.24 | 0.00 | 0.00 | 360.06 | 659.52 | 669.63 | 661.86 | 646.76 | 681.62 | 673.95 | 702.98 | 6071.16 |
| EAF [%] | 100.00 | 48.20 | 0.00 | 0.00 | 52.65 | 100.00 | 98.37 | 97.22 | 98.17 | 100.00 | 100.00 | 100.00 | 74.77 |
| UCF [%] | 100.00 | 48.20 | 0.00 | 0.00 | 52.65 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 75.29 |
| LF [%] | 103.93 | 49.97 | 0.00 | 0.00 | 52.89 | 100.11 | 98.37 | 97.22 | 98.17 | 100.13 | 102.30 | 103.26 | 75.74 |
| OF [%] | 100.00 | 48.21 | 0.00 | 0.00 | 53.90 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 75.40 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 3.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 |
| PUF [%] | 0.00 | 51.80 | 100.00 | 100.00 | 44.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.44 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.63 | 2.78 | 1.83 | 0.00 | 0.00 | 0.00 | 0.52 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 58027.28 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.34 % |
| Cumulative Energy Availability Factor (EAF) | : 73.71 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.9 % |
| Cumulative Unit Capability Factor (UCF) | : 74.26 % | Cumulative Planned Unavailability Factor (PUF) | : 19.84 % |
| Cumulative Load Factor (LF) | : 66.18 % | Cumulative Externally cause unavailability (XUF) | : 0.56 % |
| Cumulative Operating Factor (OF) | : 68.43 % | | |

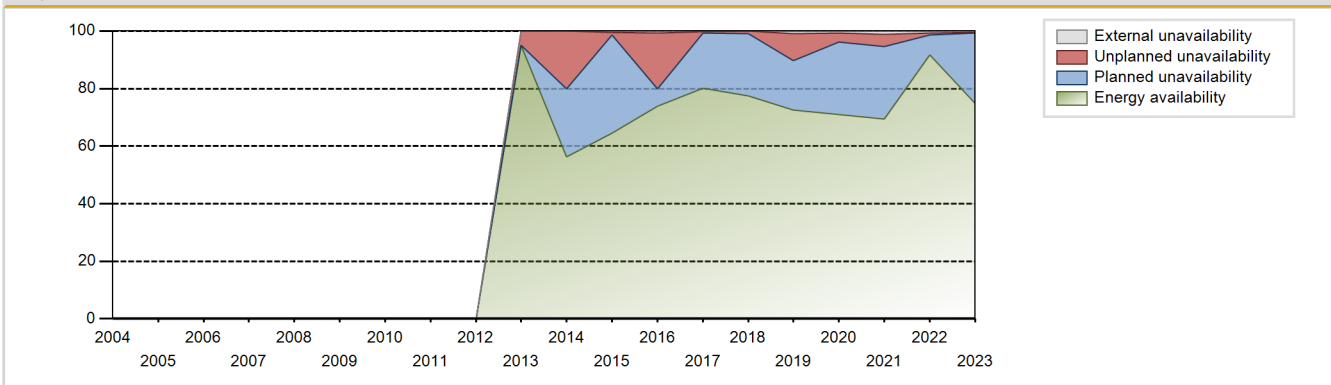
Electricity Production (net) [GWh]



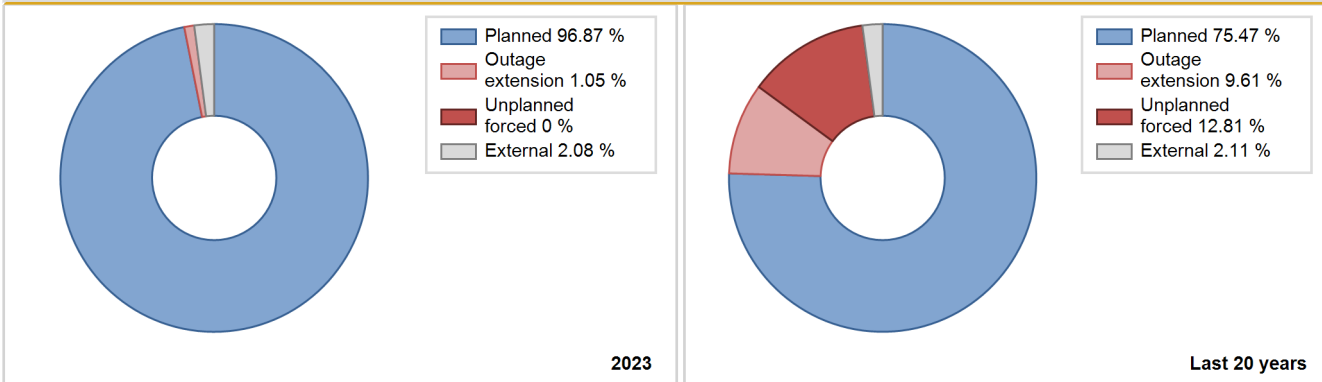
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2013 | 3893.67 | 4523 | 915 | 95.11 | 95.11 | 95.43 | 95.47 | 4.89 | 4.89 | 0.00 | 0.00 |
| 2014 | 3723.60 | 5181 | 915 | 56.36 | 56.40 | 46.46 | 59.14 | 8.50 | 20.09 | 23.50 | 0.04 |
| 2015 | 3198.24 | 3992 | 915 | 64.42 | 64.85 | 39.90 | 45.57 | 1.31 | 0.86 | 34.29 | 0.44 |
| 2016 | 5923.97 | 6615 | 915 | 73.91 | 74.64 | 73.71 | 75.31 | 11.39 | 19.46 | 5.90 | 0.72 |
| 2017 | 6366.21 | 6971 | 915 | 80.03 | 80.37 | 79.42 | 79.58 | 0.35 | 0.28 | 19.35 | 0.34 |
| 2018 | 6300.12 | 6851 | 915 | 77.50 | 77.63 | 78.60 | 78.21 | 0.91 | 0.71 | 21.65 | 0.14 |
| 2019 | 5865.73 | 6611 | 915 | 72.53 | 73.41 | 73.18 | 75.47 | 11.36 | 9.41 | 17.18 | 0.88 |
| 2020 | 5792.22 | 6349 | 915 | 71.05 | 71.66 | 72.07 | 72.28 | 3.77 | 3.32 | 25.02 | 0.61 |
| 2021 | 3235.97 | 3665 | 915 | 69.32 | 70.58 | 40.37 | 41.84 | 5.59 | 4.18 | 25.24 | 1.26 |
| 2022 | 6008.02 | 6544 | 915 | 91.79 | 92.52 | 74.96 | 74.70 | 0.20 | 0.59 | 6.89 | 0.73 |
| 2023 | 6071.16 | 6605 | 915 | 74.77 | 75.29 | 75.74 | 75.40 | 0.00 | 0.26 | 24.44 | 0.52 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2013 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 23 | | | 432 | |
| C. Inspection, maintenance or repair combined with refuelling | 1979 | | | 1559 | | |
| D. Inspection, maintenance or repair without refuelling | 152 | | | 158 | | |
| E. Testing of plant systems or components | | | | 2 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 9 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 586 |
| L. Human factor related | | | | | 21 | |
| Z. Other | | | | | 4 | |
| Subtotal | 2131 | 23 | | 1719 | 457 | 595 |
| Total | | 2154 | | | 2771 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2013 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 13 |
| 15. Reactor Cooling Systems | | 23 | | 81 |
| 16. Steam generation systems | | | | 9 |
| 31. Turbine and auxiliaries | | | | 86 |
| 32. Feedwater and Main Steam System | | | | 9 |
| 33. Circulating Water System | | | | 127 |
| 34. Miscellaneous Systems | | | | 3 |
| 41. Main Generator Systems | | | | 91 |
| 42. Electrical Power Supply Systems | | | | 5 |
| Total | | 23 | | 424 |

2023 Operating Experience

JP-45

GENKAI-3

JAPAN

Status at end of year : **Operational**
 Operator : KYUSHU (Kyushu Electric Power Co., Inc.)
 Owner : KYUSHU (Kyushu Electric Power Co., Inc.)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



Reactor Unit Details

Reactor type and model : PWR / M (4-loop)
 Thermal power : 3423 MWth
 Gross electrical power : 1180 MWe
 Reference unit power (net) : 1127 MWe

Key Dates

Construction Date : 1988-06-01
 Grid Date : 1993-06-15
 Commercial Date : 1994-03-18
 Age at end of year : 30 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2/MOX
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.1
 Refuelling frequency [month] : 13
 Part of the core refuelled [%] : 46
 Average discharge burnup [MWd/t] : 43000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.9
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 325
 Number of SG : 4
 Containment type : Confinement
 Containment design pressure [MPa] : 0.39

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.76
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

Non-electrical applications

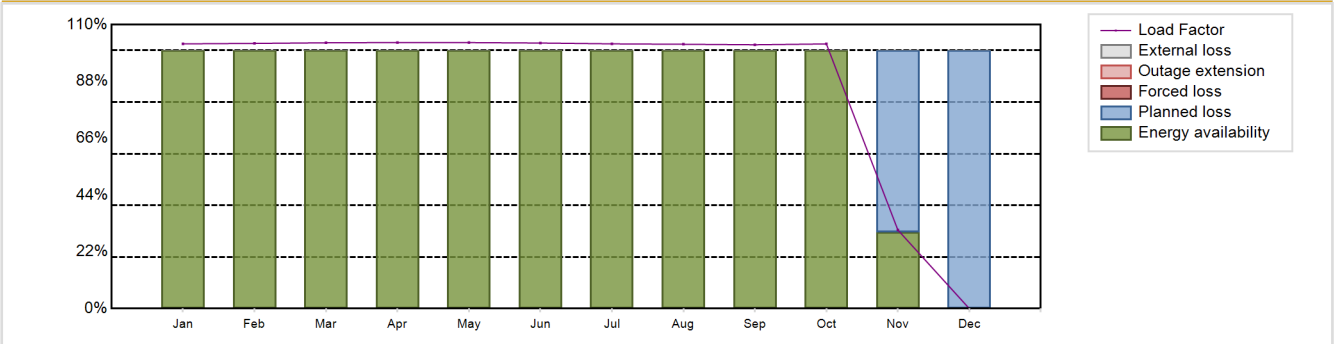
Non-electrical applications : DS

Annual Production Results (2023)

Net Energy Production : 8691.55 GW(e).h
 Energy Availability Factor (EAF) : 85.73 %
 Unit Capability Factor (UCF) : 85.73 %
 Load Factor (LF) : 88.04 %
 Operating Factor (OF) : 85.76 %
 Equivalent non-electrical energy generated (NEG) : 4.64 GW(e).h

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 14.27 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1247 hours

Annual Summary

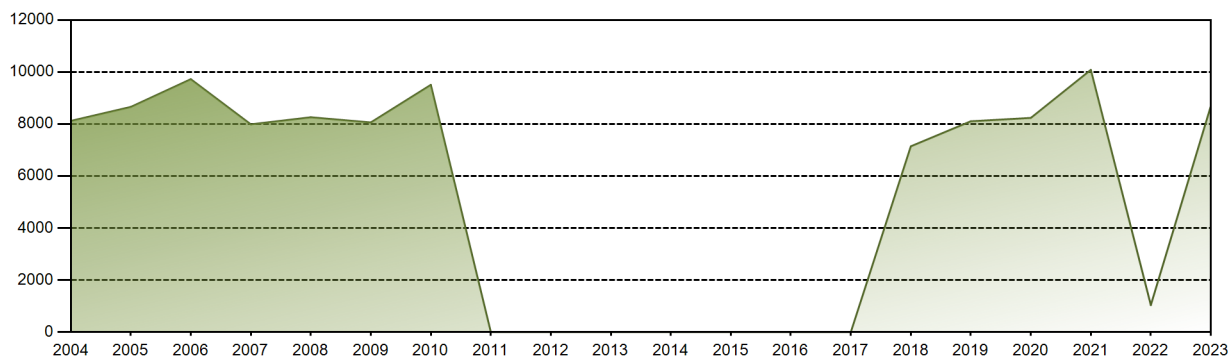


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 859.94 | 777.98 | 863.34 | 836.39 | 864.11 | 834.74 | 859.90 | 858.78 | 829.38 | 859.82 | 247.19 | 0.00 | 8691.55 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 29.69 | 0.00 | 85.73 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 29.69 | 0.00 | 85.73 |
| LF [%] | 102.56 | 102.72 | 102.96 | 103.07 | 103.06 | 102.87 | 102.55 | 102.42 | 102.21 | 102.54 | 30.46 | 0.00 | 88.04 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 30.14 | 0.00 | 85.76 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 70.31 | 100.00 | 14.27 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 192671.9 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.29 % |
| Cumulative Energy Availability Factor (EAF) | : 62.29 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.18 % |
| Cumulative Unit Capability Factor (UCF) | : 62.29 % | Cumulative Planned Unavailability Factor (PUF) | : 37.52 % |
| Cumulative Load Factor (LF) | : 63.31 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 62.56 % | | |

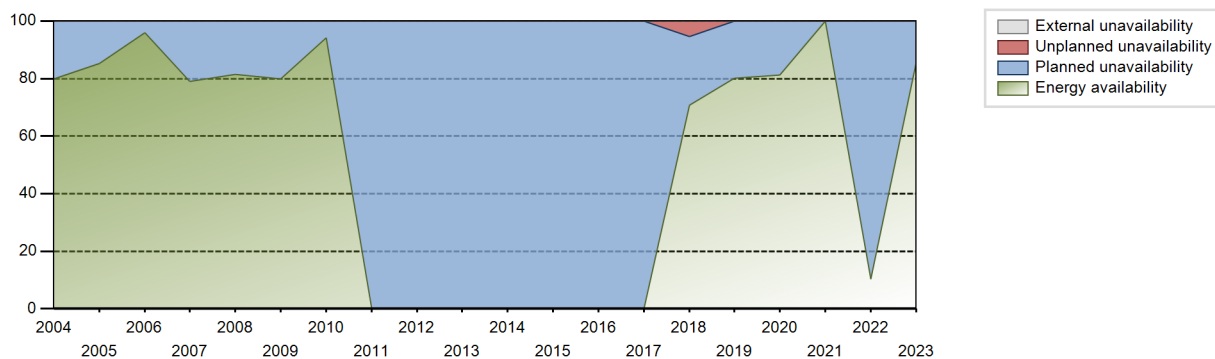
Electricity Production (net) [GWh]



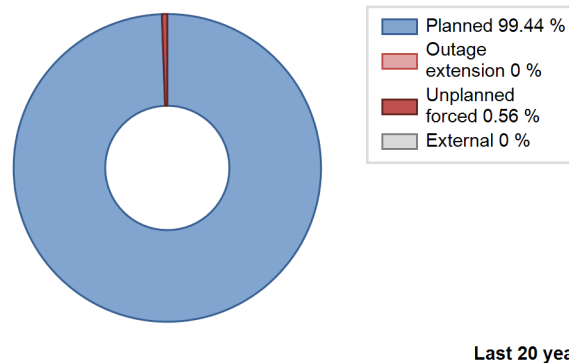
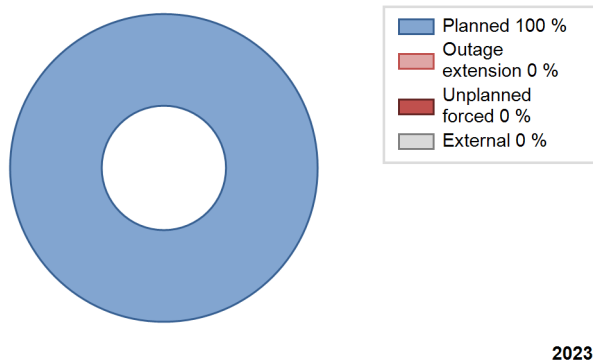
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1994 | 8795.82 | 7828 | 1127 | 96.91 | 96.91 | 97.39 | 97.00 | 0.00 | 0.00 | 3.09 | 0.00 |
| 1995 | 7356.33 | 6588 | 1127 | 74.14 | 74.14 | 74.51 | 75.21 | 0.00 | 0.00 | 25.86 | 0.00 |
| 1996 | 7444.90 | 6663 | 1127 | 74.86 | 74.86 | 75.20 | 75.85 | 0.00 | 0.00 | 25.14 | 0.00 |
| 1997 | 8259.94 | 7358 | 1127 | 83.29 | 83.29 | 83.67 | 84.00 | 0.00 | 0.00 | 16.71 | 0.00 |
| 1998 | 9633.13 | 8514 | 1127 | 97.14 | 97.14 | 97.58 | 97.19 | 0.00 | 0.00 | 2.86 | 0.00 |
| 1999 | 7999.83 | 7068 | 1127 | 80.67 | 80.67 | 81.03 | 80.68 | 0.00 | 0.00 | 19.33 | 0.00 |
| 2000 | 8109.74 | 7164 | 1127 | 81.55 | 81.55 | 81.92 | 81.56 | 0.00 | 0.00 | 18.45 | 0.00 |
| 2001 | 8205.05 | 7249 | 1127 | 82.74 | 82.74 | 83.11 | 82.75 | 0.00 | 0.00 | 17.26 | 0.00 |
| 2002 | 9561.54 | 8446 | 1127 | 96.40 | 96.40 | 96.85 | 96.42 | 0.00 | 0.00 | 3.60 | 0.00 |
| 2003 | 8667.78 | 7497 | 1127 | 85.59 | 85.59 | 87.80 | 85.58 | 0.00 | 0.00 | 14.41 | 0.00 |
| 2004 | 8121.12 | 7015 | 1127 | 79.87 | 79.87 | 82.04 | 79.86 | 0.00 | 0.00 | 20.13 | 0.00 |
| 2005 | 8658.87 | 7523 | 1127 | 85.32 | 85.32 | 87.71 | 85.88 | 0.00 | 0.00 | 14.68 | 0.00 |
| 2006 | 9725.17 | 8401 | 1127 | 95.86 | 95.86 | 98.51 | 95.90 | 0.00 | 0.00 | 4.14 | 0.00 |
| 2007 | 7988.29 | 6987 | 1127 | 79.11 | 79.11 | 80.91 | 79.76 | 0.00 | 0.00 | 20.89 | 0.00 |
| 2008 | 8259.64 | 7211 | 1127 | 81.57 | 81.57 | 83.43 | 82.09 | 0.00 | 0.00 | 18.43 | 0.00 |
| 2009 | 8061.86 | 7043 | 1127 | 79.87 | 79.87 | 81.66 | 80.40 | 0.00 | 0.00 | 20.13 | 0.00 |
| 2010 | 9506.52 | 8257 | 1127 | 94.22 | 94.22 | 96.29 | 94.26 | 0.00 | 0.00 | 5.78 | 0.00 |
| 2011 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2012 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2013 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2014 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2015 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2016 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2017 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2018 | 7143.28 | 6313 | 1127 | 70.82 | 70.82 | 72.36 | 72.07 | 7.13 | 5.44 | 23.74 | 0.00 |
| 2019 | 8106.36 | 7067 | 1127 | 80.14 | 80.14 | 82.11 | 80.67 | 0.00 | 0.00 | 19.86 | 0.00 |
| 2020 | 8236.08 | 7187 | 1127 | 81.29 | 81.29 | 83.20 | 81.82 | 0.00 | 0.00 | 18.71 | 0.00 |
| 2021 | 10083.48 | 8760 | 1127 | 100.00 | 100.00 | 102.14 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 1036.79 | 946 | 1127 | 10.34 | 10.34 | 10.50 | 10.80 | 0.00 | 0.00 | 89.66 | 0.00 |
| 2023 | 8691.55 | 7513 | 1127 | 85.73 | 85.73 | 88.04 | 85.76 | 0.00 | 0.00 | 14.27 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1994 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 15 | |
| C. Inspection, maintenance or repair combined with refuelling | 1247 | | | 1219 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 2052 | | |
| Subtotal | 1247 | | | 3271 | 15 | |
| Total | | 1247 | | | 3286 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1994 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 32. Feedwater and Main Steam System | | 15 |
| Total | | 15 |

2023 Operating Experience

JP-46

GENKAI-4

JAPAN

Status at end of year : **Operational**
 Operator : KYUSHU (Kyushu Electric Power Co., Inc.)
 Owner : KYUSHU (Kyushu Electric Power Co., Inc.)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / M (4-loop) | Construction Date | : 1992-07-15 |
| Thermal power | : 3423 MWth | Grid Date | : 1996-11-12 |
| Gross electrical power | : 1180 MWe | Commercial Date | : 1997-07-25 |
| Reference unit power (net) | : 1127 MWe | Age at end of year | : 27 years |

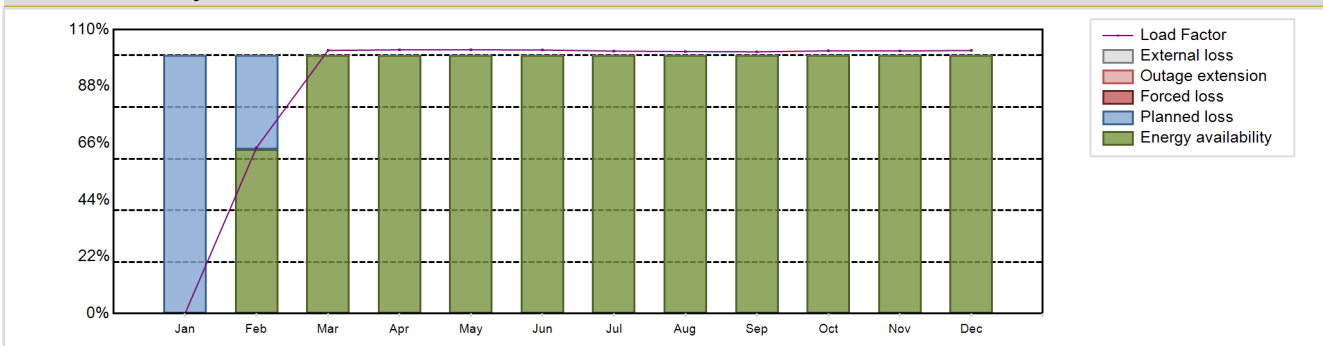
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.4 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 325 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Confinement |
| Average fuel enrichment [% of U235] | : 4.1 | Containment design pressure [MPa] | : 0.39 |
| Refuelling frequency [month] | : 13 | Secondary systems | |
| Part of the core refuelled [%] | : 46 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 44000 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 3.37 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 5.76 |
| Number of fissile fuel assemblies/bundles | : 193 | Output voltage [kV] | : 24 |
| Fuel linear heat generation rate [kW/m] | : 17.9 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 53 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 4 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : DS |

Annual Production Results (2023)

| | | | |
|--|-------------------|--|-------------|
| Net Energy Production | : 8916.52 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 88.72 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 88.72 % | Planned Unavailability Factor (PUF) | : 11.28 % |
| Load Factor (LF) | : 90.32 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 89.14 % | Total off-line time | : 951 hours |
| Equivalent non-electrical energy generated (NEG) | : 0.81 GW(e).h | | |

Annual Summary

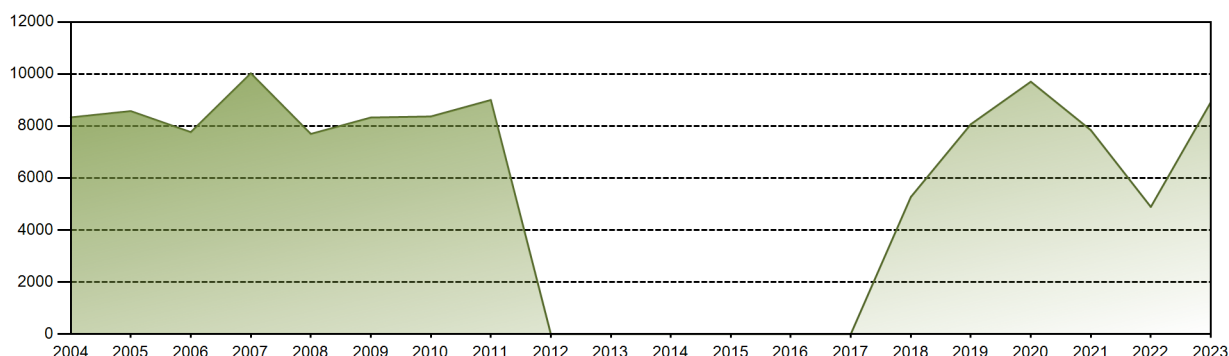


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 486.71 | 854.64 | 829.31 | 857.01 | 828.47 | 852.64 | 851.15 | 822.86 | 853.56 | 825.54 | 854.62 | 8916.51 |
| EAF [%] | 0.00 | 63.66 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.72 |
| UCF [%] | 0.00 | 63.66 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.72 |
| LF [%] | 0.00 | 64.27 | 101.93 | 102.20 | 102.21 | 102.10 | 101.69 | 101.51 | 101.41 | 101.80 | 101.74 | 101.92 | 90.32 |
| OF [%] | 0.00 | 69.20 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 89.14 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 100.00 | 36.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.28 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 170555.18 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.96 % |
| Cumulative Energy Availability Factor (EAF) | : 63.63 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.62 % |
| Cumulative Unit Capability Factor (UCF) | : 63.63 % | Cumulative Planned Unavailability Factor (PUF) | : 35.75 % |
| Cumulative Load Factor (LF) | : 64.55 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 63.91 % | | |

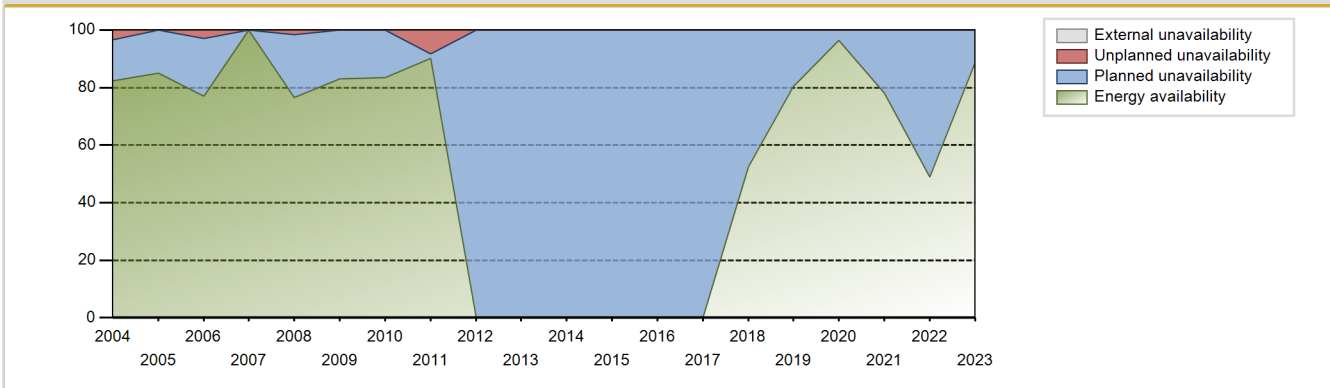
Electricity Production (net) [GWh]



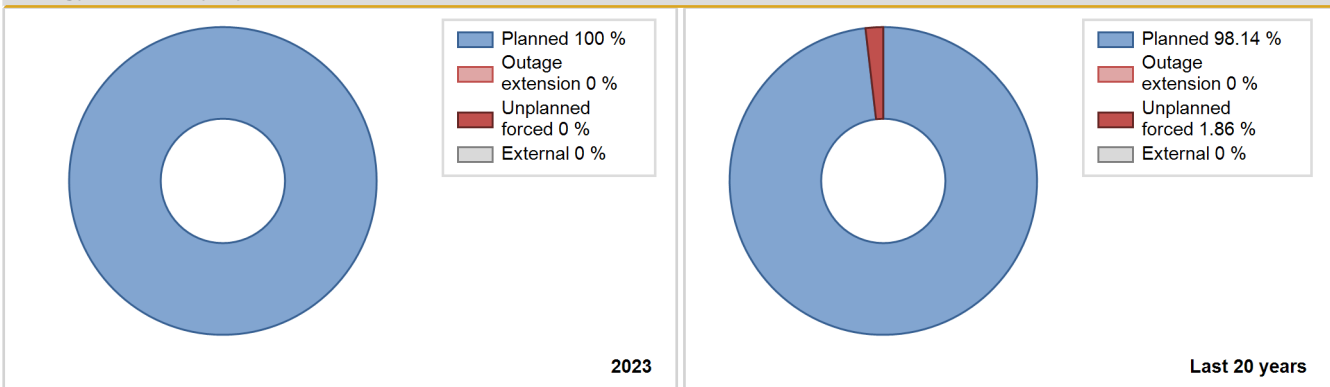
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1997 | 5841.01 | 5901 | 1127 | 99.99 | 99.99 | 100.73 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 1998 | 7634.53 | 6783 | 1127 | 76.75 | 76.75 | 77.33 | 77.43 | 0.00 | 0.00 | 23.25 | 0.00 |
| 1999 | 9716.30 | 8559 | 1127 | 97.69 | 97.69 | 98.42 | 97.71 | 0.00 | 0.00 | 2.31 | 0.00 |
| 2000 | 8181.18 | 7205 | 1127 | 82.02 | 82.02 | 82.64 | 82.02 | 0.00 | 0.00 | 17.98 | 0.00 |
| 2001 | 8107.23 | 7142 | 1127 | 81.51 | 81.51 | 82.12 | 81.53 | 0.00 | 0.00 | 18.49 | 0.00 |
| 2002 | 8208.29 | 7217 | 1127 | 82.37 | 82.37 | 83.14 | 82.39 | 0.00 | 0.00 | 17.63 | 0.00 |
| 2003 | 9678.75 | 8422 | 1127 | 96.12 | 96.12 | 98.04 | 96.14 | 0.00 | 0.00 | 3.88 | 0.00 |
| 2004 | 8330.56 | 7243 | 1127 | 82.44 | 82.44 | 84.15 | 82.46 | 4.05 | 3.48 | 14.09 | 0.00 |
| 2005 | 8572.52 | 7499 | 1127 | 85.04 | 85.04 | 86.83 | 85.61 | 0.00 | 0.00 | 14.96 | 0.00 |
| 2006 | 7765.58 | 6813 | 1127 | 76.97 | 76.97 | 78.66 | 77.77 | 3.64 | 2.91 | 20.12 | 0.00 |
| 2007 | 10025.27 | 8760 | 1127 | 100.00 | 100.00 | 101.55 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 7695.98 | 6797 | 1127 | 76.61 | 76.61 | 77.74 | 77.38 | 2.15 | 1.69 | 21.71 | 0.00 |
| 2009 | 8325.59 | 7331 | 1127 | 83.07 | 83.07 | 84.33 | 83.69 | 0.00 | 0.00 | 16.93 | 0.00 |
| 2010 | 8365.65 | 7355 | 1127 | 83.43 | 83.43 | 84.74 | 83.96 | 0.00 | 0.00 | 16.57 | 0.00 |
| 2011 | 8999.40 | 7918 | 1127 | 90.09 | 90.09 | 91.16 | 90.39 | 8.35 | 8.21 | 1.70 | 0.00 |
| 2012 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2013 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2014 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2015 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2016 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2017 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2018 | 5269.18 | 4706 | 1127 | 52.56 | 52.56 | 53.37 | 53.72 | 0.00 | 0.00 | 47.44 | 0.00 |
| 2019 | 8067.74 | 7091 | 1127 | 80.41 | 80.41 | 81.72 | 80.95 | 0.00 | 0.00 | 19.59 | 0.00 |
| 2020 | 9703.45 | 8473 | 1127 | 96.42 | 96.42 | 98.02 | 96.46 | 0.00 | 0.00 | 3.58 | 0.00 |
| 2021 | 7840.45 | 6897 | 1127 | 78.22 | 78.22 | 79.42 | 78.73 | 0.00 | 0.00 | 21.78 | 0.00 |
| 2022 | 4888.76 | 4319 | 1127 | 48.81 | 48.81 | 49.52 | 49.30 | 0.00 | 0.00 | 51.19 | 0.00 |
| 2023 | 8916.51 | 7809 | 1127 | 88.72 | 88.72 | 90.32 | 89.14 | 0.00 | 0.00 | 11.28 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1997 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 52 | |
| C. Inspection, maintenance or repair combined with refuelling | 951 | | | 1087 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 2079 | | |
| Subtotal | 951 | | | 3166 | 52 | |
| Total | | 951 | | | 3218 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1997 to 2023 |
|-----------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 15. Reactor Cooling Systems | | 9 |
| 31. Turbine and auxiliaries | | 27 |
| 41. Main Generator Systems | | 17 |
| Total | | 53 |

2023 Operating Experience

JP-47

IKATA-3

JAPAN

Status at end of year : **Operational**
 Operator : SHIKOKU (SHIKOKU ELECTRIC POWER CO., INC)
 Owner : SHIKOKU (SHIKOKU ELECTRIC POWER CO., INC)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / M (3-loop) | Construction Date | : 1990-10-01 |
| Thermal power | : 2660 MWth | Grid Date | : 1994-03-29 |
| Gross electrical power | : 890 MWe | Commercial Date | : 1994-12-15 |
| Reference unit power (net) | : 846 MWe | Age at end of year | : 29 years |

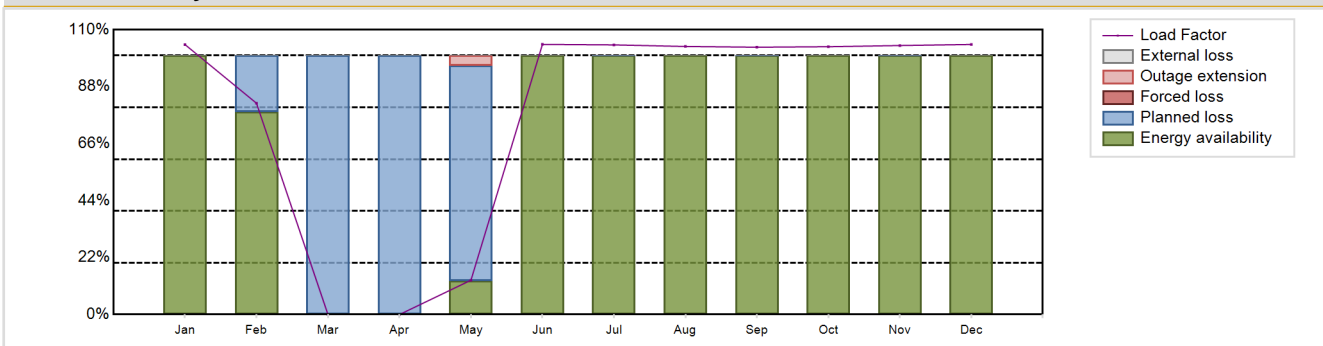
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.4 |
| Fuel material | : UO2/MOX | Reactor outlet temperature [°C] | : 321 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : 4.8 | Containment design pressure [MPa] | : 0.283 |
| Refuelling frequency [month] | : 13 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 48000 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : 2 |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 5.1 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : 23 |
| Fuel linear heat generation rate [kW/m] | : 17.1 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 48 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 4 |
| | | Non-electrical applications | : DS / DS |

Annual Production Results (2023)

| | | | |
|--|-------------------|--|--------------|
| Net Energy Production | : 5715.39 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 74.24 % | Unplanned Capability Loss Factor (UCL) | : 0.33 % |
| Unit Capability Factor (UCF) | : 74.24 % | Planned Unavailability Factor (PUF) | : 25.43 % |
| Load Factor (LF) | : 77.12 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 74.53 % | Total off-line time | : 2231 hours |
| Equivalent non-electrical energy generated (NEG) | : 1.57 GW(e).h | | |

Annual Summary

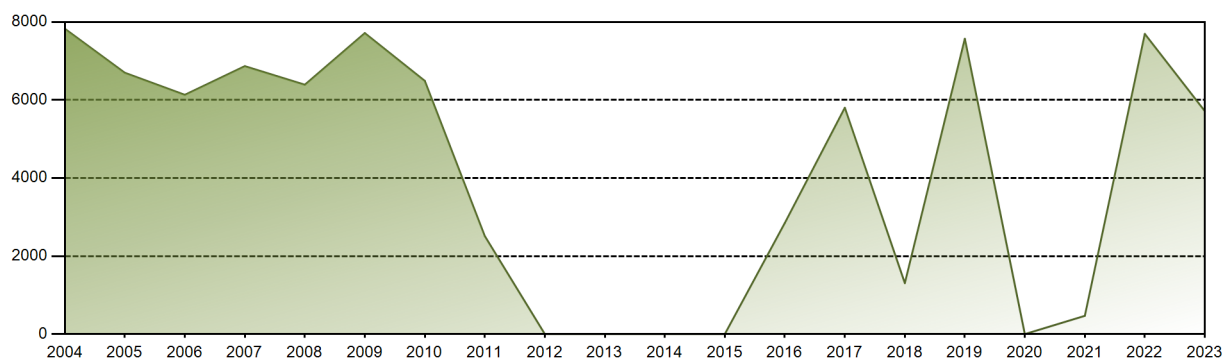


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 656.22 | 463.99 | 0.00 | 0.00 | 83.38 | 635.49 | 655.42 | 651.62 | 628.83 | 651.09 | 632.78 | 656.56 | 5715.39 |
| EAF [%] | 100.00 | 78.32 | 0.00 | 0.00 | 13.08 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 74.24 |
| UCF [%] | 100.00 | 78.32 | 0.00 | 0.00 | 13.08 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 74.24 |
| LF [%] | 104.26 | 81.61 | 0.00 | 0.00 | 13.25 | 104.33 | 104.13 | 103.53 | 103.24 | 103.44 | 103.88 | 104.31 | 77.12 |
| OF [%] | 100.00 | 78.57 | 0.00 | 0.00 | 16.26 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 74.53 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 3.83 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 |
| PUF [%] | 0.00 | 21.68 | 100.00 | 100.00 | 83.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.43 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

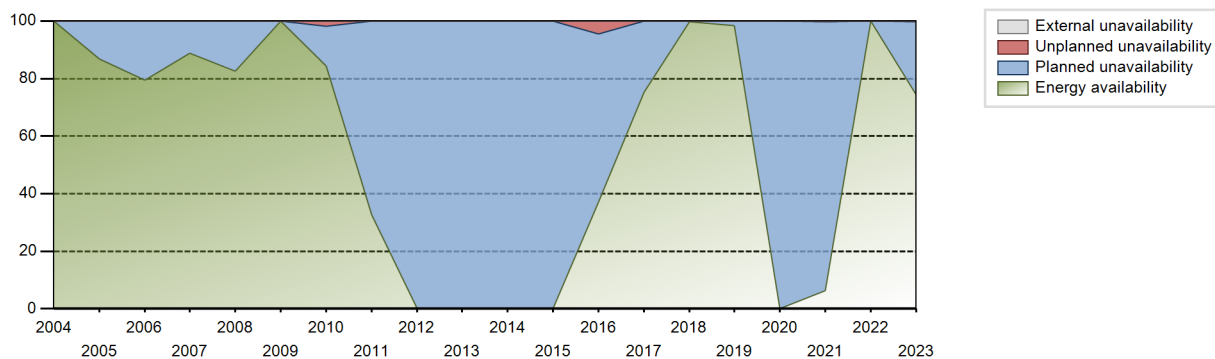
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 139484.58 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.72 % |
| Cumulative Energy Availability Factor (EAF) | : 65.66 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.7 % |
| Cumulative Unit Capability Factor (UCF) | : 65.66 % | Cumulative Planned Unavailability Factor (PUF) | : 33.63 % |
| Cumulative Load Factor (LF) | : 64.8 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 63.04 % | | |

Electricity Production (net) [GWh]

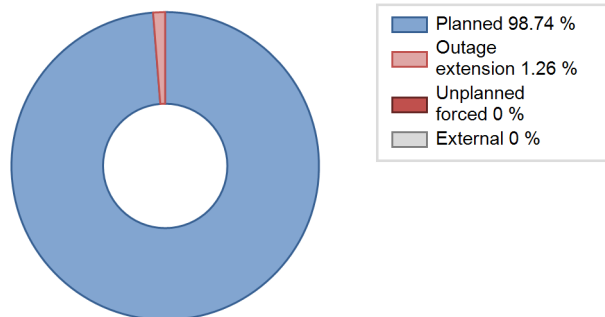


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1994 | 2195.52 | 3669 | 846 | 100.00 | 100.00 | 101.17 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1995 | 7491.81 | 8760 | 846 | 99.99 | 99.99 | 101.09 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 1996 | 5578.21 | 6621 | 846 | 74.23 | 74.23 | 75.06 | 75.38 | 0.00 | 0.00 | 25.76 | 0.00 |
| 1997 | 6134.74 | 7242 | 846 | 81.87 | 81.87 | 82.78 | 82.67 | 0.00 | 0.00 | 18.13 | 0.00 |
| 1998 | 6250.38 | 7374 | 846 | 83.43 | 83.43 | 84.34 | 84.18 | 0.00 | 0.00 | 16.57 | 0.00 |
| 1999 | 6298.35 | 7368 | 846 | 84.09 | 84.09 | 84.99 | 84.11 | 3.16 | 2.74 | 13.17 | 0.00 |
| 2000 | 6660.35 | 7790 | 846 | 88.68 | 88.68 | 89.63 | 88.68 | 10.78 | 10.71 | 0.61 | 0.00 |
| 2001 | 6210.74 | 7267 | 846 | 82.94 | 82.94 | 83.80 | 82.96 | 0.00 | 0.00 | 17.06 | 0.00 |
| 2002 | 6599.51 | 7518 | 846 | 85.82 | 85.82 | 89.05 | 85.82 | 0.00 | 0.00 | 14.18 | 0.00 |
| 2003 | 5862.10 | 6560 | 846 | 74.86 | 74.86 | 79.10 | 74.89 | 0.00 | 0.00 | 25.14 | 0.00 |
| 2004 | 7828.92 | 8784 | 846 | 100.00 | 100.00 | 105.35 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 6699.37 | 7637 | 846 | 86.84 | 86.84 | 90.40 | 87.18 | 0.00 | 0.00 | 13.16 | 0.00 |
| 2006 | 6134.56 | 6990 | 846 | 79.53 | 79.53 | 82.78 | 79.79 | 0.00 | 0.00 | 20.47 | 0.00 |
| 2007 | 6869.33 | 7813 | 846 | 88.88 | 88.88 | 92.69 | 89.19 | 0.00 | 0.00 | 11.12 | 0.00 |
| 2008 | 6392.97 | 7282 | 846 | 82.57 | 82.57 | 86.03 | 82.90 | 0.00 | 0.00 | 17.43 | 0.00 |
| 2009 | 7716.65 | 8760 | 846 | 99.96 | 99.96 | 104.12 | 100.00 | 0.04 | 0.04 | 0.00 | 0.00 |
| 2010 | 6490.71 | 7410 | 846 | 84.34 | 84.34 | 87.58 | 84.59 | 0.00 | 1.71 | 13.95 | 0.00 |
| 2011 | 2511.01 | 2852 | 846 | 32.58 | 32.58 | 33.88 | 32.56 | 0.00 | 0.00 | 67.42 | 0.00 |
| 2012 | 0.00 | 0 | 846 | 0.06 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 99.94 | 0.00 |
| 2013 | 0.00 | 0 | 846 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2014 | 0.00 | 0 | 846 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2015 | 0.00 | 0 | 846 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2016 | 2848.03 | 3322 | 846 | 37.02 | 37.02 | 38.32 | 37.82 | 0.00 | 4.53 | 58.45 | 0.00 |
| 2017 | 5802.18 | 6600 | 846 | 75.32 | 75.32 | 78.29 | 75.34 | 0.00 | 0.00 | 24.68 | 0.00 |
| 2018 | 1306.34 | 1511 | 846 | 99.72 | 99.72 | 17.63 | 17.25 | 0.00 | 0.00 | 0.28 | 0.00 |
| 2019 | 7570.95 | 8616 | 846 | 98.34 | 98.34 | 102.16 | 98.36 | 0.00 | 0.00 | 1.66 | 0.00 |
| 2020 | 0.00 | 0 | 846 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2021 | 468.08 | 606 | 846 | 6.29 | 6.29 | 6.32 | 6.92 | 5.33 | 0.35 | 93.36 | 0.00 |
| 2022 | 7695.11 | 8760 | 846 | 99.99 | 99.99 | 103.83 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2023 | 5715.39 | 6529 | 846 | 74.24 | 74.24 | 77.12 | 74.53 | 0.00 | 0.33 | 25.43 | 0.00 |

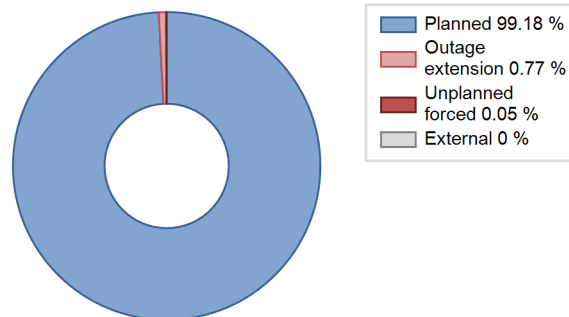
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1994 to 2023 | | |
|--|-------------|-------------|----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 5 | | | 42 | |
| C. Inspection, maintenance or repair combined with refuelling | 2203 | | | 1452 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 1594 | | |
| L. Human factor related | | 24 | | | 1 | |
| M. Governmental requirements or court decisions | | | | | | 259 |
| Z. Other | | | | | 20 | |
| Subtotal | 2203 | 29 | | 3046 | 63 | 259 |
| Total | | 2232 | | | 3368 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1994 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 13. Reactor Auxiliary Systems | 24 | 1 |
| 15. Reactor Cooling Systems | | 14 |
| 41. Main Generator Systems | 5 | 9 |
| 42. Electrical Power Supply Systems | | 34 |
| Total | 29 | 58 |

Highlights (2023)

Operation at full power in base load mode
 Conduct the 16th periodical inspection of Ikata Unit 3

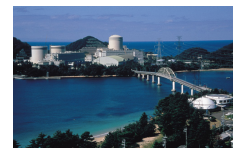
2023 Operating Experience

JP-14

MIHAMA-3

JAPAN

Status at end of year : **Operational**
 Operator : KEPCO (Kansai Electric Power Co.)
 Owner : KEPCO (Kansai Electric Power Co.)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / M (3-loop) | Construction Date | : 1972-08-07 |
| Thermal power | : 2440 MWth | Grid Date | : 1976-02-19 |
| Gross electrical power | : 826 MWe | Commercial Date | : 1976-12-01 |
| Reference unit power (net) | : 780 MWe | Age at end of year | : 47 years |

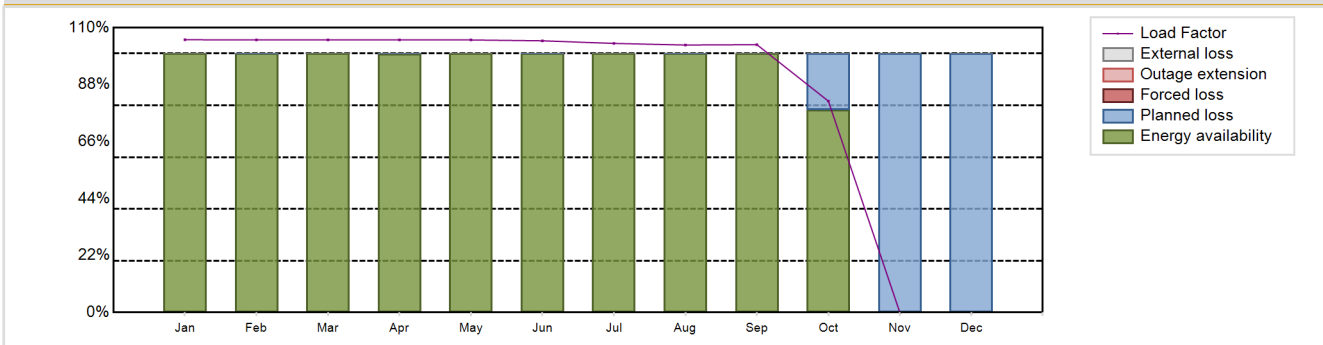
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 323 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Confinement |
| Average fuel enrichment [% of U235] | : 4.0 | Containment design pressure [MPa] | : 0.24 |
| Refuelling frequency [month] | : 13 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 43000 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 3.64 | HP cylinder inlet steam pressure [MPa] | : 5.8 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : 22 |
| Fuel linear heat generation rate [kW/m] | : 20.3 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 48 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 5823.48 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 81.44 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 81.44 % | Planned Unavailability Factor (PUF) | : 18.56 % |
| Load Factor (LF) | : 85.23 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 81.5 % | Total off-line time | : 1621 hours |

Annual Summary

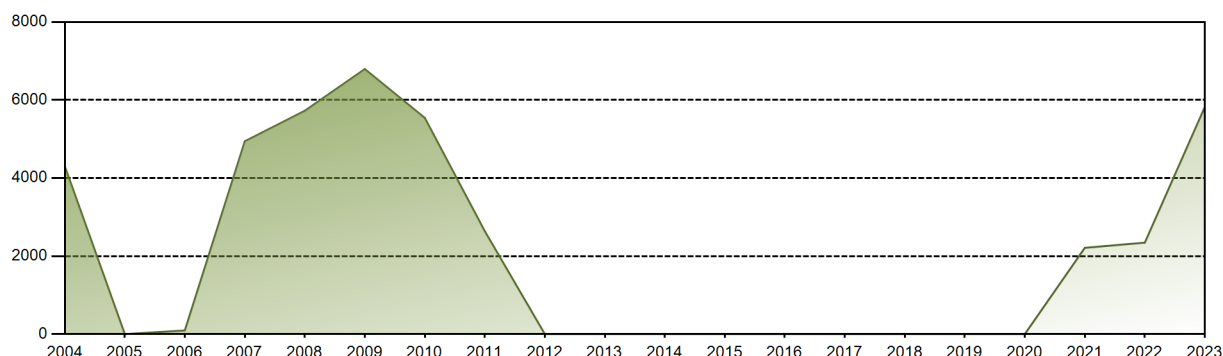


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 611.33 | 551.85 | 611.10 | 591.36 | 610.87 | 589.38 | 603.16 | 599.57 | 581.02 | 473.84 | 0.00 | 0.00 | 5823.48 |
| EAF [%] | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 78.30 | 0.00 | 0.00 | 81.44 |
| UCF [%] | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 78.30 | 0.00 | 0.00 | 81.44 |
| LF [%] | 105.34 | 105.28 | 105.30 | 105.30 | 105.26 | 104.95 | 103.94 | 103.32 | 103.46 | 81.65 | 0.00 | 0.00 | 85.23 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 78.90 | 0.00 | 0.00 | 81.50 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 21.70 | 100.00 | 100.00 | 18.56 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 179228.41 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.79 % |
| Cumulative Energy Availability Factor (EAF) | : 54.98 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.37 % |
| Cumulative Unit Capability Factor (UCF) | : 54.99 % | Cumulative Planned Unavailability Factor (PUF) | : 43.64 % |
| Cumulative Load Factor (LF) | : 55.67 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 55.7 % | | |

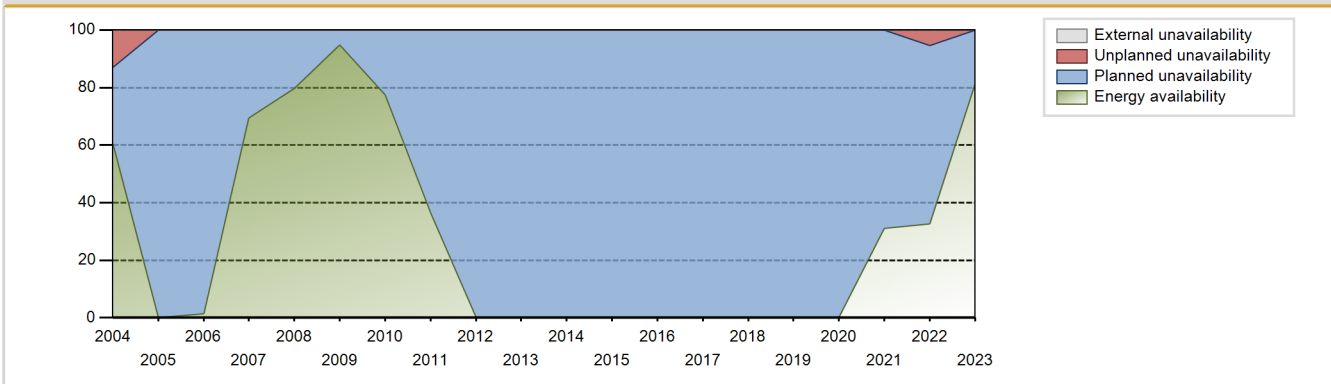
Electricity Production (net) [GWh]



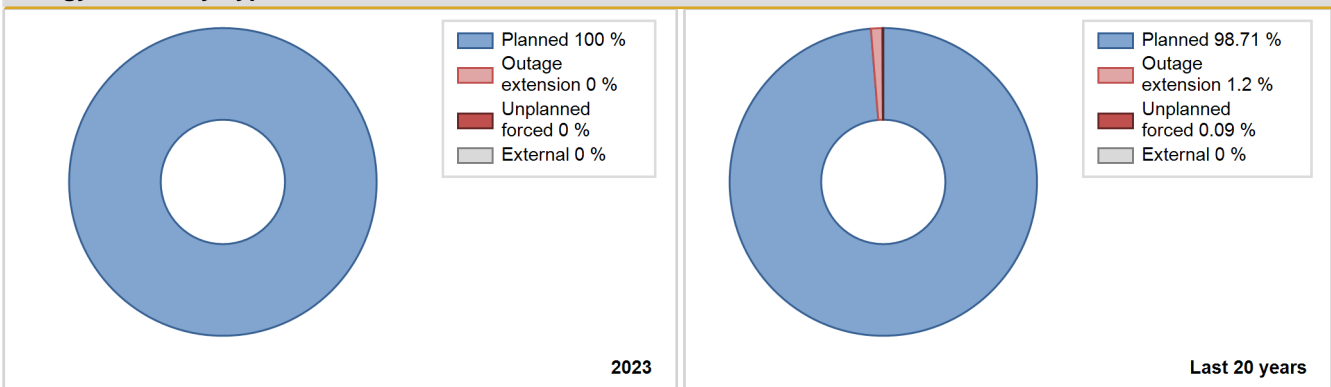
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1976 | 2615.00 | 5285 | 780 | 85.10 | 85.10 | 85.06 | 100.00 | 0.00 | 0.00 | 14.90 | 0.00 |
| 1977 | 4498.50 | 6159 | 780 | 65.85 | 65.85 | 65.84 | 70.31 | 1.27 | 0.85 | 33.31 | 0.00 |
| 1978 | 4166.60 | 5537 | 780 | 59.52 | 59.52 | 60.98 | 63.21 | 0.00 | 0.00 | 40.48 | 0.00 |
| 1979 | 1697.40 | 2307 | 780 | 24.85 | 24.85 | 24.84 | 26.34 | 0.00 | 0.00 | 75.15 | 0.00 |
| 1980 | 4597.70 | 5964 | 780 | 67.00 | 67.00 | 67.10 | 67.90 | 1.17 | 0.79 | 32.21 | 0.00 |
| 1981 | 5832.90 | 7607 | 780 | 85.16 | 85.16 | 85.37 | 86.84 | 0.33 | 0.28 | 14.55 | 0.00 |
| 1982 | 5239.10 | 6952 | 780 | 76.38 | 76.38 | 76.68 | 79.36 | 0.00 | 0.00 | 23.62 | 0.00 |
| 1983 | 4818.00 | 6330 | 780 | 70.63 | 70.63 | 70.51 | 72.26 | 0.00 | 0.00 | 29.37 | 0.00 |
| 1984 | 5353.73 | 6906 | 780 | 77.82 | 77.82 | 78.14 | 78.62 | 0.00 | 0.00 | 22.18 | 0.00 |
| 1985 | 4971.94 | 6426 | 780 | 72.65 | 72.65 | 72.77 | 73.36 | 0.00 | 0.00 | 27.35 | 0.00 |
| 1986 | 6848.35 | 8760 | 780 | 99.78 | 99.78 | 100.23 | 100.00 | 0.00 | 0.00 | 0.22 | 0.00 |
| 1987 | 4822.71 | 6268 | 780 | 71.55 | 71.55 | 70.58 | 71.55 | 3.89 | 2.90 | 25.55 | 0.00 |
| 1988 | 4261.32 | 5625 | 780 | 64.04 | 64.04 | 62.20 | 64.04 | 5.10 | 3.44 | 32.53 | 0.00 |
| 1989 | 5299.69 | 6834 | 780 | 78.01 | 78.01 | 77.56 | 78.01 | 0.00 | 0.00 | 21.99 | 0.00 |
| 1990 | 6867.04 | 8760 | 780 | 99.98 | 99.98 | 100.50 | 100.00 | 0.00 | 0.00 | 0.02 | 0.00 |
| 1991 | 4246.18 | 5495 | 780 | 59.68 | 59.68 | 62.14 | 62.73 | 0.00 | 0.00 | 40.32 | 0.00 |
| 1992 | 4709.88 | 6095 | 780 | 68.54 | 68.54 | 68.74 | 69.39 | 0.00 | 0.00 | 31.46 | 0.00 |
| 1993 | 4526.62 | 5951 | 780 | 66.11 | 66.42 | 66.25 | 67.93 | 0.74 | 0.50 | 33.08 | 0.31 |
| 1994 | 6623.04 | 8486 | 780 | 96.81 | 96.83 | 96.93 | 96.87 | 1.78 | 1.76 | 1.42 | 0.01 |
| 1995 | 3389.17 | 4534 | 780 | 49.61 | 49.74 | 49.60 | 51.76 | 21.69 | 13.77 | 36.49 | 0.13 |
| 1996 | 4491.42 | 5760 | 780 | 65.30 | 65.50 | 65.55 | 65.57 | 0.00 | 0.00 | 34.50 | 0.19 |
| 1997 | 6262.81 | 7963 | 780 | 91.24 | 91.24 | 91.66 | 90.90 | 0.00 | 0.00 | 8.76 | 0.00 |
| 1998 | 5979.86 | 7788 | 780 | 87.10 | 87.10 | 87.52 | 88.90 | 1.39 | 1.23 | 11.66 | 0.00 |
| 1999 | 5795.30 | 7398 | 780 | 84.44 | 84.44 | 84.82 | 84.45 | 3.45 | 3.01 | 12.54 | 0.00 |
| 2000 | 4784.98 | 6117 | 780 | 69.60 | 69.61 | 69.84 | 69.64 | 15.88 | 13.15 | 17.25 | 0.00 |
| 2001 | 6853.68 | 8760 | 780 | 99.96 | 99.99 | 100.31 | 100.00 | 0.00 | 0.00 | 0.01 | 0.03 |
| 2002 | 5248.01 | 6732 | 780 | 76.84 | 76.84 | 76.81 | 76.85 | 5.19 | 4.21 | 18.95 | 0.00 |
| 2003 | 6111.49 | 7701 | 780 | 87.91 | 87.91 | 89.44 | 87.91 | 0.00 | 0.00 | 12.09 | 0.00 |
| 2004 | 4301.26 | 5319 | 780 | 60.48 | 60.48 | 62.78 | 60.55 | 2.06 | 13.02 | 26.50 | 0.00 |
| 2005 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2006 | 92.08 | 181 | 780 | 1.35 | 1.35 | 1.35 | 2.07 | 0.00 | 0.00 | 98.65 | 0.00 |
| 2007 | 4943.91 | 6190 | 780 | 69.45 | 69.45 | 72.36 | 70.66 | 0.00 | 0.00 | 30.55 | 0.00 |
| 2008 | 5725.55 | 7049 | 780 | 79.72 | 79.72 | 83.57 | 80.25 | 0.00 | 0.00 | 20.28 | 0.00 |
| 2009 | 6795.53 | 8315 | 780 | 94.86 | 94.86 | 99.45 | 94.92 | 0.00 | 0.00 | 5.14 | 0.00 |
| 2010 | 5541.00 | 6823 | 780 | 77.39 | 77.39 | 81.09 | 77.89 | 0.00 | 0.00 | 22.61 | 0.00 |
| 2011 | 2637.14 | 3203 | 780 | 36.51 | 36.51 | 38.60 | 36.56 | 0.00 | 0.00 | 63.49 | 0.00 |
| 2012 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|--------|------|
| 2013 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2014 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2015 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2016 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2017 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2018 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2019 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2020 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2021 | 2211.25 | 2804 | 780 | 31.12 | 31.12 | 32.36 | 32.01 | 0.00 | 0.00 | 68.88 | 0.00 |
| 2022 | 2343.68 | 2908 | 780 | 32.70 | 32.70 | 34.30 | 33.20 | 0.00 | 5.48 | 61.82 | 0.00 |
| 2023 | 5823.48 | 7139 | 780 | 81.44 | 81.44 | 85.23 | 81.50 | 0.00 | 0.00 | 18.56 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1976 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 103 | |
| C. Inspection, maintenance or repair combined with refuelling | 1621 | | | 2012 | | |
| E. Testing of plant systems or components | | | | 0 | 3 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 1764 | | |
| L. Human factor related | | | | | 6 | |
| Subtotal | 1621 | | | 3776 | 112 | |
| Total | | 1621 | | | 3888 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1976 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 23 |
| 13. Reactor Auxiliary Systems | | 10 |
| 15. Reactor Cooling Systems | | 8 |
| 16. Steam generation systems | | 23 |
| 32. Feedwater and Main Steam System | | 43 |
| 34. Miscellaneous Systems | | 3 |
| Total | | 110 |

2023 Operating Experience

JP-50

OHI-3

JAPAN

Status at end of year : **Operational**
 Operator : KEPCO (Kansai Electric Power Co.)
 Owner : KEPCO (Kansai Electric Power Co.)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / M (4-loop) | Construction Date | : 1987-10-03 |
| Thermal power | : 3423 MWth | Grid Date | : 1991-06-07 |
| Gross electrical power | : 1180 MWe | Commercial Date | : 1991-12-18 |
| Reference unit power (net) | : 1127 MWe | Age at end of year | : 32 years |

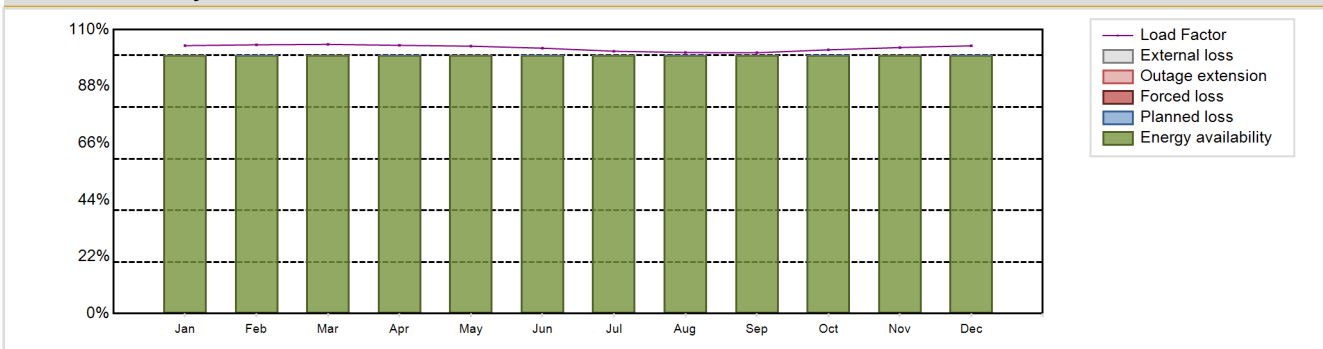
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 325 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Confinement |
| Average fuel enrichment [% of U235] | : 4.1 | Containment design pressure [MPa] | : 0.4 |
| Refuelling frequency [month] | : 13 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 44000 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 3.37 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Number of fissile fuel assemblies/bundles | : 193 | Output voltage [kV] | : 24 |
| Fuel linear heat generation rate [kW/m] | : 17.9 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 53 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 4 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : DS |

Annual Production Results (2023)

| | | | |
|--|--------------------|--|-----------|
| Net Energy Production | : 10162.58 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 100 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 100 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 102.94 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |
| Equivalent non-electrical energy generated (NEG) | : 16.83 GW(e).h | | |

Annual Summary

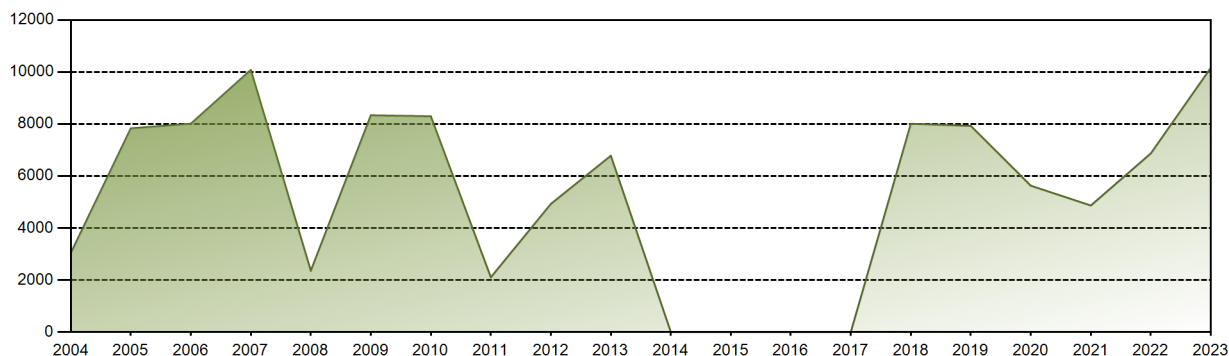


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 870.37 | 788.49 | 874.43 | 843.27 | 868.57 | 834.25 | 852.24 | 848.02 | 819.93 | 856.82 | 836.37 | 869.80 | 10162.58 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| LF [%] | 103.80 | 104.11 | 104.29 | 103.92 | 103.59 | 102.81 | 101.64 | 101.14 | 101.05 | 102.19 | 103.07 | 103.73 | 102.94 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 211335.37 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.82 % |
| Cumulative Energy Availability Factor (EAF) | : 65.73 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.22 % |
| Cumulative Unit Capability Factor (UCF) | : 65.75 % | Cumulative Planned Unavailability Factor (PUF) | : 30.03 % |
| Cumulative Load Factor (LF) | : 66.71 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 66.03 % | | |

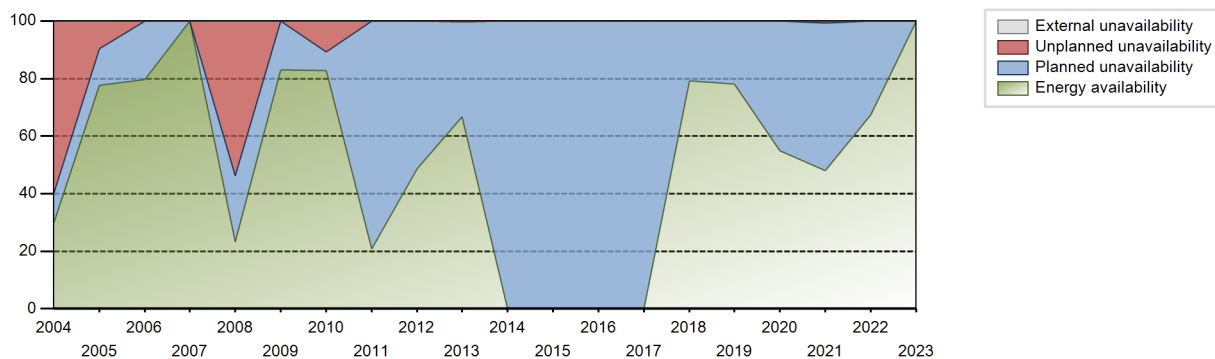
Electricity Production (net) [GWh]



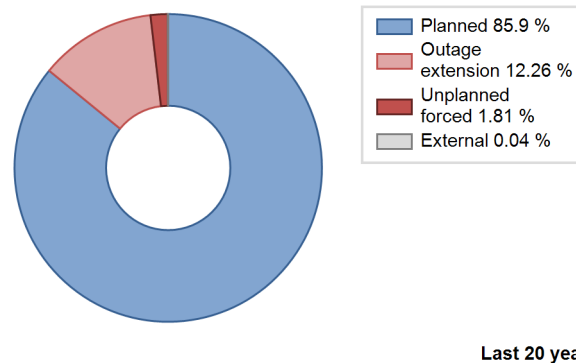
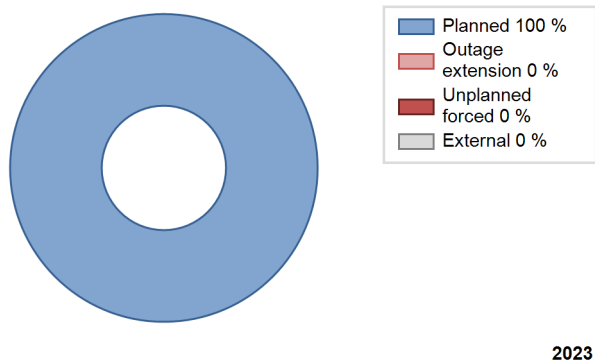
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1991 | 2524.41 | 3228 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1992 | 9954.69 | 8784 | 1127 | 99.98 | 99.98 | 100.56 | 100.00 | 0.00 | 0.00 | 0.02 | 0.00 |
| 1993 | 7863.69 | 7025 | 1127 | 79.43 | 79.43 | 79.65 | 80.19 | 0.00 | 0.00 | 20.57 | 0.00 |
| 1994 | 8139.08 | 7265 | 1127 | 82.53 | 82.53 | 82.44 | 82.93 | 0.00 | 0.00 | 17.47 | 0.00 |
| 1995 | 7701.72 | 6887 | 1127 | 77.82 | 77.82 | 78.01 | 78.62 | 0.00 | 0.00 | 22.18 | 0.00 |
| 1996 | 9957.45 | 8784 | 1127 | 99.99 | 99.99 | 100.58 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 1997 | 8333.01 | 7385 | 1127 | 83.88 | 83.88 | 84.41 | 84.30 | 0.00 | 0.00 | 16.12 | 0.00 |
| 1998 | 8872.74 | 7867 | 1127 | 89.30 | 89.30 | 89.87 | 89.81 | 0.00 | 0.00 | 10.70 | 0.00 |
| 1999 | 8892.35 | 7875 | 1127 | 89.52 | 89.89 | 90.07 | 89.90 | 0.00 | 0.00 | 10.11 | 0.37 |
| 2000 | 8868.86 | 7824 | 1127 | 89.06 | 89.06 | 89.59 | 89.07 | 0.00 | 0.00 | 10.94 | 0.00 |
| 2001 | 8474.65 | 7481 | 1127 | 85.38 | 85.38 | 85.84 | 85.40 | 0.00 | 0.00 | 14.62 | 0.01 |
| 2002 | 9918.68 | 8760 | 1127 | 99.99 | 99.99 | 100.47 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2003 | 8683.19 | 7525 | 1127 | 85.89 | 85.89 | 87.95 | 85.90 | 0.00 | 0.00 | 14.11 | 0.00 |
| 2004 | 3040.18 | 2634 | 1127 | 30.01 | 30.01 | 30.71 | 29.99 | 0.00 | 59.84 | 10.15 | 0.00 |
| 2005 | 7834.00 | 6968 | 1127 | 77.64 | 77.64 | 79.35 | 79.54 | 7.12 | 9.73 | 12.63 | 0.00 |
| 2006 | 8012.30 | 7001 | 1127 | 79.62 | 79.62 | 81.16 | 79.92 | 0.00 | 0.00 | 20.38 | 0.00 |
| 2007 | 10080.14 | 8760 | 1127 | 99.99 | 99.99 | 102.10 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2008 | 2355.61 | 2081 | 1127 | 23.36 | 23.36 | 23.80 | 23.69 | 0.00 | 53.75 | 22.90 | 0.00 |
| 2009 | 8335.16 | 7282 | 1127 | 83.08 | 83.08 | 84.43 | 83.13 | 0.00 | 0.00 | 16.92 | 0.00 |
| 2010 | 8297.03 | 7299 | 1127 | 82.76 | 82.76 | 84.04 | 83.32 | 11.51 | 10.76 | 6.48 | 0.00 |
| 2011 | 2104.70 | 1834 | 1127 | 20.89 | 20.89 | 21.32 | 20.94 | 0.00 | 0.00 | 79.11 | 0.00 |
| 2012 | 4925.65 | 4325 | 1127 | 48.78 | 48.78 | 49.76 | 49.24 | 0.00 | 0.00 | 51.22 | 0.00 |
| 2013 | 6779.28 | 5879 | 1127 | 66.75 | 67.10 | 68.67 | 67.11 | 0.00 | 0.00 | 32.90 | 0.36 |
| 2014 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2015 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2016 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2017 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2018 | 8009.80 | 6967 | 1127 | 79.13 | 79.13 | 81.13 | 79.53 | 0.00 | 0.00 | 20.87 | 0.00 |
| 2019 | 7928.91 | 6881 | 1127 | 78.12 | 78.12 | 80.31 | 78.55 | 0.00 | 0.00 | 21.88 | 0.00 |
| 2020 | 5627.87 | 4834 | 1127 | 54.99 | 54.99 | 56.85 | 55.03 | 0.00 | 0.00 | 45.01 | 0.00 |
| 2021 | 4866.36 | 4303 | 1127 | 48.13 | 48.13 | 49.29 | 49.12 | 1.32 | 0.64 | 51.22 | 0.00 |
| 2022 | 6869.56 | 5943 | 1127 | 67.48 | 67.48 | 69.58 | 67.84 | 0.00 | 0.00 | 32.52 | 0.00 |
| 2023 | 10162.58 | 8760 | 1127 | 100.00 | 100.00 | 102.94 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1991 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 349 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1128 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 658 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 919 | | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 30 | |
| Subtotal | | | | 2705 | 379 | |
| Total | | 0 | | | 3084 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1991 to 2023 |
|-------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 210 |
| 13. Reactor Auxiliary Systems | | 17 |
| 15. Reactor Cooling Systems | | 152 |
| Total | | 379 |

2023 Operating Experience

JP-51

OHI-4

JAPAN

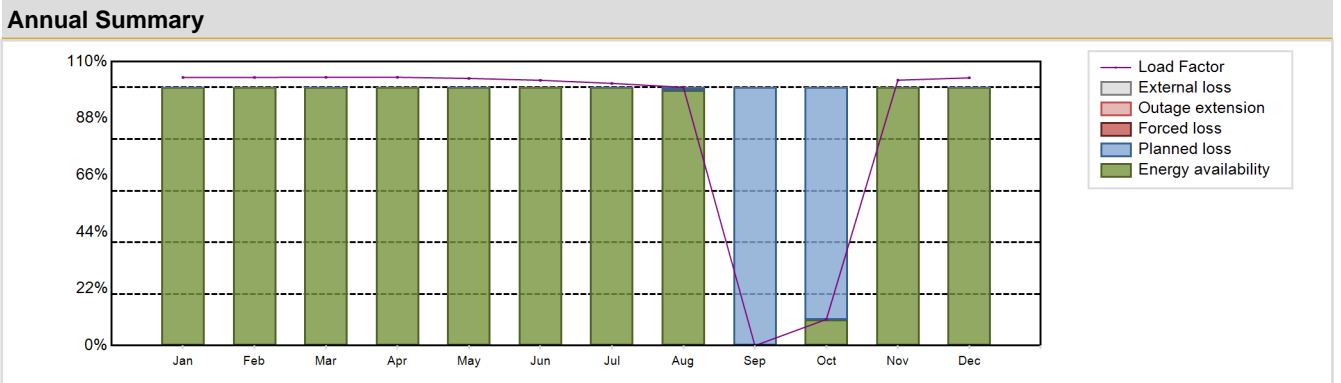
Status at end of year : **Operational**
 Operator : KEPCO (Kansai Electric Power Co.)
 Owner : KEPCO (Kansai Electric Power Co.)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / M (4-loop) | Construction Date | : 1988-06-13 |
| Thermal power | : 3423 MWth | Grid Date | : 1992-06-19 |
| Gross electrical power | : 1180 MWe | Commercial Date | : 1993-02-02 |
| Reference unit power (net) | : 1127 MWe | Age at end of year | : 31 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.7 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 325 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.4 |
| Average fuel enrichment [% of U235] | : 4.1 | Secondary systems | |
| Refuelling frequency [month] | : 13 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 44000 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.37 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : 24 |
| Number of fissile fuel assemblies/bundles | : 193 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.9 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 53 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | : DS |

| Annual Production Results (2023) | | | |
|--|-------------------|--|--------------|
| Net Energy Production | : 8554.07 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 84.06 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 84.06 % | Planned Unavailability Factor (PUF) | : 15.94 % |
| Load Factor (LF) | : 86.65 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 84.42 % | Total off-line time | : 1365 hours |
| Equivalent non-electrical energy generated (NEG) | : 0 GW(e).h | | |

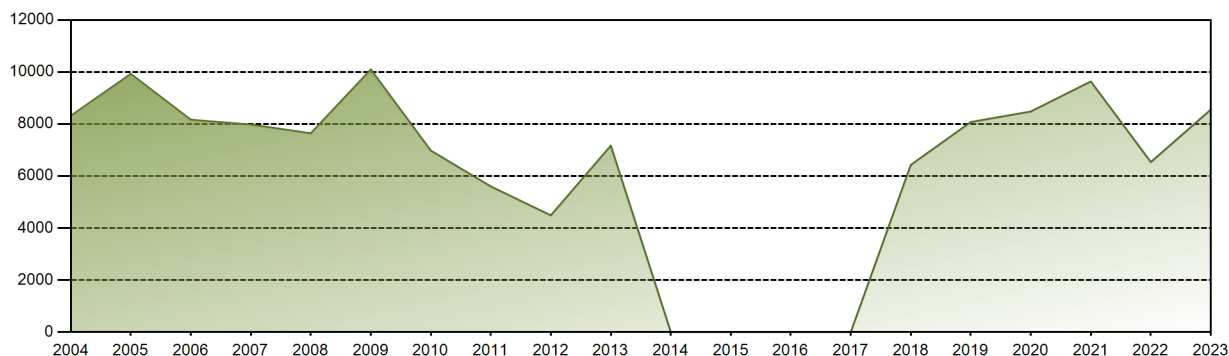


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 870.65 | 786.73 | 871.50 | 843.31 | 867.82 | 833.89 | 851.76 | 839.00 | 0.00 | 85.45 | 834.35 | 869.61 | 8554.07 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.98 | 0.00 | 10.08 | 100.00 | 100.00 | 84.06 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.98 | 0.00 | 10.08 | 100.00 | 100.00 | 84.06 |
| LF [%] | 103.84 | 103.88 | 103.94 | 103.93 | 103.50 | 102.77 | 101.58 | 100.06 | 0.00 | 10.19 | 102.82 | 103.71 | 86.65 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.46 | 0.00 | 13.84 | 100.00 | 100.00 | 84.42 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.02 | 100.00 | 89.92 | 0.00 | 0.00 | 15.94 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 216888.2 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.98 % |
| Cumulative Energy Availability Factor (EAF) | : 69.79 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.51 % |
| Cumulative Unit Capability Factor (UCF) | : 69.8 % | Cumulative Planned Unavailability Factor (PUF) | : 28.69 % |
| Cumulative Load Factor (LF) | : 71.01 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 70 % | | |

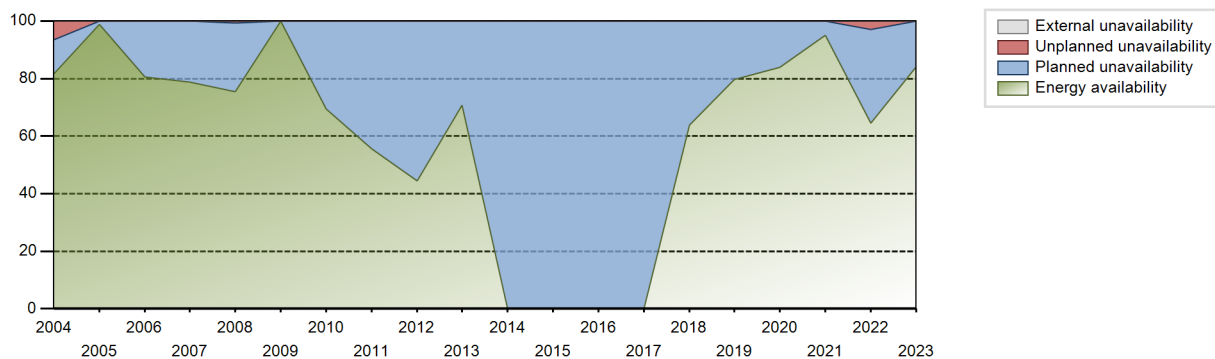
Electricity Production (net) [GWh]



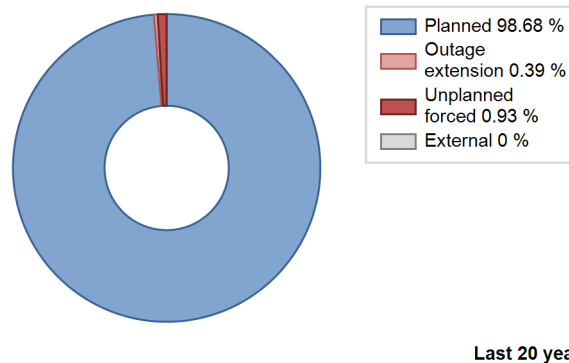
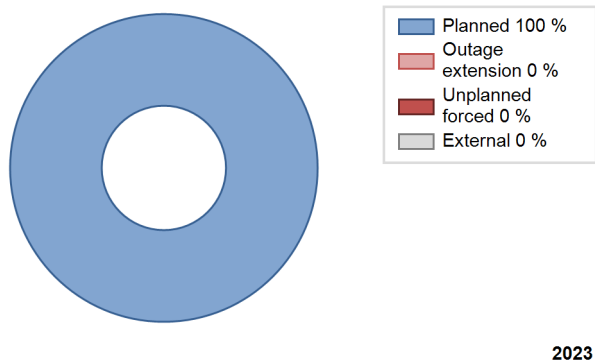
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1993 | 9923.46 | 8760 | 1127 | 99.98 | 99.98 | 100.51 | 100.00 | 0.00 | 0.00 | 0.02 | 0.00 |
| 1994 | 7851.52 | 7063 | 1127 | 79.68 | 79.68 | 79.53 | 80.63 | 0.00 | 0.00 | 20.32 | 0.00 |
| 1995 | 7495.11 | 6695 | 1127 | 75.63 | 75.63 | 75.92 | 76.43 | 0.00 | 0.00 | 24.37 | 0.00 |
| 1996 | 7051.09 | 6221 | 1127 | 70.81 | 70.81 | 71.23 | 70.82 | 16.12 | 13.61 | 15.58 | 0.00 |
| 1997 | 7660.20 | 6756 | 1127 | 77.10 | 77.10 | 77.59 | 77.12 | 22.89 | 22.89 | 0.01 | 0.00 |
| 1998 | 8839.42 | 7835 | 1127 | 88.96 | 88.96 | 89.54 | 89.44 | 0.00 | 0.00 | 11.04 | 0.00 |
| 1999 | 8903.44 | 7872 | 1127 | 89.54 | 89.85 | 90.18 | 89.86 | 0.00 | 0.00 | 10.15 | 0.31 |
| 2000 | 8649.77 | 7629 | 1127 | 86.83 | 86.83 | 87.38 | 86.85 | 0.00 | 0.00 | 13.17 | 0.00 |
| 2001 | 9283.56 | 8179 | 1127 | 93.36 | 93.36 | 94.03 | 93.37 | 0.00 | 0.00 | 6.64 | 0.00 |
| 2002 | 9217.09 | 8017 | 1127 | 91.50 | 91.50 | 93.36 | 91.52 | 0.00 | 0.00 | 8.50 | 0.00 |
| 2003 | 8762.57 | 7557 | 1127 | 86.26 | 86.26 | 88.76 | 86.27 | 0.00 | 0.00 | 13.74 | 0.00 |
| 2004 | 8318.19 | 7186 | 1127 | 81.78 | 81.78 | 84.03 | 81.81 | 7.44 | 6.57 | 11.65 | 0.00 |
| 2005 | 9929.00 | 8657 | 1127 | 98.77 | 98.77 | 100.57 | 98.82 | 0.00 | 0.00 | 1.23 | 0.00 |
| 2006 | 8163.92 | 7087 | 1127 | 80.66 | 80.66 | 82.69 | 80.90 | 0.00 | 0.00 | 19.34 | 0.00 |
| 2007 | 7978.56 | 6934 | 1127 | 78.87 | 78.87 | 80.82 | 79.16 | 0.00 | 0.00 | 21.13 | 0.00 |
| 2008 | 7642.69 | 6654 | 1127 | 75.41 | 75.41 | 77.20 | 75.75 | 0.79 | 0.60 | 23.98 | 0.00 |
| 2009 | 10097.36 | 8760 | 1127 | 99.99 | 99.99 | 102.28 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2010 | 6977.31 | 6109 | 1127 | 69.41 | 69.41 | 70.67 | 69.74 | 0.00 | 0.00 | 30.59 | 0.00 |
| 2011 | 5599.90 | 4872 | 1127 | 55.56 | 55.56 | 56.72 | 55.62 | 0.00 | 0.00 | 44.44 | 0.00 |
| 2012 | 4486.58 | 3941 | 1127 | 44.41 | 44.41 | 45.32 | 44.87 | 0.00 | 0.00 | 55.59 | 0.00 |
| 2013 | 7167.72 | 6191 | 1127 | 70.67 | 70.67 | 72.60 | 70.67 | 0.00 | 0.00 | 29.33 | 0.00 |
| 2014 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2015 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2016 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2017 | 0.00 | 0 | 1127 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2018 | 6428.38 | 5623 | 1127 | 63.79 | 63.79 | 65.11 | 64.19 | 0.00 | 0.00 | 36.21 | 0.00 |
| 2019 | 8077.29 | 7011 | 1127 | 79.65 | 79.65 | 81.82 | 80.03 | 0.00 | 0.00 | 20.35 | 0.00 |
| 2020 | 8481.35 | 7378 | 1127 | 83.95 | 83.95 | 85.67 | 83.99 | 0.00 | 0.00 | 16.05 | 0.00 |
| 2021 | 9636.22 | 8357 | 1127 | 95.07 | 95.07 | 97.61 | 95.40 | 0.00 | 0.00 | 4.93 | 0.00 |
| 2022 | 6536.56 | 5681 | 1127 | 64.47 | 64.47 | 66.21 | 64.85 | 0.00 | 3.01 | 32.51 | 0.00 |
| 2023 | 8554.07 | 7395 | 1127 | 84.06 | 84.06 | 86.65 | 84.42 | 0.00 | 0.00 | 15.94 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1993 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 117 | |
| C. Inspection, maintenance or repair combined with refuelling | 1365 | | | 999 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 670 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 906 | | |
| Z. Other | | | | | 19 | |
| Subtotal | 1365 | | | 2575 | 136 | |
| Total | | 1365 | | | 2711 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1993 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 31. Turbine and auxiliaries | | 19 |
| 32. Feedwater and Main Steam System | | 9 |
| 41. Main Generator Systems | | 107 |
| Total | | 137 |

2023 Operating Experience

JP-28

SENDAI-1

JAPAN

Status at end of year : **Operational**
 Operator : KYUSHU (Kyushu Electric Power Co., Inc.)
 Owner : KYUSHU (Kyushu Electric Power Co., Inc.)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : SIEMENS (Siemens AG, Power Generation)



Reactor Unit Details

Reactor type and model : PWR / M (3-loop)
 Thermal power : 2660 MWth
 Gross electrical power : 890 MWe
 Reference unit power (net) : 846 MWe

Key Dates

Construction Date : 1979-12-15
 Grid Date : 1983-09-16
 Commercial Date : 1984-07-04
 Age at end of year : 40 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.8
 Refuelling frequency [month] : 13
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 49000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.1
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Confinement
 Containment design pressure [MPa] : 0.22

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.07
 Output voltage [kV] : 23
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

Non-electrical applications

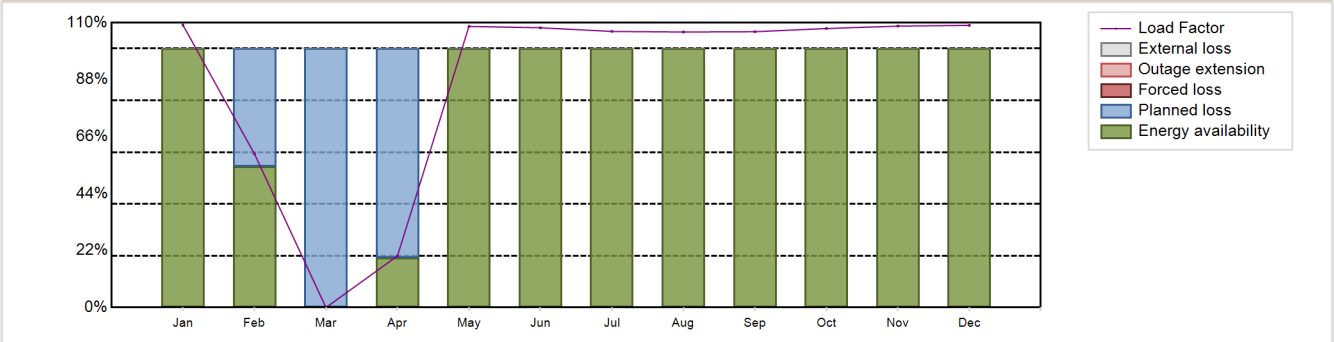
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6502.42 GW(e).h
 Energy Availability Factor (EAF) : 81.37 %
 Unit Capability Factor (UCF) : 81.37 %
 Load Factor (LF) : 87.74 %
 Operating Factor (OF) : 81.82 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 18.63 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1593 hours

Annual Summary

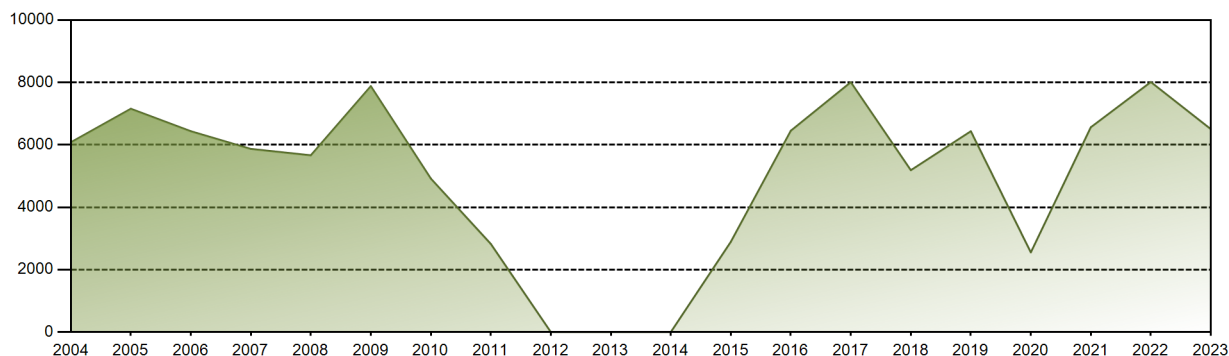


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 686.51 | 337.31 | 0.00 | 121.38 | 683.35 | 658.13 | 671.12 | 669.69 | 648.83 | 678.20 | 661.98 | 685.92 | 6502.42 |
| EAF [%] | 100.00 | 54.43 | 0.00 | 19.18 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 81.37 |
| UCF [%] | 100.00 | 54.43 | 0.00 | 19.18 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 81.37 |
| LF [%] | 109.07 | 59.33 | 0.00 | 19.93 | 108.57 | 108.05 | 106.63 | 106.40 | 106.52 | 107.75 | 108.68 | 108.98 | 87.74 |
| OF [%] | 100.00 | 54.91 | 0.00 | 24.17 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 81.82 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 45.57 | 100.00 | 80.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.63 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 225366.52 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.51 % |
| Cumulative Energy Availability Factor (EAF) | : 72.41 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.7 % |
| Cumulative Unit Capability Factor (UCF) | : 72.41 % | Cumulative Planned Unavailability Factor (PUF) | : 26.88 % |
| Cumulative Load Factor (LF) | : 74.89 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 72.91 % | | |

Electricity Production (net) [GWh]

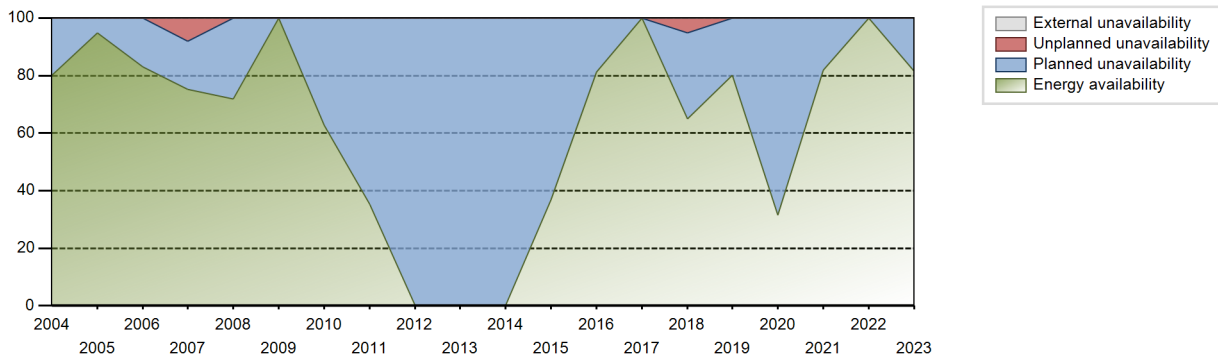


Performance for Years of Commercial Operation

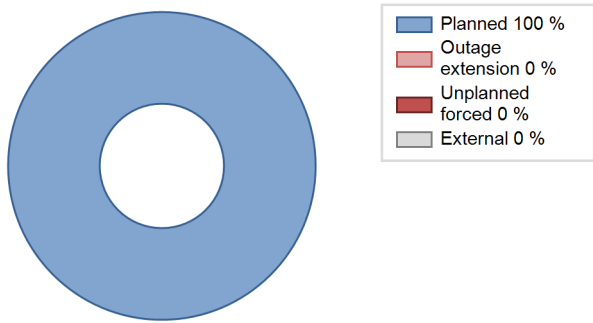
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|--------|--------|------|------|--------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 6069.77 | 7487 | 846 | 100.00 | 100.00 | 101.06 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1985 | 5890.27 | 6964 | 846 | 78.68 | 78.68 | 79.48 | 79.50 | 0.00 | 0.00 | 21.32 | 0.00 |
| 1986 | 6084.02 | 7224 | 846 | 81.36 | 81.36 | 82.09 | 82.47 | 0.00 | 0.00 | 18.64 | 0.00 |
| 1987 | 6113.36 | 7261 | 846 | 81.74 | 81.74 | 82.49 | 82.89 | 0.00 | 0.00 | 18.26 | 0.00 |
| 1988 | 5683.09 | 6756 | 846 | 75.81 | 75.81 | 76.48 | 76.91 | 0.00 | 0.00 | 24.19 | 0.00 |
| 1989 | 7381.33 | 8641 | 846 | 98.69 | 98.69 | 99.60 | 98.64 | 0.00 | 0.00 | 1.31 | 0.00 |
| 1990 | 6154.95 | 7307 | 846 | 82.31 | 82.31 | 83.05 | 83.41 | 0.00 | 0.00 | 17.69 | 0.00 |
| 1991 | 5590.69 | 6684 | 846 | 74.76 | 74.76 | 75.44 | 76.30 | 1.23 | 0.93 | 24.31 | 0.00 |
| 1992 | 5713.89 | 6780 | 846 | 76.08 | 76.08 | 76.89 | 77.19 | 0.00 | 0.00 | 23.92 | 0.00 |
| 1993 | 6619.24 | 7753 | 846 | 88.43 | 88.43 | 89.32 | 88.50 | 0.00 | 0.00 | 11.57 | 0.00 |
| 1994 | 5778.34 | 6762 | 846 | 77.17 | 77.17 | 77.97 | 77.19 | 0.00 | 0.00 | 22.83 | 0.00 |
| 1995 | 5780.32 | 6863 | 846 | 77.28 | 77.28 | 78.00 | 78.34 | 0.00 | 0.00 | 22.72 | 0.00 |
| 1996 | 5185.37 | 6157 | 846 | 69.09 | 69.09 | 69.78 | 70.09 | 0.00 | 0.00 | 30.91 | 0.00 |
| 1997 | 7216.68 | 8449 | 846 | 96.40 | 96.40 | 97.38 | 96.45 | 0.00 | 0.00 | 3.60 | 0.00 |
| 1998 | 5291.22 | 6311 | 846 | 70.64 | 70.64 | 71.40 | 72.04 | 4.67 | 3.46 | 25.90 | 0.00 |
| 1999 | 6057.57 | 7082 | 846 | 80.83 | 80.83 | 81.74 | 80.84 | 3.06 | 2.55 | 16.62 | 0.00 |
| 2000 | 5654.00 | 6609 | 846 | 75.23 | 75.23 | 76.08 | 75.24 | 9.23 | 7.65 | 17.12 | 0.00 |
| 2001 | 7367.04 | 8614 | 846 | 98.31 | 98.31 | 99.41 | 98.33 | 0.00 | 0.00 | 1.69 | 0.00 |
| 2002 | 6323.03 | 7333 | 846 | 83.68 | 83.68 | 85.32 | 83.71 | 0.00 | 0.00 | 16.32 | 0.00 |
| 2003 | 6282.06 | 7278 | 846 | 83.08 | 83.08 | 84.77 | 83.08 | 0.00 | 0.00 | 16.92 | 0.00 |
| 2004 | 6080.79 | 7043 | 846 | 80.15 | 80.15 | 81.83 | 80.18 | 0.00 | 0.00 | 19.85 | 0.00 |
| 2005 | 7155.81 | 8305 | 846 | 94.74 | 94.74 | 96.56 | 94.81 | 0.00 | 0.00 | 5.26 | 0.00 |
| 2006 | 6436.58 | 7330 | 846 | 82.92 | 82.92 | 86.85 | 83.68 | 0.00 | 0.00 | 17.08 | 0.00 |
| 2007 | 5868.86 | 6660 | 846 | 75.21 | 75.21 | 79.19 | 76.03 | 0.00 | 8.05 | 16.74 | 0.00 |
| 2008 | 5665.09 | 6396 | 846 | 71.92 | 71.92 | 76.23 | 72.81 | 0.00 | 0.00 | 28.08 | 0.00 |
| 2009 | 7880.10 | 8760 | 846 | 100.00 | 100.00 | 106.33 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 4919.57 | 5571 | 846 | 62.67 | 62.67 | 66.38 | 63.60 | 0.00 | 0.00 | 37.33 | 0.00 |
| 2011 | 2823.75 | 3097 | 846 | 35.32 | 35.32 | 38.10 | 35.35 | 0.00 | 0.00 | 64.68 | 0.00 |
| 2012 | 0.00 | 0 | 846 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2013 | 0.00 | 0 | 846 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2014 | 0.00 | 0 | 846 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2015 | 2893.82 | 3351 | 846 | 36.84 | 36.84 | 39.05 | 38.25 | 0.00 | 0.00 | 63.16 | 0.00 |
| 2016 | 6452.27 | 7188 | 846 | 81.16 | 81.16 | 86.83 | 81.83 | 0.00 | 0.00 | 18.84 | 0.00 |
| 2017 | 8007.73 | 8760 | 846 | 100.00 | 100.00 | 108.05 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 5186.62 | 5756 | 846 | 65.03 | 65.03 | 69.99 | 65.71 | 0.00 | 5.10 | 29.87 | 0.00 |
| 2019 | 6434.71 | 7058 | 846 | 80.07 | 80.07 | 86.83 | 80.57 | 0.00 | 0.00 | 19.93 | 0.00 |
| 2020 | 2552.25 | 2818 | 846 | 31.58 | 31.58 | 34.34 | 32.08 | 0.00 | 0.00 | 68.42 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2021 | 6563.52 | 7215 | 846 | 81.90 | 81.90 | 88.57 | 82.36 | 0.00 | 0.00 | 18.10 | 0.00 |
| 2022 | 8012.33 | 8760 | 846 | 100.00 | 100.00 | 108.11 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 6502.42 | 7167 | 846 | 81.37 | 81.37 | 87.74 | 81.82 | 0.00 | 0.00 | 18.63 | 0.00 |

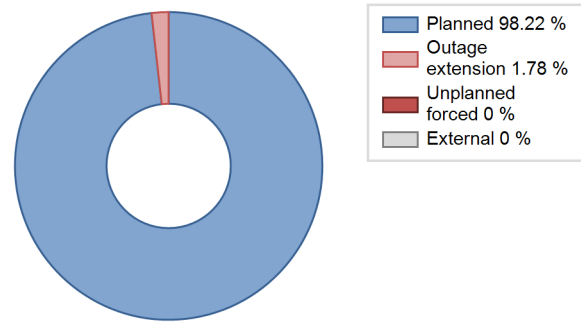
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 59 | |
| C. Inspection, maintenance or repair combined with refuelling | 1593 | | | 1449 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 914 | | |
| Subtotal | 1593 | | | 2363 | 59 | |
| Total | | 1593 | | | 2422 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 11 |
| 12. Reactor I&C Systems | | 1 |
| 13. Reactor Auxiliary Systems | | 7 |
| 16. Steam generation systems | | 17 |
| 31. Turbine and auxiliaries | | 6 |
| 32. Feedwater and Main Steam System | | 16 |
| Total | | 58 |

2023 Operating Experience

JP-37

SENDAI-2

JAPAN

Status at end of year : **Operational**
 Operator : KYUSHU (Kyushu Electric Power Co., Inc.)
 Owner : KYUSHU (Kyushu Electric Power Co., Inc.)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : SIEMENS (Siemens AG, Power Generation)



Reactor Unit Details

Reactor type and model : PWR / M (3-loop)
 Thermal power : 2660 MWth
 Gross electrical power : 890 MWe
 Reference unit power (net) : 846 MWe

Key Dates

Construction Date : 1981-10-12
 Grid Date : 1985-04-05
 Commercial Date : 1985-11-28
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.8
 Refuelling frequency [month] : 13
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 49000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.1
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Confinement
 Containment design pressure [MPa] : 0.22

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.07
 Output voltage [kV] : 23
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

Non-electrical applications

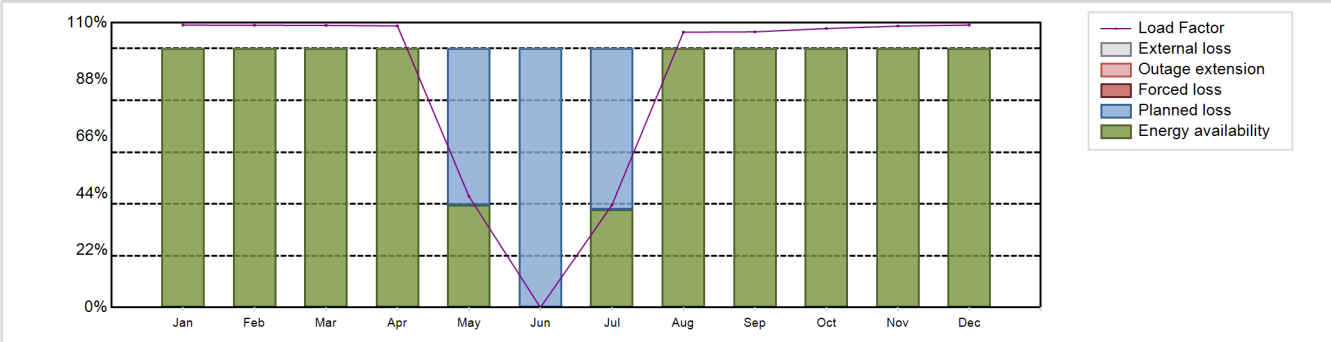
: none

Annual Production Results (2023)

Net Energy Production : 6518.1 GW(e).h
 Energy Availability Factor (EAF) : 81.37 %
 Unit Capability Factor (UCF) : 81.37 %
 Load Factor (LF) : 87.95 %
 Operating Factor (OF) : 81.82 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 18.63 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1593 hours

Annual Summary

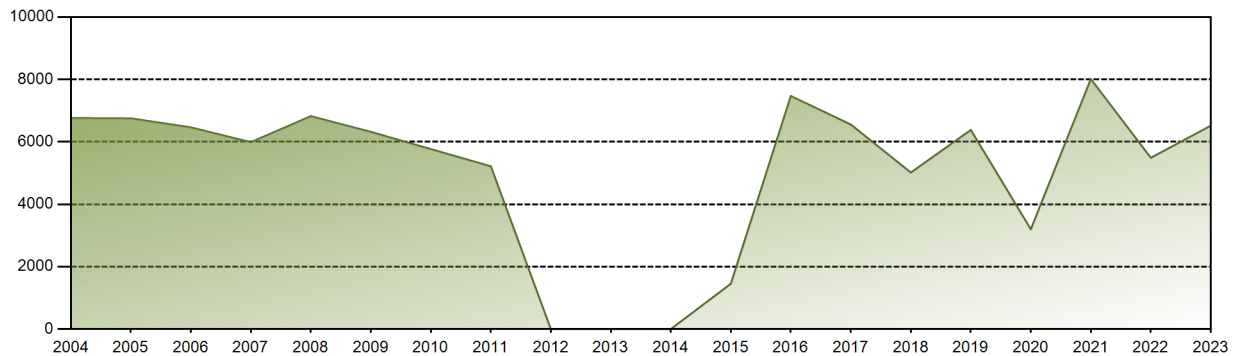


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 686.50 | 619.78 | 685.75 | 662.42 | 270.09 | 0.00 | 248.92 | 669.34 | 648.49 | 678.23 | 662.01 | 686.57 | 6518.10 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 39.48 | 0.00 | 37.91 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 81.37 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 39.48 | 0.00 | 37.91 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 81.37 |
| LF [%] | 109.07 | 109.02 | 108.95 | 108.75 | 42.91 | 0.00 | 39.55 | 106.34 | 106.46 | 107.75 | 108.68 | 109.08 | 87.95 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 39.92 | 0.00 | 42.74 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 81.82 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 60.52 | 100.00 | 62.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.63 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 211260.85 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.04 % |
| Cumulative Energy Availability Factor (EAF) | : 73.16 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.03 % |
| Cumulative Unit Capability Factor (UCF) | : 73.16 % | Cumulative Planned Unavailability Factor (PUF) | : 26.82 % |
| Cumulative Load Factor (LF) | : 75.28 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 73.58 % | | |

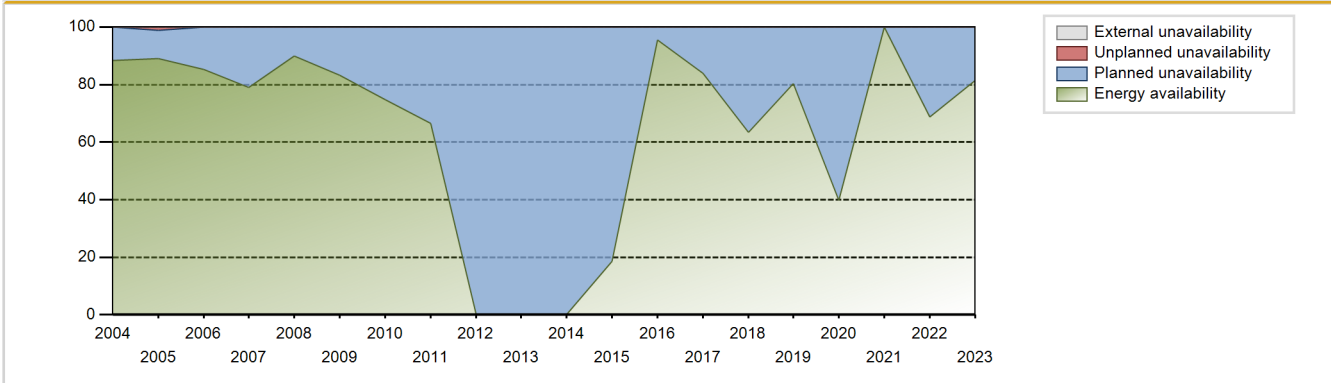
Electricity Production (net) [GWh]



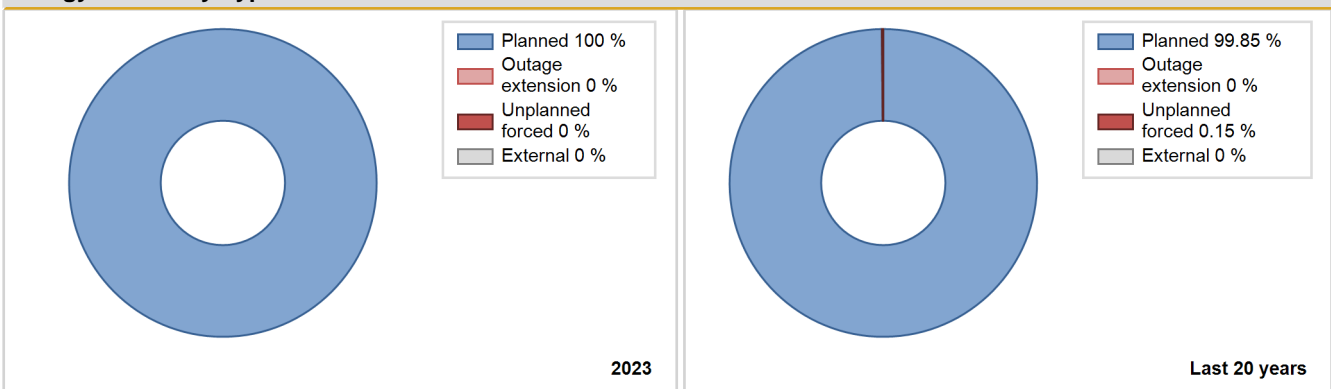
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 2816.07 | 4327 | 846 | 100.00 | 100.00 | 101.22 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1986 | 5996.37 | 7112 | 846 | 80.14 | 80.14 | 80.91 | 81.19 | 0.00 | 0.00 | 19.86 | 0.00 |
| 1987 | 6080.60 | 7211 | 846 | 81.18 | 81.18 | 82.05 | 82.32 | 0.00 | 0.00 | 18.82 | 0.00 |
| 1988 | 7409.79 | 8665 | 846 | 98.70 | 98.70 | 99.71 | 98.65 | 0.00 | 0.00 | 1.30 | 0.00 |
| 1989 | 4999.37 | 5950 | 846 | 66.84 | 66.84 | 67.46 | 67.92 | 0.00 | 0.00 | 33.16 | 0.00 |
| 1990 | 6160.14 | 7309 | 846 | 82.37 | 82.37 | 83.12 | 83.44 | 0.00 | 0.00 | 17.63 | 0.00 |
| 1991 | 5665.26 | 6732 | 846 | 75.72 | 75.72 | 76.44 | 76.85 | 0.00 | 0.00 | 24.28 | 0.00 |
| 1992 | 7385.32 | 8639 | 846 | 98.30 | 98.30 | 99.38 | 98.35 | 0.00 | 0.00 | 1.70 | 0.00 |
| 1993 | 5821.98 | 6632 | 846 | 77.69 | 77.69 | 78.56 | 75.71 | 0.00 | 0.00 | 22.31 | 0.00 |
| 1994 | 5568.78 | 6557 | 846 | 74.30 | 74.30 | 75.14 | 74.85 | 0.00 | 0.00 | 25.70 | 0.00 |
| 1995 | 5658.40 | 6709 | 846 | 75.50 | 75.50 | 76.35 | 76.59 | 0.00 | 0.00 | 24.50 | 0.00 |
| 1996 | 7359.31 | 8617 | 846 | 98.05 | 98.05 | 99.03 | 98.10 | 0.00 | 0.00 | 1.95 | 0.00 |
| 1997 | 5950.29 | 7034 | 846 | 79.44 | 79.44 | 80.29 | 80.30 | 0.00 | 0.00 | 20.56 | 0.00 |
| 1998 | 5899.10 | 6973 | 846 | 78.72 | 78.72 | 79.60 | 79.60 | 0.00 | 0.00 | 21.28 | 0.00 |
| 1999 | 5658.29 | 6612 | 846 | 75.47 | 75.47 | 76.35 | 75.48 | 0.00 | 0.00 | 24.53 | 0.00 |
| 2000 | 7370.17 | 8614 | 846 | 98.04 | 98.04 | 99.18 | 98.06 | 0.00 | 0.00 | 1.96 | 0.00 |
| 2001 | 6210.15 | 7260 | 846 | 82.86 | 82.86 | 83.80 | 82.88 | 0.00 | 0.00 | 17.14 | 0.00 |
| 2002 | 6255.46 | 7257 | 846 | 82.83 | 82.83 | 84.41 | 82.84 | 0.00 | 0.00 | 17.17 | 0.00 |
| 2003 | 6348.77 | 7315 | 846 | 83.38 | 83.38 | 85.67 | 83.50 | 0.00 | 0.00 | 16.62 | 0.00 |
| 2004 | 6762.55 | 7774 | 846 | 88.48 | 88.48 | 91.00 | 88.50 | 0.00 | 0.00 | 11.52 | 0.00 |
| 2005 | 6752.80 | 7895 | 846 | 88.94 | 88.94 | 91.12 | 90.13 | 1.17 | 1.05 | 10.01 | 0.00 |
| 2006 | 6464.16 | 7548 | 846 | 85.35 | 85.35 | 87.22 | 86.16 | 0.00 | 0.00 | 14.65 | 0.00 |
| 2007 | 5989.31 | 6996 | 846 | 79.05 | 79.05 | 80.82 | 79.86 | 0.00 | 0.00 | 20.95 | 0.00 |
| 2008 | 6824.28 | 7897 | 846 | 89.86 | 89.86 | 91.83 | 89.90 | 0.00 | 0.00 | 10.14 | 0.00 |
| 2009 | 6320.24 | 7355 | 846 | 83.19 | 83.19 | 85.28 | 83.96 | 0.00 | 0.00 | 16.81 | 0.00 |
| 2010 | 5767.52 | 6630 | 846 | 74.78 | 74.78 | 77.82 | 75.68 | 0.00 | 0.00 | 25.22 | 0.00 |
| 2011 | 5216.82 | 5833 | 846 | 66.55 | 66.55 | 70.39 | 66.59 | 0.00 | 0.00 | 33.45 | 0.00 |
| 2012 | 0.00 | 0 | 846 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2013 | 0.00 | 0 | 846 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2014 | 0.00 | 0 | 846 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2015 | 1452.66 | 1729 | 846 | 18.63 | 18.63 | 19.60 | 19.74 | 0.00 | 0.00 | 81.37 | 0.00 |
| 2016 | 7468.59 | 8401 | 846 | 95.60 | 95.60 | 100.50 | 95.64 | 0.00 | 0.00 | 4.40 | 0.00 |
| 2017 | 6554.16 | 7401 | 846 | 83.87 | 83.87 | 88.44 | 84.49 | 0.00 | 0.00 | 16.13 | 0.00 |
| 2018 | 5016.93 | 5618 | 846 | 63.46 | 63.46 | 67.70 | 64.13 | 0.00 | 0.00 | 36.54 | 0.00 |
| 2019 | 6381.17 | 7082 | 846 | 80.38 | 80.38 | 86.10 | 80.84 | 0.00 | 0.00 | 19.62 | 0.00 |
| 2020 | 3197.98 | 3538 | 846 | 39.82 | 39.82 | 43.03 | 40.28 | 0.00 | 0.00 | 60.18 | 0.00 |
| 2021 | 8012.55 | 8760 | 846 | 100.00 | 100.00 | 108.12 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 5488.22 | 6063 | 846 | 68.71 | 68.71 | 74.06 | 69.21 | 0.00 | 0.00 | 31.29 | 0.00 |
| 2023 | 6518.10 | 7167 | 846 | 81.37 | 81.37 | 87.95 | 81.82 | 0.00 | 0.00 | 18.63 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 3 | |
| C. Inspection, maintenance or repair combined with refuelling | 1545 | | | 1439 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 900 | | |
| Subtotal | 1545 | | | 2339 | 3 | |
| Total | | 1545 | | | 2342 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1985 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 32. Feedwater and Main Steam System | | | | 3 |
| Total | | | | 3 |

2023 Operating Experience

JP-8

TAKAHAMA-1

JAPAN

Status at end of year : **Operational**
 Operator : KEPCO (Kansai Electric Power Co.)
 Owner : KEPCO (Kansai Electric Power Co.)
 Reactor Supplier : WH/MHI (WESTINGHOUSE ELECTRIC CORPORATION / MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



Reactor Unit Details

Reactor type and model : PWR / M (3-loop)
 Thermal power : 2440 MWth
 Gross electrical power : 826 MWe
 Reference unit power (net) : 780 MWe

Key Dates

Construction Date : 1970-04-25
 Grid Date : 1974-03-27
 Commercial Date : 1974-11-14
 Age at end of year : 49 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.0
 Refuelling frequency [month] : 13
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 43000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.64
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 20.3
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 323
 Number of SG : 3
 Containment type : Confinement
 Containment design pressure [MPa] : 0.24

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.8
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

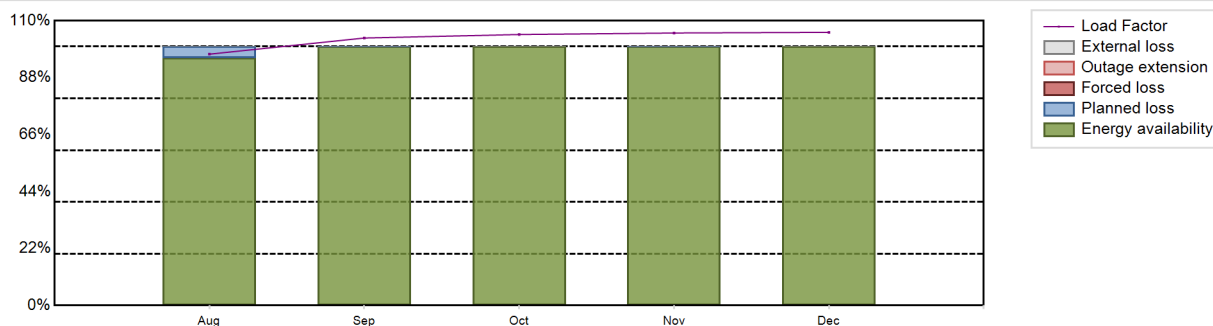
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 2936.1 GW(e).h
 Energy Availability Factor (EAF) : 99.13 %
 Unit Capability Factor (UCF) : 99.13 %
 Load Factor (LF) : 103.19 %
 Operating Factor (OF) : 99.59 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.87 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 15 hours

Annual Summary

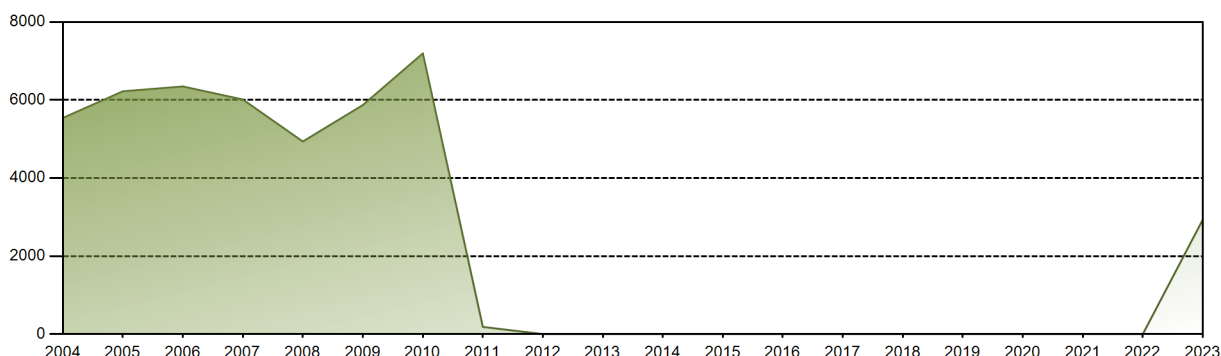


| | Jan | Feb | Mar | Apr | Jul | May | Jun | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-----|-----|-----|-----|-----|-----|-----|--------|--------|--------|--------|--------|---------|
| GW(e)-h | | | | | | | | 545.18 | 580.23 | 607.36 | 591.12 | 612.21 | 2936.11 |
| EAF [%] | | | | | | | | 95.62 | 99.99 | 100.00 | 99.99 | 100.00 | 99.13 |
| UCF [%] | | | | | | | | 95.62 | 99.99 | 100.00 | 99.99 | 100.00 | 99.13 |
| LF [%] | | | | | | | | 97.08 | 103.32 | 104.66 | 105.26 | 105.50 | 103.19 |
| OF [%] | | | | | | | | 97.92 | 100.00 | 100.00 | 100.00 | 100.00 | 99.59 |
| FLR [%] | | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | | | | | | | | 4.38 | 0.01 | 0.00 | 0.01 | 0.00 | 0.87 |
| XUF [%] | | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 177250.1 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.31 % |
| Cumulative Energy Availability Factor (EAF) | : 69.81 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.78 % |
| Cumulative Unit Capability Factor (UCF) | : 69.84 % | Cumulative Planned Unavailability Factor (PUF) | : 25.38 % |
| Cumulative Load Factor (LF) | : 70.84 % | Cumulative Externally cause unavailability (XUF) | : 0.03 % |
| Cumulative Operating Factor (OF) | : 70.99 % | | |

Electricity Production (net) [GWh]

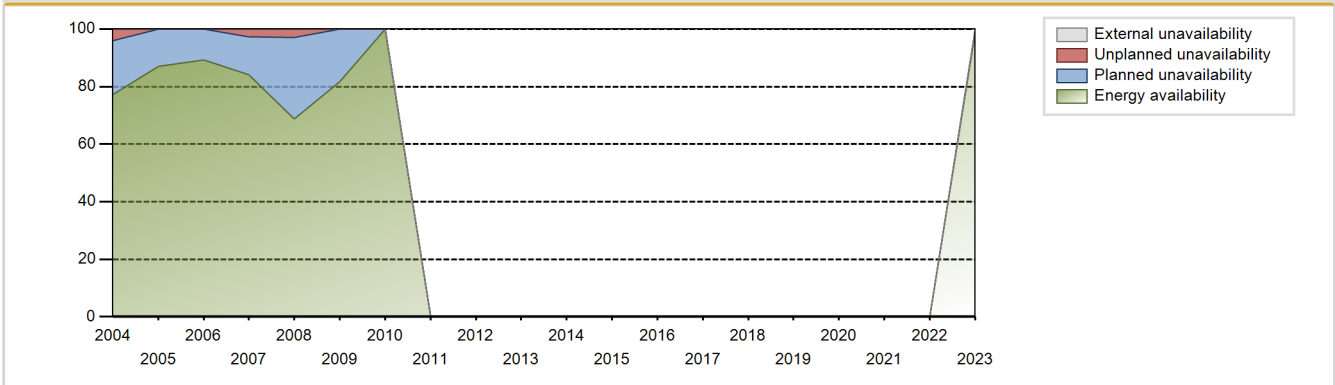


Performance for Years of Commercial Operation

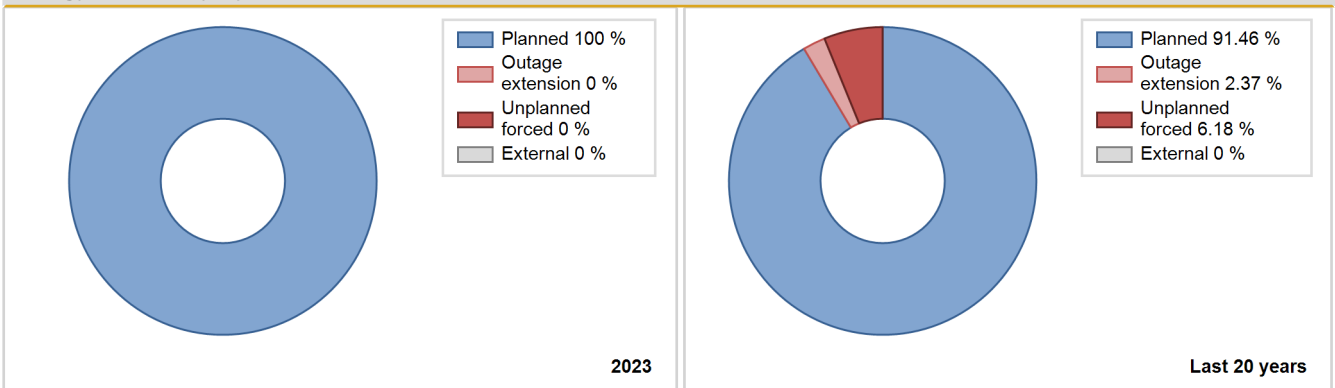
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1974 | 2660.40 | 4392 | 780 | 94.03 | 94.03 | 92.81 | 93.99 | 5.08 | 5.03 | 0.93 | 0.00 |
| 1975 | 4980.40 | 6938 | 780 | 72.81 | 72.81 | 72.89 | 79.20 | 12.81 | 10.70 | 16.49 | 0.00 |
| 1976 | 3170.10 | 4900 | 780 | 46.19 | 46.19 | 46.27 | 55.78 | 19.20 | 10.98 | 42.83 | 0.00 |
| 1977 | 383.80 | 569 | 780 | 5.61 | 5.61 | 5.62 | 6.50 | 94.39 | 94.39 | 0.00 | 0.00 |
| 1978 | 2762.50 | 4088 | 780 | 40.42 | 40.42 | 40.43 | 46.67 | 5.59 | 2.39 | 57.18 | 0.00 |
| 1979 | 1648.90 | 2269 | 780 | 24.14 | 24.14 | 24.13 | 25.90 | 0.00 | 0.00 | 75.86 | 0.00 |
| 1980 | 2705.10 | 3604 | 780 | 39.42 | 39.42 | 39.48 | 41.03 | 0.00 | 0.00 | 60.58 | 0.00 |
| 1981 | 3990.20 | 5180 | 780 | 58.33 | 58.33 | 58.40 | 59.13 | 0.00 | 0.00 | 41.67 | 0.00 |
| 1982 | 3872.10 | 5085 | 780 | 56.50 | 56.50 | 56.67 | 58.05 | 0.00 | 0.00 | 43.50 | 0.00 |
| 1983 | 5716.20 | 7403 | 780 | 83.72 | 83.72 | 83.66 | 84.51 | 0.65 | 0.54 | 15.74 | 0.00 |
| 1984 | 3537.44 | 4586 | 780 | 51.41 | 51.41 | 51.63 | 52.21 | 0.54 | 0.28 | 48.31 | 0.00 |
| 1985 | 5000.77 | 6473 | 780 | 72.84 | 72.84 | 73.19 | 73.89 | 0.00 | 0.00 | 27.16 | 0.00 |
| 1986 | 5070.31 | 6507 | 780 | 73.86 | 73.86 | 74.21 | 74.28 | 1.25 | 0.94 | 25.21 | 0.00 |
| 1987 | 4701.39 | 6148 | 780 | 70.18 | 70.18 | 68.81 | 70.18 | 18.82 | 16.27 | 13.55 | 0.00 |
| 1988 | 4147.14 | 5351 | 780 | 60.92 | 60.92 | 60.53 | 60.92 | 0.00 | 0.00 | 39.08 | 0.00 |
| 1989 | 4877.26 | 6311 | 780 | 72.04 | 72.04 | 71.38 | 72.04 | 0.00 | 0.00 | 27.96 | 0.00 |
| 1990 | 6265.50 | 8002 | 780 | 90.76 | 90.76 | 91.70 | 91.35 | 0.00 | 0.00 | 9.24 | 0.00 |
| 1991 | 4795.05 | 6202 | 780 | 68.25 | 68.25 | 70.18 | 70.80 | 0.00 | 0.00 | 31.75 | 0.00 |
| 1992 | 4644.96 | 6051 | 780 | 67.62 | 67.62 | 67.79 | 68.89 | 1.28 | 0.88 | 31.50 | 0.00 |
| 1993 | 3299.67 | 4458 | 780 | 48.36 | 48.36 | 48.29 | 50.89 | 30.51 | 21.23 | 30.41 | 0.00 |
| 1994 | 4024.04 | 5146 | 780 | 58.84 | 58.84 | 58.89 | 58.74 | 0.00 | 0.00 | 41.16 | 0.00 |
| 1995 | 6585.13 | 8485 | 780 | 96.05 | 96.05 | 96.38 | 96.86 | 0.00 | 0.00 | 3.95 | 0.00 |
| 1996 | 3358.80 | 4331 | 780 | 48.81 | 48.82 | 49.02 | 49.31 | 8.78 | 4.70 | 46.48 | 0.01 |
| 1997 | 4674.40 | 6000 | 780 | 68.10 | 68.10 | 68.41 | 68.49 | 0.00 | 0.00 | 31.90 | 0.00 |
| 1998 | 6856.82 | 8760 | 780 | 99.99 | 99.99 | 100.35 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 1999 | 5704.24 | 7291 | 780 | 83.22 | 84.30 | 83.48 | 83.23 | 0.00 | 0.00 | 15.70 | 1.08 |
| 2000 | 6008.07 | 7716 | 780 | 87.42 | 87.42 | 87.69 | 87.84 | 0.47 | 0.41 | 12.17 | 0.00 |
| 2001 | 6005.80 | 7731 | 780 | 87.62 | 87.62 | 87.90 | 88.25 | 0.70 | 0.62 | 11.76 | 0.00 |
| 2002 | 6056.31 | 7749 | 780 | 88.44 | 88.44 | 88.64 | 88.46 | 0.00 | 0.00 | 11.56 | 0.00 |
| 2003 | 6247.16 | 7637 | 780 | 87.17 | 87.17 | 91.43 | 87.18 | 0.00 | 0.00 | 12.83 | 0.00 |
| 2004 | 5539.92 | 6785 | 780 | 77.21 | 77.21 | 80.86 | 77.24 | 4.89 | 3.97 | 18.81 | 0.00 |
| 2005 | 6222.49 | 7659 | 780 | 87.07 | 87.07 | 91.07 | 87.43 | 0.00 | 0.00 | 12.93 | 0.00 |
| 2006 | 6347.13 | 7811 | 780 | 89.16 | 89.16 | 92.89 | 89.17 | 0.00 | 0.00 | 10.84 | 0.00 |
| 2007 | 6012.94 | 7399 | 780 | 84.15 | 84.15 | 88.00 | 84.46 | 0.00 | 2.66 | 13.19 | 0.00 |
| 2008 | 4935.75 | 6077 | 780 | 68.84 | 68.84 | 72.04 | 69.18 | 4.11 | 2.95 | 28.21 | 0.00 |
| 2009 | 5870.09 | 7193 | 780 | 81.73 | 81.73 | 85.91 | 82.11 | 0.00 | 0.00 | 18.27 | 0.00 |
| 2010 | 7193.46 | 8760 | 780 | 99.99 | 99.99 | 105.28 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |

| | | | | | | | | | | | |
|------|--|------|-----|-------|-------|--------|-------|------|------|------|------|
| 2011 | 183.43 | 226 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | Data not available - Suspended Operation | | | | | | | | | | |
| 2023 | 2936.11 | 3633 | 780 | 99.13 | 99.13 | 103.19 | 99.59 | 0.00 | 0.00 | 0.87 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1974 to 2023 | | |
|--|-------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 375 | |
| C. Inspection, maintenance or repair combined with refuelling | 5127 | | | 2110 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 194 | | |
| E. Testing of plant systems or components | | | | 0 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 50 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 2580 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 1 | |
| Z. Other | | | | | 10 | |
| Subtotal | 5127 | | | 4934 | 386 | 3 |
| Total | | 5127 | | | 5323 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1974 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 7 |
| 12. Reactor I&C Systems | | 7 |
| 15. Reactor Cooling Systems | | 95 |
| 16. Steam generation systems | | 219 |
| 31. Turbine and auxiliaries | | 25 |
| 32. Feedwater and Main Steam System | | 24 |
| 42. Electrical Power Supply Systems | | 1 |
| Total | | 378 |

2023 Operating Experience

JP-13

TAKAHAMA-2

JAPAN

Status at end of year : **Operational**
 Operator : KEPCO (Kansai Electric Power Co.)
 Owner : KEPCO (Kansai Electric Power Co.)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / M (3-loop) | Construction Date | : 1971-03-09 |
| Thermal power | : 2440 MWth | Grid Date | : 1975-01-17 |
| Gross electrical power | : 826 MWe | Commercial Date | : 1975-11-14 |
| Reference unit power (net) | : 780 MWe | Age at end of year | : 48 years |

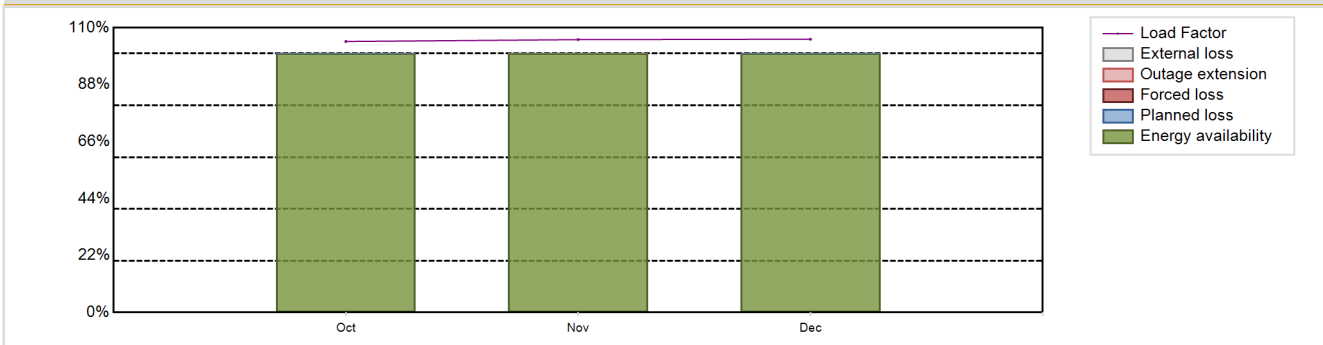
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 323 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Confinement |
| Average fuel enrichment [% of U235] | : 4.0 | Containment design pressure [MPa] | : 0.24 |
| Refuelling frequency [month] | : 13 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 43000 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 3.64 | HP cylinder inlet steam pressure [MPa] | : 5.8 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : 22 |
| Fuel linear heat generation rate [kW/m] | : 20.3 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 48 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|------------|
| Net Energy Production | : 1987.78 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.99 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 99.99 % | Planned Unavailability Factor (PUF) | : 0.01 % |
| Load Factor (LF) | : 105.21 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 15 hours |

Annual Summary

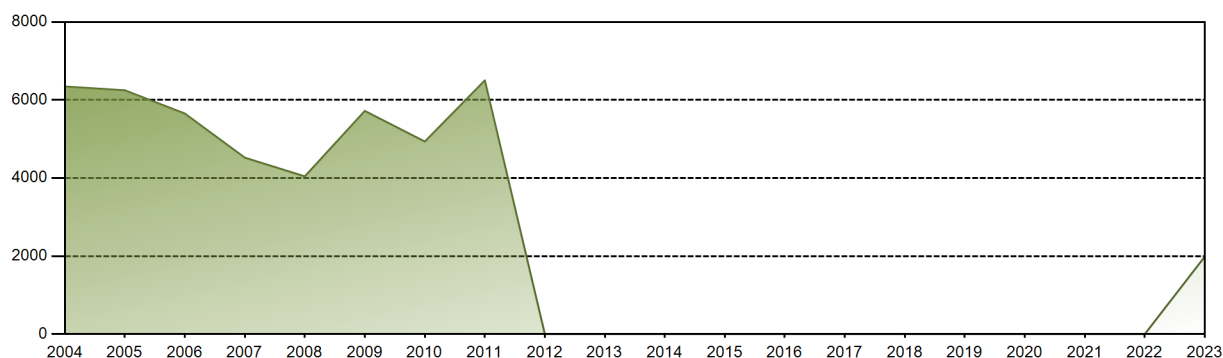


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|--------|--------|---------|
| GW(e)-h | | | | | | | | | | 607.43 | 591.89 | 612.62 | 1811.95 |
| EAF [%] | | | | | | | | | | 99.99 | 100.00 | 99.99 | 99.99 |
| UCF [%] | | | | | | | | | | 99.99 | 100.00 | 99.99 | 99.99 |
| LF [%] | | | | | | | | | | 104.67 | 105.39 | 105.57 | 105.21 |
| OF [%] | | | | | | | | | | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | | | | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | | | | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | | | | | | | | | | 0.01 | 0.00 | 0.01 | 0.01 |
| XUF [%] | | | | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 174645.78 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.64 % |
| Cumulative Energy Availability Factor (EAF) | : 68.93 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.72 % |
| Cumulative Unit Capability Factor (UCF) | : 69.03 % | Cumulative Planned Unavailability Factor (PUF) | : 27.25 % |
| Cumulative Load Factor (LF) | : 70.29 % | Cumulative Externally cause unavailability (XUF) | : 0.1 % |
| Cumulative Operating Factor (OF) | : 70.38 % | | |

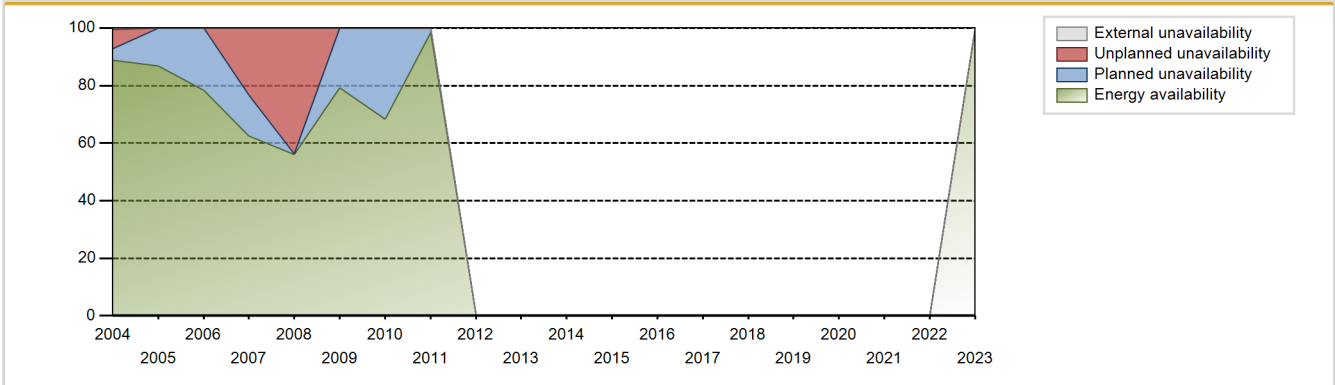
Electricity Production (net) [GWh]



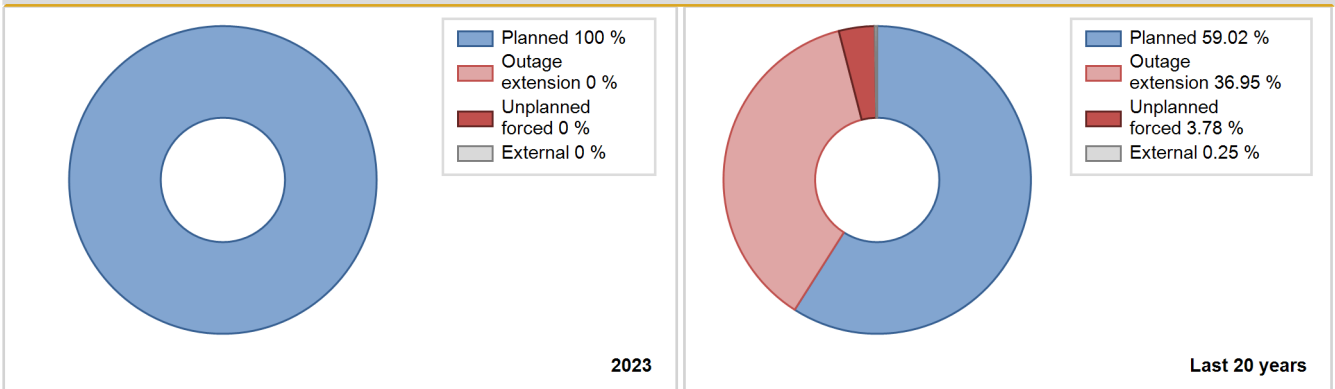
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 3168.50 | 5532 | 780 | 99.55 | 99.55 | 100.44 | 100.00 | 0.00 | 0.00 | 0.45 | 0.00 |
| 1976 | 3728.80 | 6214 | 780 | 54.17 | 54.17 | 54.42 | 70.74 | 23.83 | 16.94 | 28.89 | 0.00 |
| 1977 | 4742.00 | 6429 | 780 | 69.40 | 69.40 | 69.40 | 73.39 | 0.11 | 0.08 | 30.52 | 0.00 |
| 1978 | 4170.30 | 5751 | 780 | 61.04 | 61.04 | 61.03 | 65.65 | 0.59 | 0.37 | 38.59 | 0.00 |
| 1979 | 1281.00 | 1826 | 780 | 18.75 | 18.75 | 18.75 | 20.84 | 0.00 | 0.00 | 81.25 | 0.00 |
| 1980 | 5751.10 | 7450 | 780 | 83.72 | 83.72 | 83.94 | 84.81 | 0.92 | 0.78 | 15.51 | 0.00 |
| 1981 | 4763.20 | 6198 | 780 | 69.55 | 69.55 | 69.71 | 70.75 | 0.30 | 0.21 | 30.23 | 0.00 |
| 1982 | 4133.90 | 5407 | 780 | 60.26 | 60.26 | 60.50 | 61.72 | 0.62 | 0.37 | 39.36 | 0.00 |
| 1983 | 3549.40 | 4645 | 780 | 51.74 | 51.74 | 51.95 | 53.03 | 0.80 | 0.42 | 47.84 | 0.00 |
| 1984 | 4503.14 | 5746 | 780 | 65.38 | 65.38 | 65.72 | 65.41 | 0.00 | 0.00 | 34.62 | 0.00 |
| 1985 | 4967.39 | 6466 | 780 | 72.38 | 72.38 | 72.70 | 73.81 | 18.83 | 16.79 | 10.83 | 0.00 |
| 1986 | 3997.83 | 5183 | 780 | 58.37 | 58.37 | 58.51 | 59.17 | 0.81 | 0.48 | 41.16 | 0.00 |
| 1987 | 4621.76 | 6154 | 780 | 67.31 | 70.25 | 67.64 | 70.25 | 0.00 | 0.00 | 29.75 | 2.94 |
| 1988 | 3071.35 | 4001 | 780 | 45.55 | 45.55 | 44.83 | 45.55 | 10.15 | 5.15 | 49.31 | 0.00 |
| 1989 | 3991.50 | 5213 | 780 | 59.51 | 59.51 | 58.42 | 59.51 | 0.00 | 0.00 | 40.49 | 0.00 |
| 1990 | 1727.89 | 2218 | 780 | 20.85 | 20.85 | 25.29 | 25.32 | 0.00 | 0.00 | 79.15 | 0.00 |
| 1991 | 2265.80 | 3054 | 780 | 32.25 | 32.25 | 33.16 | 34.86 | 23.38 | 9.84 | 57.91 | 0.00 |
| 1992 | 4873.75 | 6226 | 780 | 70.80 | 70.80 | 71.13 | 70.88 | 0.00 | 0.00 | 29.20 | 0.00 |
| 1993 | 5757.04 | 7426 | 780 | 83.96 | 83.96 | 84.26 | 84.77 | 0.00 | 0.00 | 16.04 | 0.00 |
| 1994 | 3357.26 | 4299 | 780 | 49.29 | 49.29 | 49.13 | 49.08 | 0.00 | 0.00 | 50.71 | 0.00 |
| 1995 | 4458.67 | 5906 | 780 | 65.12 | 65.12 | 65.25 | 67.42 | 5.98 | 4.14 | 30.74 | 0.00 |
| 1996 | 6709.05 | 8629 | 780 | 97.34 | 97.66 | 97.92 | 98.24 | 2.33 | 2.33 | 0.01 | 0.32 |
| 1997 | 4981.24 | 6306 | 780 | 72.51 | 72.51 | 72.90 | 71.99 | 0.54 | 0.39 | 27.10 | 0.00 |
| 1998 | 5972.92 | 7657 | 780 | 86.96 | 86.96 | 87.42 | 87.41 | 0.00 | 0.00 | 13.04 | 0.00 |
| 1999 | 5989.80 | 7717 | 780 | 87.17 | 87.20 | 87.66 | 88.09 | 0.99 | 0.87 | 11.93 | 0.03 |
| 2000 | 6849.93 | 8784 | 780 | 99.50 | 99.50 | 99.98 | 100.00 | 0.49 | 0.49 | 0.01 | 0.00 |
| 2001 | 5900.98 | 7572 | 780 | 85.99 | 85.99 | 86.36 | 86.44 | 0.50 | 0.43 | 13.57 | 0.00 |
| 2002 | 6097.67 | 7626 | 780 | 87.04 | 87.04 | 89.24 | 87.05 | 0.00 | 0.00 | 12.96 | 0.00 |
| 2003 | 5470.78 | 6717 | 780 | 76.40 | 76.40 | 80.07 | 76.68 | 1.39 | 1.33 | 22.27 | 0.00 |
| 2004 | 6346.62 | 7839 | 780 | 88.87 | 89.33 | 92.63 | 89.24 | 7.07 | 6.80 | 3.87 | 0.46 |
| 2005 | 6249.51 | 7625 | 780 | 86.74 | 86.74 | 91.46 | 87.04 | 0.00 | 0.00 | 13.26 | 0.00 |
| 2006 | 5653.43 | 6890 | 780 | 78.31 | 78.31 | 82.74 | 78.65 | 0.00 | 0.00 | 21.69 | 0.00 |
| 2007 | 4521.77 | 5483 | 780 | 62.53 | 62.53 | 66.18 | 62.59 | 0.00 | 23.29 | 14.18 | 0.00 |
| 2008 | 4042.51 | 4949 | 780 | 56.05 | 56.05 | 59.00 | 56.34 | 0.00 | 43.66 | 0.29 | 0.00 |
| 2009 | 5720.06 | 6978 | 780 | 79.28 | 79.28 | 83.71 | 79.66 | 0.00 | 0.00 | 20.72 | 0.00 |
| 2010 | 4935.20 | 6017 | 780 | 68.28 | 68.28 | 72.23 | 68.69 | 0.08 | 0.05 | 31.66 | 0.00 |
| 2011 | 6502.50 | 7895 | 780 | 98.42 | 98.42 | 104.00 | 98.49 | 0.00 | 0.00 | 1.58 | 0.00 |

| | | | | | | | | | | | |
|------|--|------|-----|-------|-------|--------|--------|------|------|------|------|
| 2012 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | Data not available - Suspended Operation | | | | | | | | | | |
| 2023 | 1987.78 | 2457 | 780 | 99.99 | 99.99 | 105.21 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|--|-------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 282 | |
| C. Inspection, maintenance or repair combined with refuelling | 6303 | | | 2457 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 9 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 55 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 2393 | | |
| L. Human factor related | | | | | 5 | |
| Z. Other | | | | | 16 | |
| Subtotal | 6303 | | | 4914 | 303 | |
| Total | | 6303 | | | 5217 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 197 |
| 16. Steam generation systems | | 74 |
| 31. Turbine and auxiliaries | | 18 |
| 32. Feedwater and Main Steam System | | 7 |
| 42. Electrical Power Supply Systems | | 6 |
| Total | | 302 |

2023 Operating Experience

JP-29

TAKAHAMA-3

JAPAN

Status at end of year : **Operational**
 Operator : KEPCO (Kansai Electric Power Co.)
 Owner : KEPCO (Kansai Electric Power Co.)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



Reactor Unit Details

Reactor type and model : PWR / M (3-loop)
 Thermal power : 2660 MWth
 Gross electrical power : 870 MWe
 Reference unit power (net) : 830 MWe

Key Dates

Construction Date : 1980-12-12
 Grid Date : 1984-05-09
 Commercial Date : 1985-01-17
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2/MOX
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.1
 Refuelling frequency [month] : 13
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 40000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.1
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Confinement
 Containment design pressure [MPa] : 0.28

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.1
 Output voltage [kV] : 23
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

Non-electrical applications

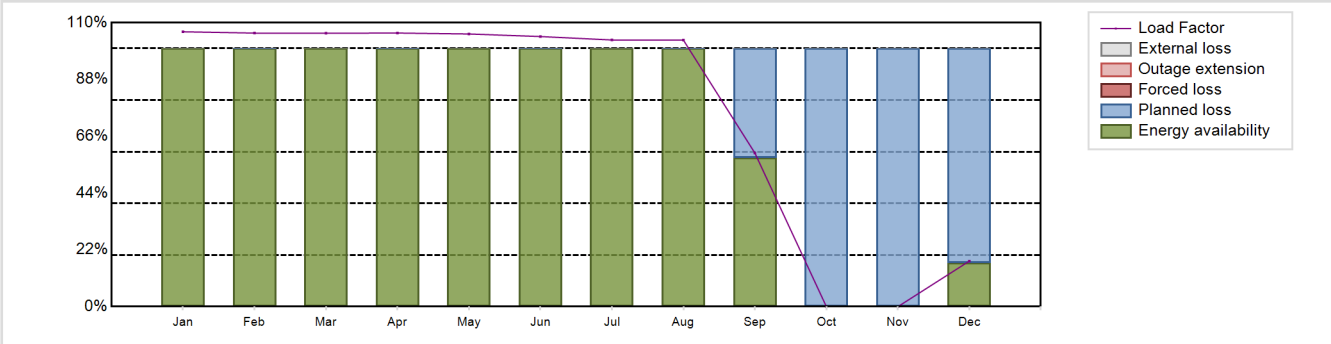
Non-electrical applications : DS

Annual Production Results (2023)

Net Energy Production : 5552.8 GW(e).h
 Energy Availability Factor (EAF) : 72.75 %
 Unit Capability Factor (UCF) : 72.75 %
 Load Factor (LF) : 76.37 %
 Operating Factor (OF) : 73.08 %
 Equivalent non-electrical energy generated (NEG) : 8.67 GW(e).h

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 27.25 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 2358 hours

Annual Summary

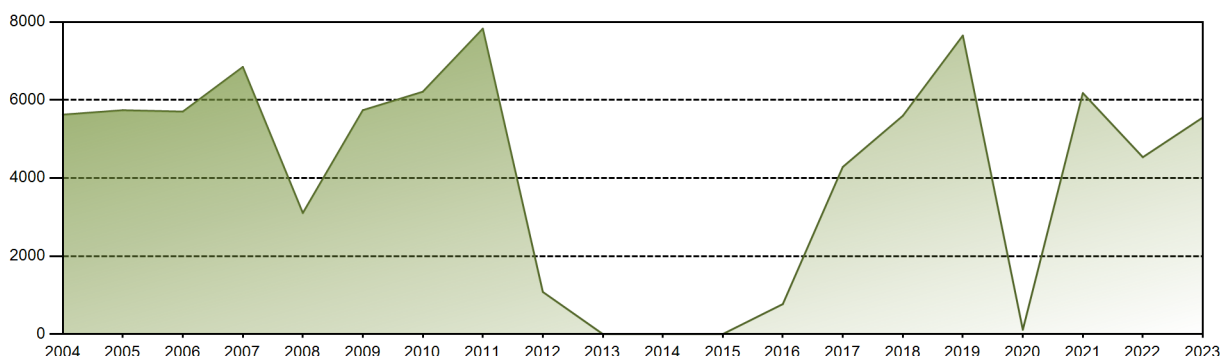


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 657.45 | 590.98 | 653.94 | 633.38 | 652.12 | 625.16 | 637.79 | 637.57 | 355.46 | 0.00 | 0.00 | 108.94 | 5552.80 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 | 57.69 | 0.00 | 0.00 | 16.87 | 72.75 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 | 57.69 | 0.00 | 0.00 | 16.87 | 72.75 |
| LF [%] | 106.47 | 105.96 | 105.90 | 105.99 | 105.60 | 104.61 | 103.28 | 103.25 | 59.48 | 0.00 | 0.00 | 17.64 | 76.37 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 58.19 | 0.00 | 0.00 | 20.30 | 73.08 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 42.31 | 100.00 | 100.00 | 83.13 | 27.25 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 201395.56 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.27 % |
| Cumulative Energy Availability Factor (EAF) | : 70.79 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.45 % |
| Cumulative Unit Capability Factor (UCF) | : 70.81 % | Cumulative Planned Unavailability Factor (PUF) | : 28.74 % |
| Cumulative Load Factor (LF) | : 71 % | Cumulative Externally cause unavailability (XUF) | : 0.03 % |
| Cumulative Operating Factor (OF) | : 69.19 % | | |

Electricity Production (net) [GWh]

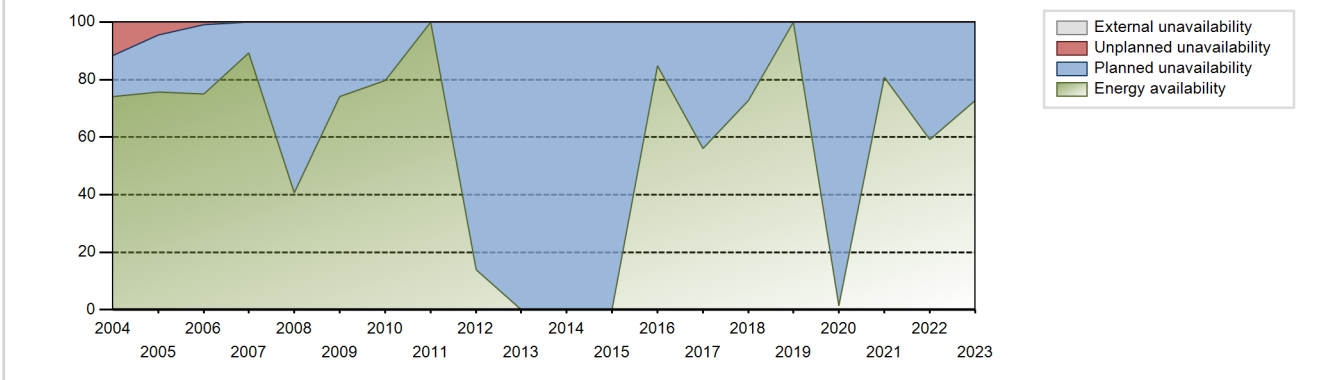


Performance for Years of Commercial Operation

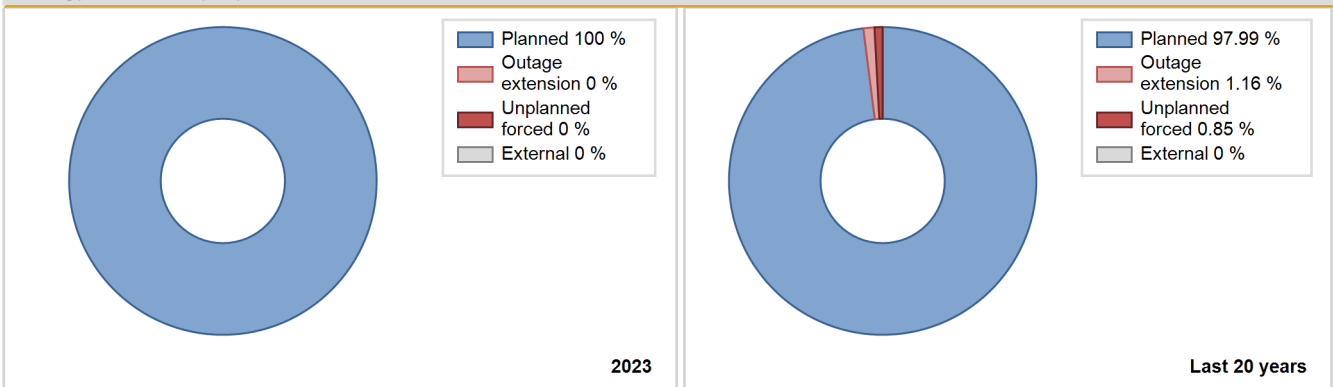
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 6199.46 | 7426 | 830 | 83.31 | 83.31 | 84.14 | 83.36 | 0.00 | 0.00 | 16.69 | 0.00 |
| 1986 | 6833.58 | 8215 | 830 | 93.08 | 93.08 | 93.99 | 93.78 | 0.00 | 0.00 | 6.92 | 0.00 |
| 1987 | 6030.38 | 7265 | 830 | 82.93 | 82.93 | 82.94 | 82.93 | 0.00 | 0.00 | 17.07 | 0.00 |
| 1988 | 5743.18 | 6948 | 830 | 79.10 | 79.10 | 78.77 | 79.10 | 0.42 | 0.33 | 20.57 | 0.00 |
| 1989 | 5987.22 | 7138 | 830 | 81.48 | 81.48 | 82.35 | 81.48 | 0.00 | 0.00 | 18.52 | 0.00 |
| 1990 | 6775.04 | 8143 | 830 | 91.88 | 91.88 | 93.18 | 92.96 | 0.00 | 0.00 | 8.12 | 0.00 |
| 1991 | 5513.55 | 6641 | 830 | 73.86 | 73.86 | 75.83 | 75.81 | 0.00 | 0.00 | 26.14 | 0.00 |
| 1992 | 6059.91 | 7292 | 830 | 82.22 | 82.22 | 83.12 | 83.01 | 0.00 | 0.00 | 17.78 | 0.00 |
| 1993 | 5804.78 | 6983 | 830 | 77.57 | 77.57 | 79.84 | 79.71 | 0.00 | 0.00 | 22.43 | 0.00 |
| 1994 | 7361.14 | 8760 | 830 | 100.00 | 100.00 | 101.24 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1995 | 5662.92 | 6809 | 830 | 77.00 | 77.00 | 77.89 | 77.73 | 0.00 | 0.00 | 23.00 | 0.00 |
| 1996 | 5479.31 | 6576 | 830 | 74.24 | 74.24 | 75.15 | 74.86 | 0.00 | 0.00 | 25.76 | 0.00 |
| 1997 | 6028.89 | 7206 | 830 | 81.88 | 81.88 | 82.92 | 82.26 | 0.00 | 0.00 | 18.12 | 0.00 |
| 1998 | 6853.72 | 8161 | 830 | 93.11 | 93.11 | 94.26 | 93.16 | 0.00 | 0.00 | 6.89 | 0.00 |
| 1999 | 6833.42 | 8131 | 830 | 92.80 | 93.85 | 93.98 | 92.82 | 0.00 | 0.00 | 6.15 | 1.05 |
| 2000 | 5898.88 | 7023 | 830 | 79.94 | 79.94 | 80.91 | 79.95 | 0.00 | 0.00 | 20.06 | 0.00 |
| 2001 | 6167.20 | 7340 | 830 | 83.77 | 83.77 | 84.82 | 83.79 | 0.00 | 0.00 | 16.23 | 0.00 |
| 2002 | 6463.31 | 7654 | 830 | 87.35 | 87.35 | 88.89 | 87.37 | 0.00 | 0.00 | 12.65 | 0.00 |
| 2003 | 7355.67 | 8421 | 830 | 96.11 | 96.11 | 101.17 | 96.13 | 0.00 | 0.00 | 3.89 | 0.00 |
| 2004 | 5625.10 | 6512 | 830 | 74.11 | 74.11 | 77.15 | 74.13 | 8.83 | 11.68 | 14.21 | 0.00 |
| 2005 | 5738.44 | 6656 | 830 | 75.61 | 75.61 | 78.92 | 75.98 | 0.00 | 4.58 | 19.81 | 0.00 |
| 2006 | 5702.85 | 6604 | 830 | 75.04 | 75.04 | 78.43 | 75.39 | 0.02 | 0.82 | 24.14 | 0.00 |
| 2007 | 6847.38 | 7834 | 830 | 89.37 | 89.37 | 94.18 | 89.43 | 0.00 | 0.00 | 10.63 | 0.00 |
| 2008 | 3102.63 | 3608 | 830 | 40.65 | 40.65 | 42.56 | 41.07 | 0.00 | 0.00 | 59.35 | 0.00 |
| 2009 | 5738.94 | 6525 | 830 | 74.19 | 74.19 | 78.93 | 74.49 | 0.00 | 0.00 | 25.81 | 0.00 |
| 2010 | 6212.08 | 7006 | 830 | 79.70 | 79.70 | 85.44 | 79.98 | 0.00 | 0.00 | 20.30 | 0.00 |
| 2011 | 7828.83 | 8760 | 830 | 99.99 | 99.99 | 107.67 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2012 | 1079.91 | 1223 | 830 | 13.92 | 13.92 | 14.81 | 13.92 | 0.00 | 0.00 | 86.08 | 0.00 |
| 2013 | 0.00 | 0 | 830 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2014 | 0.00 | 0 | 830 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2015 | 0.00 | 0 | 830 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2016 | 768.25 | 915 | 830 | 84.77 | 84.77 | 10.54 | 10.42 | 0.00 | 0.00 | 15.23 | 0.00 |
| 2017 | 4284.64 | 4944 | 830 | 56.03 | 56.03 | 58.93 | 56.44 | 0.00 | 0.00 | 43.97 | 0.00 |
| 2018 | 5595.11 | 6402 | 830 | 72.75 | 72.75 | 76.95 | 73.08 | 0.00 | 0.00 | 27.25 | 0.00 |
| 2019 | 7651.68 | 8760 | 830 | 99.99 | 99.99 | 105.24 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2020 | 111.74 | 131 | 830 | 1.45 | 1.45 | 1.53 | 1.49 | 0.00 | 0.00 | 98.55 | 0.00 |
| 2021 | 6178.54 | 7111 | 830 | 80.80 | 80.80 | 84.98 | 81.18 | 0.00 | 0.00 | 19.20 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 4534.48 | 5226 | 830 | 59.24 | 59.24 | 62.37 | 59.66 | 0.00 | 0.00 | 40.76 | 0.00 |
| 2023 | 5552.80 | 6402 | 830 | 72.75 | 72.75 | 76.37 | 73.08 | 0.00 | 0.00 | 27.25 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 3 | |
| C. Inspection, maintenance or repair combined with refuelling | 2358 | | | 1613 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 17 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 872 | | |
| H. Nuclear regulatory requirements | | | | | 10 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| M. Governmental requirements or court decisions | | | | | | 169 |
| Z. Other | | | | | 26 | |
| Subtotal | 2358 | | | 2502 | 39 | 171 |
| Total | | 2358 | | | 2712 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 11 |
| 13. Reactor Auxiliary Systems | | 2 |
| 16. Steam generation systems | | 10 |
| 31. Turbine and auxiliaries | | 16 |
| 32. Feedwater and Main Steam System | | 0 |
| Total | | 39 |

2023 Operating Experience

JP-30

TAKAHAMA-4

JAPAN

Status at end of year : **Operational**
 Operator : KEPCO (Kansai Electric Power Co.)
 Owner : KEPCO (Kansai Electric Power Co.)
 Reactor Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



Reactor Unit Details

Reactor type and model : PWR / M (3-loop)
 Thermal power : 2660 MWth
 Gross electrical power : 870 MWe
 Reference unit power (net) : 830 MWe

Key Dates

Construction Date : 1981-03-19
 Grid Date : 1984-11-01
 Commercial Date : 1985-06-05
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.1
 Refuelling frequency [month] : 13
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 40000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.1
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 321
 Number of SG : 3
 Containment type : Confinement
 Containment design pressure [MPa] : 0.28

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.21
 Output voltage [kV] : 23
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

Non-electrical applications

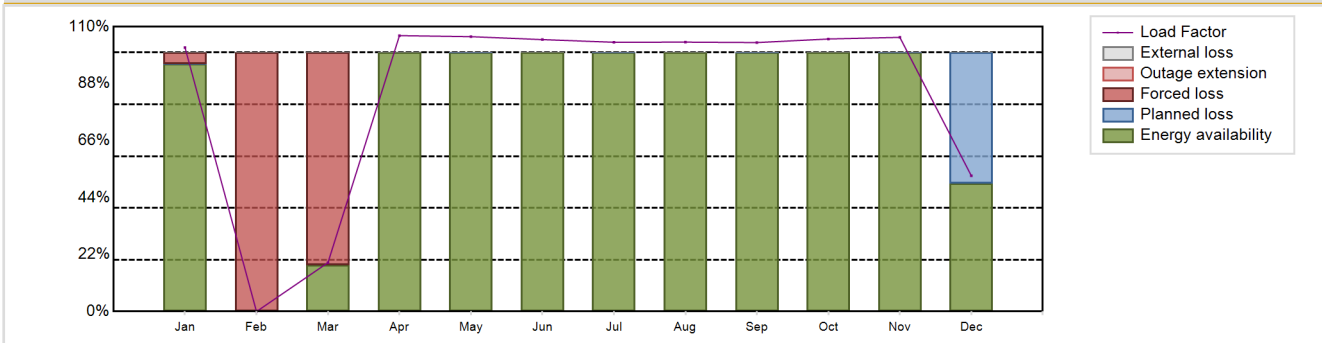
Non-electrical applications : DS

Annual Production Results (2023)

Net Energy Production : 6177.84 GW(e).h
 Energy Availability Factor (EAF) : 80.68 %
 Unit Capability Factor (UCF) : 80.68 %
 Load Factor (LF) : 84.97 %
 Operating Factor (OF) : 80.92 %
 Equivalent non-electrical energy generated (NEG) : 0 GW(e).h

Forced Loss Rate (FLR) : 15.69 %
 Unplanned Capability Loss Factor (UCL) : 15.02 %
 Planned Unavailability Factor (PUF) : 4.3 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1671 hours

Annual Summary

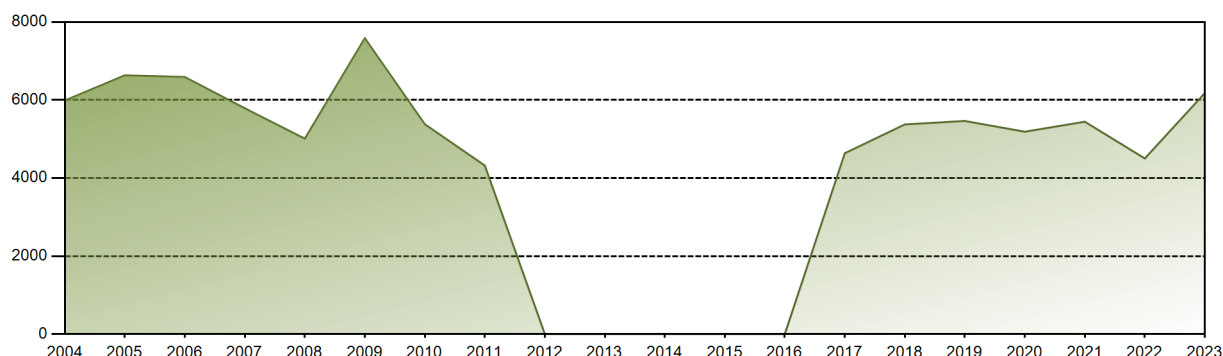


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 629.66 | 0.00 | 116.63 | 636.80 | 655.48 | 627.57 | 642.20 | 642.43 | 620.77 | 649.96 | 632.76 | 323.59 | 6177.84 |
| EAF [%] | 95.61 | 0.00 | 17.89 | 100.00 | 100.00 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 100.00 | 49.38 | 80.68 |
| UCF [%] | 95.61 | 0.00 | 17.89 | 100.00 | 100.00 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 100.00 | 49.38 | 80.68 |
| LF [%] | 101.97 | 0.00 | 18.89 | 106.56 | 106.15 | 105.02 | 104.00 | 104.03 | 103.88 | 105.25 | 105.88 | 52.40 | 84.97 |
| OF [%] | 95.56 | 0.00 | 20.30 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 49.87 | 80.92 |
| FLR [%] | 4.39 | 100.00 | 82.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.69 |
| UCL [%] | 4.39 | 100.00 | 82.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.02 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 50.62 | 4.30 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 200221.43 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.88 % |
| Cumulative Energy Availability Factor (EAF) | : 71.95 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.82 % |
| Cumulative Unit Capability Factor (UCF) | : 71.98 % | Cumulative Planned Unavailability Factor (PUF) | : 27.19 % |
| Cumulative Load Factor (LF) | : 71.32 % | Cumulative Externally cause unavailability (XUF) | : 0.03 % |
| Cumulative Operating Factor (OF) | : 69.54 % | | |

Electricity Production (net) [GWh]

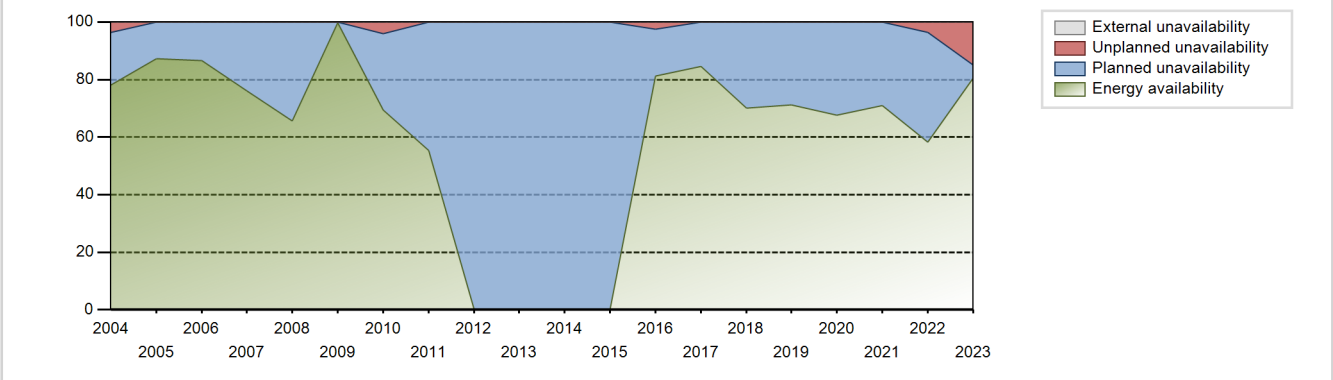


Performance for Years of Commercial Operation

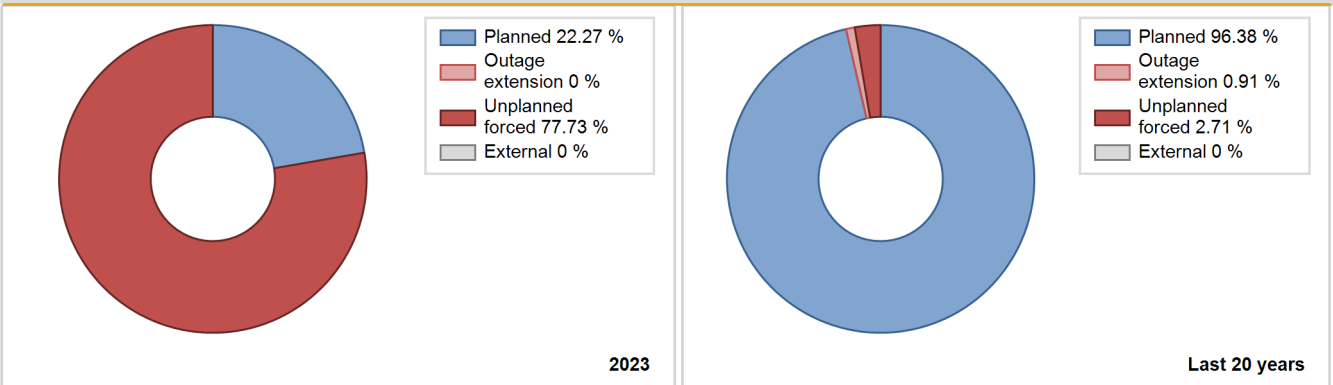
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 5479.31 | 6887 | 830 | 100.00 | 100.00 | 101.21 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1986 | 5864.02 | 7073 | 830 | 79.59 | 79.59 | 80.65 | 80.74 | 0.00 | 0.00 | 20.41 | 0.00 |
| 1987 | 5588.52 | 6743 | 830 | 76.97 | 76.97 | 76.86 | 76.97 | 0.00 | 0.00 | 23.03 | 0.00 |
| 1988 | 6437.90 | 7666 | 830 | 87.27 | 87.27 | 88.30 | 87.27 | 0.00 | 0.00 | 12.73 | 0.00 |
| 1989 | 6802.70 | 8167 | 830 | 93.23 | 93.23 | 93.56 | 93.23 | 0.00 | 0.00 | 6.77 | 0.00 |
| 1990 | 5174.56 | 6233 | 830 | 68.98 | 68.98 | 71.17 | 71.15 | 0.00 | 0.00 | 31.02 | 0.00 |
| 1991 | 6170.12 | 7409 | 830 | 83.05 | 83.05 | 84.86 | 84.58 | 0.00 | 0.00 | 16.95 | 0.00 |
| 1992 | 6048.41 | 7265 | 830 | 81.93 | 81.93 | 82.96 | 82.71 | 0.00 | 0.00 | 18.07 | 0.00 |
| 1993 | 7210.91 | 8578 | 830 | 97.86 | 97.86 | 99.18 | 97.92 | 0.00 | 0.00 | 2.14 | 0.00 |
| 1994 | 5767.17 | 6861 | 830 | 78.51 | 78.51 | 79.32 | 78.32 | 0.00 | 0.00 | 21.49 | 0.00 |
| 1995 | 5651.76 | 6785 | 830 | 76.72 | 76.72 | 77.73 | 77.45 | 0.00 | 0.00 | 23.28 | 0.00 |
| 1996 | 5666.52 | 6785 | 830 | 76.68 | 76.68 | 77.72 | 77.24 | 0.00 | 0.00 | 23.32 | 0.00 |
| 1997 | 7367.27 | 8760 | 830 | 99.99 | 99.99 | 101.33 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 1998 | 6470.18 | 7727 | 830 | 87.79 | 87.79 | 88.99 | 88.21 | 0.00 | 0.00 | 12.21 | 0.00 |
| 1999 | 5500.34 | 6542 | 830 | 74.64 | 75.83 | 75.65 | 74.68 | 3.70 | 2.92 | 21.25 | 1.20 |
| 2000 | 6099.01 | 7254 | 830 | 82.57 | 82.57 | 83.65 | 82.58 | 0.00 | 0.00 | 17.43 | 0.00 |
| 2001 | 7364.55 | 8760 | 830 | 99.99 | 99.99 | 101.29 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2002 | 6145.46 | 7316 | 830 | 83.50 | 83.50 | 84.52 | 83.52 | 0.00 | 0.00 | 16.50 | 0.00 |
| 2003 | 6490.21 | 7531 | 830 | 85.98 | 85.98 | 89.26 | 85.97 | 0.00 | 0.00 | 14.02 | 0.00 |
| 2004 | 5987.82 | 6868 | 830 | 78.17 | 78.17 | 82.13 | 78.19 | 0.00 | 3.71 | 18.12 | 0.00 |
| 2005 | 6633.20 | 7657 | 830 | 87.35 | 87.35 | 91.23 | 87.41 | 0.00 | 0.00 | 12.65 | 0.00 |
| 2006 | 6589.83 | 7612 | 830 | 86.56 | 86.56 | 90.63 | 86.89 | 0.00 | 0.00 | 13.44 | 0.00 |
| 2007 | 5787.60 | 6688 | 830 | 76.04 | 76.04 | 79.60 | 76.35 | 0.00 | 0.00 | 23.96 | 0.00 |
| 2008 | 5009.76 | 5825 | 830 | 65.56 | 65.56 | 68.71 | 66.31 | 0.00 | 0.00 | 34.44 | 0.00 |
| 2009 | 7584.98 | 8760 | 830 | 99.67 | 99.67 | 104.32 | 100.00 | 0.00 | 0.00 | 0.33 | 0.00 |
| 2010 | 5379.61 | 6130 | 830 | 69.45 | 69.45 | 73.99 | 69.98 | 5.60 | 4.12 | 26.43 | 0.00 |
| 2011 | 4320.16 | 4847 | 830 | 55.29 | 55.29 | 59.42 | 55.33 | 0.00 | 0.00 | 44.71 | 0.00 |
| 2012 | 0.00 | 0 | 830 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2013 | 0.00 | 0 | 830 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2014 | 0.00 | 0 | 830 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2015 | 0.00 | 0 | 830 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2016 | 0.00 | 0 | 830 | 81.24 | 81.24 | 0.00 | 0.00 | 2.96 | 2.48 | 16.28 | 0.00 |
| 2017 | 4636.34 | 5362 | 830 | 84.51 | 84.51 | 63.77 | 61.21 | 0.00 | 0.00 | 15.49 | 0.00 |
| 2018 | 5374.49 | 6167 | 830 | 70.04 | 70.04 | 73.92 | 70.40 | 0.00 | 0.00 | 29.96 | 0.00 |
| 2019 | 5463.11 | 6251 | 830 | 71.31 | 71.31 | 75.14 | 71.36 | 0.00 | 0.00 | 28.69 | 0.00 |
| 2020 | 5187.90 | 5969 | 830 | 67.55 | 67.55 | 71.16 | 67.95 | 0.00 | 0.00 | 32.45 | 0.00 |
| 2021 | 5443.67 | 6247 | 830 | 70.94 | 70.94 | 74.87 | 71.31 | 0.00 | 0.00 | 29.06 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2022 | 4502.02 | 5132 | 830 | 58.17 | 58.17 | 61.92 | 58.58 | 0.00 | 3.54 | 38.29 | 0.00 |
| 2023 | 6177.84 | 7089 | 830 | 80.68 | 80.68 | 84.97 | 80.92 | 15.69 | 15.02 | 4.30 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1338 | | | 65 | |
| C. Inspection, maintenance or repair combined with refuelling | 373 | | | 1408 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 1000 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| M. Governmental requirements or court decisions | | | | | | 243 |
| Z. Other | | | | | 9 | |
| Subtotal | 373 | 1338 | | 2408 | 74 | 246 |
| Total | | 1711 | | | 2728 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1985 to 2023 | |
|------------------------------|------------|-------------|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | 1338 | | 42 |
| 15. Reactor Cooling Systems | | | | 8 |
| 16. Steam generation systems | | | | 9 |
| 41. Main Generator Systems | | | | 15 |
| Total | | 1338 | | 74 |

2023 Operating Experience

KR-7

HANBIT-1

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------|--------------------|--------------|
| Reactor type and model | : PWR / WH F | Construction Date | : 1981-06-04 |
| Thermal power | : 2787 MWth | Grid Date | : 1986-03-05 |
| Gross electrical power | : 1025 MWe | Commercial Date | : 1986-08-25 |
| Reference unit power (net) | : 995 MWe | Age at end of year | : 37 years |

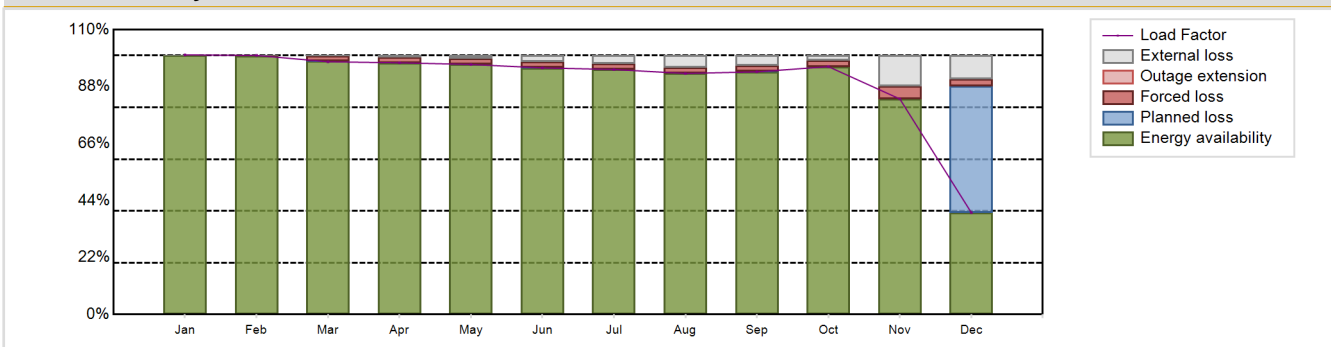
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.4 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 326 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 4.65 | Containment design pressure [MPa] | : 0.41 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 41 | Number of turbine-generators per unit/reactor | : 4 |
| Average discharge burnup [MWd/t] | : 18190 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 3.658 | HP cylinder inlet steam pressure [MPa] | : 6.54 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : 22 |
| Fuel linear heat generation rate [kW/m] | : 17.83 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 28 | Number of main condensate pumps | : 4 |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : 3 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|------------------|--|-------------|
| Net Energy Production | : 7885.1 GW(e).h | Forced Loss Rate (FLR) | : 2.28 % |
| Energy Availability Factor (EAF) | : 90.45 % | Unplanned Capability Loss Factor (UCL) | : 2.19 % |
| Unit Capability Factor (UCF) | : 93.64 % | Planned Unavailability Factor (PUF) | : 4.18 % |
| Load Factor (LF) | : 90.46 % | Externally cause unavailability (XUF) | : 3.19 % |
| Operating Factor (OF) | : 96 % | Total off-line time | : 350 hours |

Annual Summary

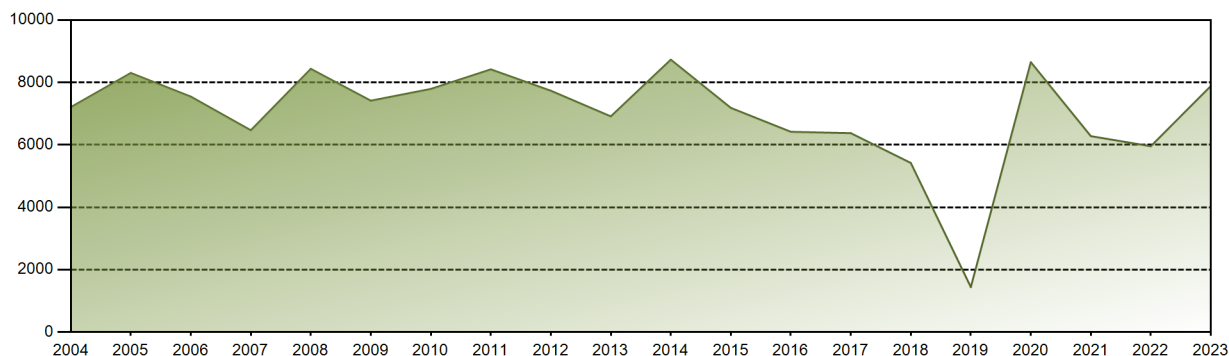


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 742.38 | 669.06 | 722.70 | 696.46 | 714.84 | 682.35 | 700.50 | 689.09 | 671.44 | 708.67 | 596.41 | 291.19 | 7885.10 |
| EAF [%] | 100.00 | 99.90 | 97.83 | 97.22 | 96.56 | 95.25 | 94.63 | 93.09 | 93.72 | 95.73 | 83.25 | 39.33 | 90.45 |
| UCF [%] | 100.00 | 99.90 | 97.91 | 97.73 | 97.73 | 97.67 | 97.70 | 97.62 | 97.66 | 97.50 | 94.95 | 48.32 | 93.64 |
| LF [%] | 100.28 | 100.06 | 97.62 | 97.22 | 96.56 | 95.25 | 94.63 | 93.09 | 93.72 | 95.73 | 83.25 | 39.33 | 90.46 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 52.96 | 96.00 |
| FLR [%] | 0.00 | 0.10 | 2.03 | 2.27 | 2.27 | 2.25 | 2.30 | 2.38 | 2.25 | 2.50 | 5.05 | 5.35 | 2.28 |
| UCL [%] | 0.00 | 0.10 | 2.02 | 2.27 | 2.27 | 2.25 | 2.30 | 2.38 | 2.25 | 2.50 | 5.05 | 2.73 | 2.19 |
| PUF [%] | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 48.95 | 4.18 |
| XUF [%] | 0.00 | 0.00 | 0.08 | 0.51 | 1.17 | 2.43 | 3.07 | 4.53 | 3.94 | 1.77 | 11.70 | 8.99 | 3.19 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 262282.77 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.03 % |
| Cumulative Energy Availability Factor (EAF) | : 83.93 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.67 % |
| Cumulative Unit Capability Factor (UCF) | : 84.25 % | Cumulative Planned Unavailability Factor (PUF) | : 13.07 % |
| Cumulative Load Factor (LF) | : 85.47 % | Cumulative Externally cause unavailability (XUF) | : 0.32 % |
| Cumulative Operating Factor (OF) | : 84.9 % | | |

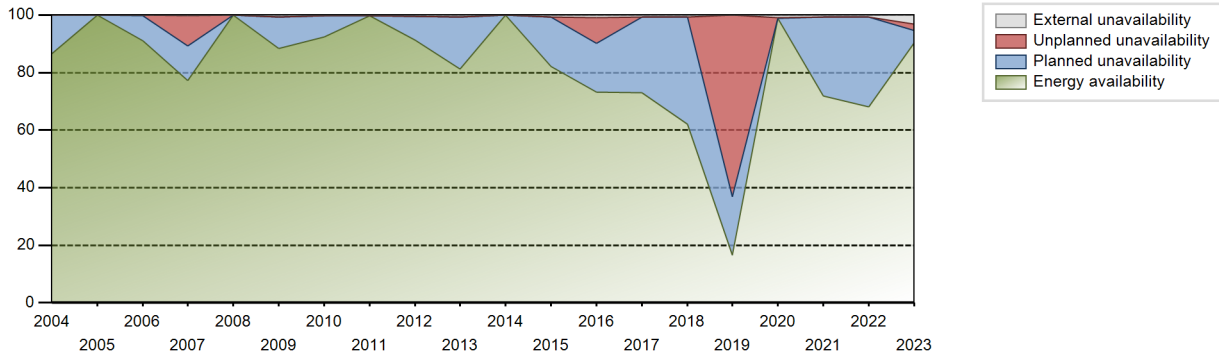
Electricity Production (net) [GWh]



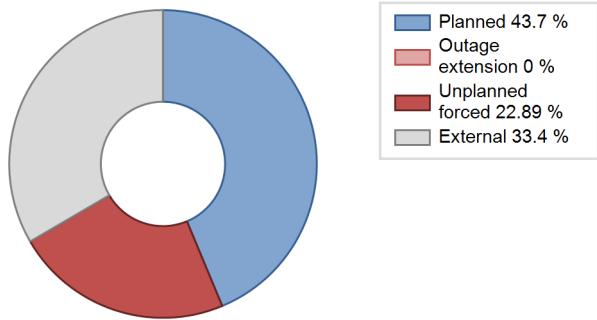
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 2467.92 | 2928 | 900 | 94.44 | 94.67 | 89.14 | 94.47 | 3.50 | 3.43 | 1.89 | 0.23 |
| 1987 | 5973.92 | 6870 | 900 | 78.77 | 78.77 | 75.77 | 78.42 | 2.26 | 1.82 | 19.41 | 0.00 |
| 1988 | 6199.62 | 6844 | 900 | 77.91 | 77.91 | 78.42 | 77.91 | 0.98 | 0.77 | 21.31 | 0.00 |
| 1989 | 6451.79 | 7136 | 900 | 81.46 | 81.46 | 81.83 | 81.46 | 0.34 | 0.27 | 18.26 | 0.00 |
| 1990 | 6897.48 | 7507 | 900 | 85.70 | 85.70 | 87.49 | 85.70 | 0.21 | 0.18 | 14.12 | 0.00 |
| 1991 | 6695.62 | 7383 | 900 | 84.27 | 84.27 | 84.93 | 84.28 | 0.27 | 0.23 | 15.50 | 0.00 |
| 1992 | 6947.35 | 7600 | 900 | 86.52 | 86.52 | 87.88 | 86.52 | 0.14 | 0.13 | 13.35 | 0.00 |
| 1993 | 6723.95 | 7603 | 900 | 86.79 | 86.79 | 85.29 | 86.79 | 0.00 | 0.00 | 13.21 | 0.00 |
| 1994 | 8230.12 | 8751 | 890 | 99.45 | 99.45 | 105.56 | 99.90 | 0.47 | 0.47 | 0.08 | 0.00 |
| 1995 | 6094.64 | 6781 | 900 | 74.94 | 74.94 | 77.30 | 77.41 | 1.58 | 1.20 | 23.85 | 0.00 |
| 1996 | 6755.47 | 7255 | 900 | 81.35 | 81.37 | 85.45 | 82.59 | 0.47 | 0.39 | 18.24 | 0.02 |
| 1997 | 8236.06 | 8741 | 900 | 99.39 | 99.39 | 104.47 | 99.78 | 0.52 | 0.52 | 0.09 | 0.01 |
| 1998 | 7104.49 | 7599 | 900 | 85.49 | 85.49 | 90.11 | 86.75 | 0.32 | 0.28 | 14.23 | 0.00 |
| 1999 | 6729.98 | 7242 | 900 | 81.07 | 81.07 | 85.36 | 82.67 | 0.41 | 0.33 | 18.60 | 0.00 |
| 2000 | 7215.09 | 7696 | 900 | 87.51 | 87.51 | 91.27 | 87.61 | 0.01 | 0.01 | 12.48 | 0.00 |
| 2001 | 8346.44 | 8760 | 900 | 99.94 | 99.94 | 105.87 | 100.00 | 0.00 | 0.00 | 0.06 | 0.00 |
| 2002 | 7419.03 | 7867 | 900 | 88.81 | 88.81 | 94.10 | 89.81 | 0.43 | 0.38 | 10.81 | 0.00 |
| 2003 | 7074.39 | 7593 | 900 | 86.32 | 86.34 | 89.73 | 86.68 | 2.68 | 2.38 | 11.28 | 0.02 |
| 2004 | 7207.19 | 7688 | 900 | 86.69 | 86.69 | 91.17 | 87.52 | 0.04 | 0.03 | 13.28 | 0.00 |
| 2005 | 8302.85 | 8760 | 900 | 99.95 | 99.97 | 105.31 | 100.00 | 0.00 | 0.00 | 0.03 | 0.02 |
| 2006 | 7545.07 | 8030 | 945 | 91.06 | 91.06 | 91.14 | 91.67 | 0.17 | 0.15 | 8.78 | 0.00 |
| 2007 | 6466.51 | 6855 | 942 | 77.26 | 77.62 | 78.36 | 78.25 | 11.85 | 10.44 | 11.95 | 0.36 |
| 2008 | 8434.70 | 8784 | 953 | 99.86 | 99.99 | 100.76 | 100.00 | 0.00 | 0.00 | 0.01 | 0.13 |
| 2009 | 7414.03 | 7785 | 953 | 88.45 | 89.05 | 88.81 | 88.87 | 0.00 | 0.00 | 10.95 | 0.60 |
| 2010 | 7791.08 | 8158 | 953 | 92.41 | 92.68 | 93.33 | 93.13 | 0.00 | 0.00 | 7.32 | 0.27 |
| 2011 | 8417.70 | 8760 | 953 | 99.80 | 99.95 | 100.83 | 100.00 | 0.00 | 0.00 | 0.05 | 0.16 |
| 2012 | 7733.46 | 8103 | 959 | 91.31 | 91.76 | 91.80 | 92.25 | 0.00 | 0.00 | 8.24 | 0.45 |
| 2013 | 6911.44 | 7204 | 997 | 81.23 | 81.94 | 81.66 | 82.24 | 0.00 | 0.00 | 18.06 | 0.71 |
| 2014 | 8729.35 | 8760 | 997 | 100.00 | 100.00 | 99.95 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 7184.07 | 7289 | 997 | 82.02 | 82.65 | 82.26 | 83.21 | 0.20 | 0.17 | 17.18 | 0.63 |
| 2016 | 6417.05 | 6539 | 996 | 73.15 | 74.13 | 73.35 | 74.44 | 10.68 | 8.86 | 17.01 | 0.97 |
| 2017 | 6374.24 | 6484 | 996 | 72.97 | 73.78 | 73.06 | 74.02 | 0.00 | 0.00 | 26.22 | 0.81 |
| 2018 | 5419.36 | 5506 | 995 | 62.03 | 62.67 | 62.18 | 62.85 | 0.00 | 0.00 | 37.33 | 0.64 |
| 2019 | 1440.24 | 1472 | 995 | 16.52 | 16.55 | 16.52 | 16.80 | 0.00 | 63.06 | 20.39 | 0.03 |
| 2020 | 8648.72 | 8784 | 995 | 98.92 | 99.89 | 98.95 | 100.00 | 0.07 | 0.07 | 0.04 | 0.96 |
| 2021 | 6278.25 | 6411 | 995 | 71.96 | 72.76 | 72.03 | 73.18 | 0.01 | 0.01 | 27.24 | 0.79 |
| 2022 | 5955.26 | 6067 | 995 | 68.16 | 68.83 | 68.32 | 69.26 | 0.01 | 0.00 | 31.17 | 0.67 |

2023 7885.10 8410 995 90.45 93.64 90.46 96.00 2.28 2.19 4.18 3.19

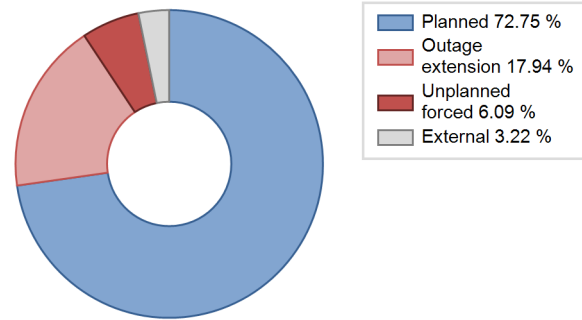
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 65 | |
| C. Inspection, maintenance or repair combined with refuelling | 350 | | | 1103 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 5 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 112 | |
| P. Fire | | | | | 36 | |
| Z. Other | | | | | | 1 |
| Subtotal | 350 | | | 1108 | 213 | 1 |
| Total | | 350 | | | 1322 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 115 |
| 15. Reactor Cooling Systems | | 37 |
| 16. Steam generation systems | | 0 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 22 |
| 32. Feedwater and Main Steam System | | 2 |
| 34. Miscellaneous Systems | | 0 |
| 41. Main Generator Systems | | 29 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 209 |

Highlights (2023)

27th Refueling and maintenance(23.12.17~24.2.28)

2023 Operating Experience

KR-8

HANBIT-2

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------|--------------------|--------------|
| Reactor type and model | : PWR / WH F | Construction Date | : 1981-12-01 |
| Thermal power | : 2787 MWth | Grid Date | : 1986-11-11 |
| Gross electrical power | : 1024 MWe | Commercial Date | : 1987-06-10 |
| Reference unit power (net) | : 988 MWe | Age at end of year | : 37 years |

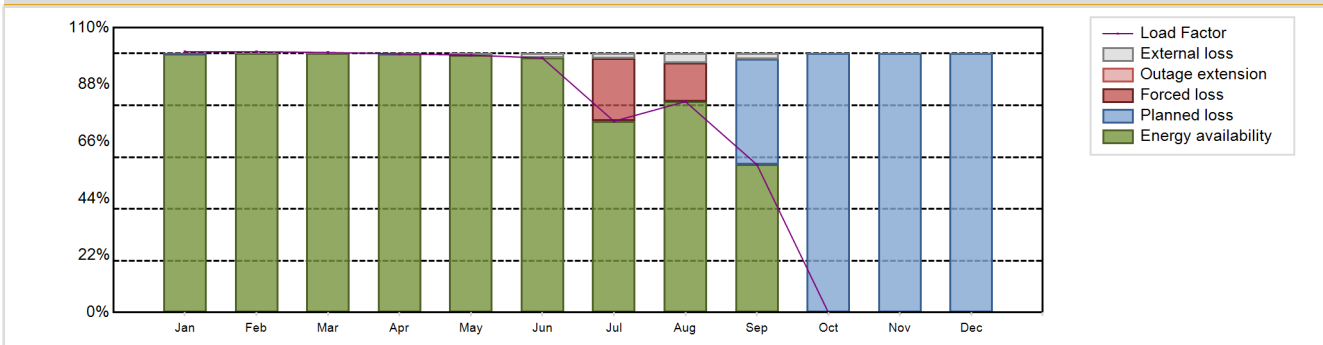
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.4 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 326 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 4.65 | Containment design pressure [MPa] | : 0.41 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 41 | Number of turbine-generators per unit/reactor | : 4 |
| Average discharge burnup [MWd/t] | : 17960 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 3.658 | HP cylinder inlet steam pressure [MPa] | : 6.54 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : 22 |
| Fuel linear heat generation rate [kW/m] | : 17.83 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 28 | Number of main condensate pumps | : 4 |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : 3 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 5835.89 GW(e).h | Forced Loss Rate (FLR) | : 4.66 % |
| Energy Availability Factor (EAF) | : 67.28 % | Unplanned Capability Loss Factor (UCL) | : 3.33 % |
| Unit Capability Factor (UCF) | : 68.1 % | Planned Unavailability Factor (PUF) | : 28.57 % |
| Load Factor (LF) | : 67.43 % | Externally cause unavailability (XUF) | : 0.82 % |
| Operating Factor (OF) | : 68.12 % | Total off-line time | : 2793 hours |

Annual Summary

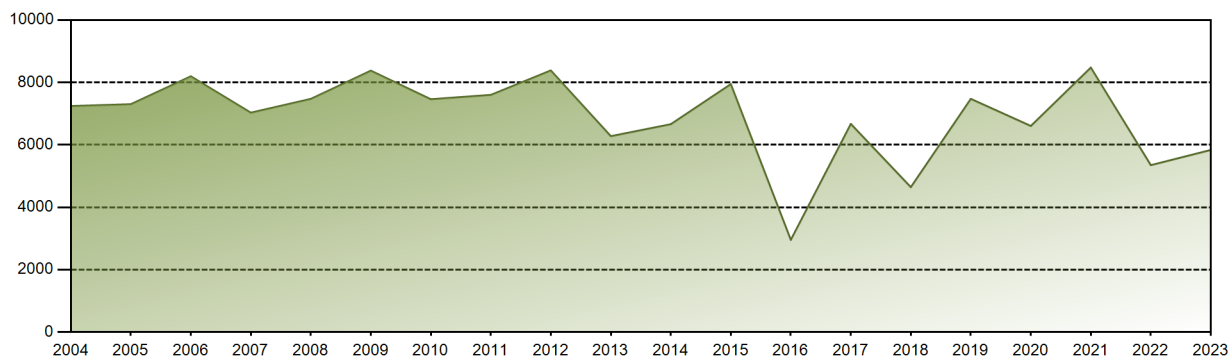


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 740.39 | 668.78 | 738.18 | 710.48 | 730.85 | 698.94 | 543.01 | 598.85 | 406.40 | 0.00 | 0.00 | 0.00 | 5835.89 |
| EAF [%] | 99.95 | 100.00 | 100.00 | 99.94 | 99.42 | 98.25 | 73.87 | 81.47 | 57.13 | 0.00 | 0.00 | 0.00 | 67.28 |
| UCF [%] | 99.95 | 100.00 | 100.00 | 99.97 | 100.00 | 100.00 | 75.66 | 85.06 | 59.16 | 0.00 | 0.00 | 0.00 | 68.10 |
| LF [%] | 100.72 | 100.73 | 100.42 | 99.88 | 99.43 | 98.25 | 73.87 | 81.47 | 57.13 | 0.00 | 0.00 | 0.00 | 67.43 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 75.81 | 82.93 | 61.39 | 0.00 | 0.00 | 0.00 | 68.12 |
| FLR [%] | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.27 | 14.94 | 0.00 | 0.00 | 0.00 | 0.00 | 4.66 |
| UCL [%] | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.24 | 14.94 | 0.00 | 0.00 | 0.00 | 0.00 | 3.33 |
| PUF [%] | 0.02 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.10 | 0.00 | 40.84 | 100.00 | 100.00 | 100.00 | 28.57 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.04 | 0.58 | 1.75 | 1.79 | 3.59 | 2.03 | 0.00 | 0.00 | 0.00 | 0.82 |

Historical Summary

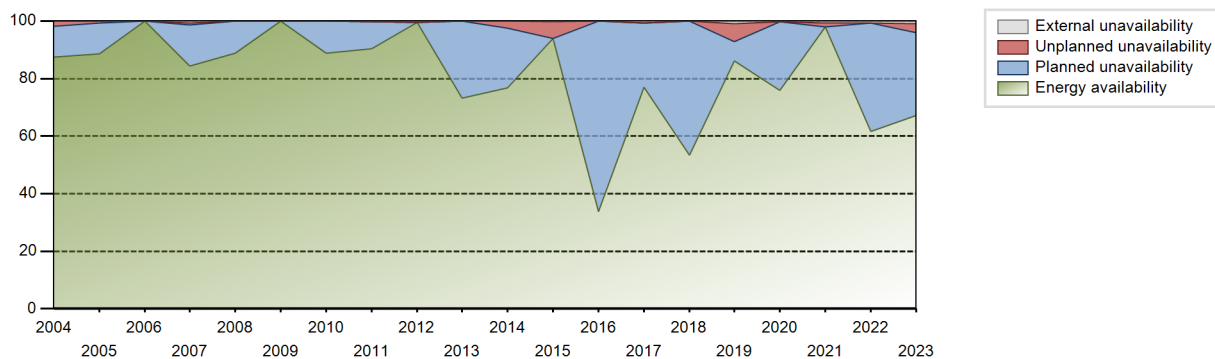
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 252060.83 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.92 % |
| Cumulative Energy Availability Factor (EAF) | : 82.35 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.95 % |
| Cumulative Unit Capability Factor (UCF) | : 82.54 % | Cumulative Planned Unavailability Factor (PUF) | : 16.51 % |
| Cumulative Load Factor (LF) | : 83.68 % | Cumulative Externally cause unavailability (XUF) | : 0.2 % |
| Cumulative Operating Factor (OF) | : 83.27 % | | |

Electricity Production (net) [GWh]

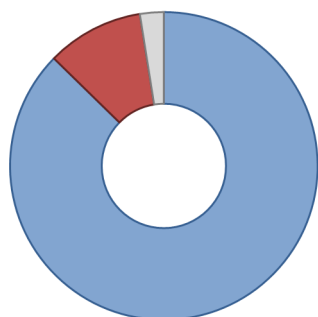


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|-------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 4297.03 | 4826 | 900 | 98.15 | 98.15 | 97.02 | 98.07 | 1.85 | 1.85 | 0.00 | 0.00 |
| 1988 | 6280.88 | 7085 | 900 | 80.65 | 80.65 | 79.45 | 80.66 | 0.31 | 0.25 | 19.10 | 0.00 |
| 1989 | 5703.24 | 6446 | 900 | 73.60 | 73.60 | 72.34 | 73.58 | 6.35 | 4.99 | 21.42 | 0.00 |
| 1990 | 5964.51 | 6757 | 900 | 77.13 | 77.13 | 75.65 | 77.13 | 1.27 | 0.99 | 21.87 | 0.00 |
| 1991 | 6714.99 | 7433 | 900 | 84.85 | 84.85 | 85.17 | 84.85 | 0.35 | 0.30 | 14.85 | 0.00 |
| 1992 | 6434.62 | 7259 | 900 | 82.64 | 82.64 | 81.39 | 82.64 | 0.41 | 0.34 | 17.02 | 0.00 |
| 1993 | 6930.49 | 7506 | 900 | 85.69 | 85.83 | 87.91 | 85.68 | 1.23 | 1.07 | 13.10 | 0.15 |
| 1994 | 7132.86 | 7687 | 890 | 85.55 | 85.55 | 91.49 | 87.75 | 0.00 | 0.00 | 14.45 | 0.00 |
| 1995 | 6036.45 | 6696 | 900 | 74.20 | 74.20 | 76.57 | 76.44 | 1.06 | 0.80 | 25.00 | 0.00 |
| 1996 | 7656.10 | 8189 | 900 | 91.59 | 91.65 | 96.84 | 93.23 | 0.00 | 0.00 | 8.35 | 0.06 |
| 1997 | 6657.34 | 7453 | 900 | 81.21 | 81.21 | 84.44 | 85.08 | 0.84 | 0.68 | 18.11 | 0.00 |
| 1998 | 6010.35 | 6583 | 900 | 74.39 | 74.50 | 76.23 | 75.15 | 0.00 | 0.00 | 25.49 | 0.11 |
| 1999 | 6718.91 | 7301 | 900 | 82.08 | 82.08 | 85.22 | 83.34 | 1.66 | 1.38 | 16.54 | 0.00 |
| 2000 | 7144.06 | 7753 | 900 | 87.07 | 87.07 | 90.37 | 88.26 | 0.31 | 0.27 | 12.66 | 0.00 |
| 2001 | 7169.67 | 7726 | 900 | 87.08 | 87.08 | 90.94 | 88.20 | 0.01 | 0.01 | 12.91 | 0.00 |
| 2002 | 8194.23 | 8744 | 900 | 99.61 | 99.90 | 103.93 | 99.82 | 0.06 | 0.06 | 0.04 | 0.29 |
| 2003 | 7413.30 | 7931 | 900 | 89.63 | 89.66 | 94.03 | 90.54 | 0.00 | 0.00 | 10.34 | 0.03 |
| 2004 | 7242.94 | 7764 | 900 | 87.51 | 87.51 | 91.62 | 88.39 | 2.05 | 1.83 | 10.66 | 0.00 |
| 2005 | 7302.40 | 7881 | 900 | 88.62 | 88.64 | 92.62 | 89.97 | 0.70 | 0.62 | 10.74 | 0.02 |
| 2006 | 8195.68 | 8719 | 939 | 99.92 | 99.99 | 99.64 | 99.53 | 0.00 | 0.00 | 0.01 | 0.07 |
| 2007 | 7030.06 | 7523 | 936 | 84.37 | 85.11 | 85.74 | 85.88 | 0.62 | 0.53 | 14.36 | 0.74 |
| 2008 | 7472.86 | 7850 | 947 | 88.91 | 89.05 | 89.83 | 89.37 | 0.00 | 0.00 | 10.95 | 0.13 |
| 2009 | 8376.93 | 8760 | 947 | 99.94 | 99.99 | 100.98 | 100.00 | 0.00 | 0.00 | 0.01 | 0.05 |
| 2010 | 7461.45 | 7830 | 947 | 88.86 | 88.95 | 89.94 | 89.38 | 0.00 | 0.00 | 11.05 | 0.09 |
| 2011 | 7600.63 | 7988 | 947 | 90.38 | 90.67 | 91.62 | 91.19 | 0.00 | 0.00 | 9.33 | 0.29 |
| 2012 | 8383.44 | 8784 | 958 | 99.47 | 99.97 | 99.62 | 100.00 | 0.01 | 0.01 | 0.01 | 0.50 |
| 2013 | 6277.11 | 6509 | 958 | 73.22 | 73.25 | 74.80 | 74.30 | 0.00 | 0.00 | 26.75 | 0.03 |
| 2014 | 6661.49 | 6789 | 977 | 76.84 | 76.92 | 77.83 | 77.50 | 2.91 | 2.30 | 20.78 | 0.08 |
| 2015 | 7944.95 | 8060 | 984 | 93.91 | 94.18 | 92.17 | 92.01 | 5.82 | 5.82 | 0.01 | 0.26 |
| 2016 | 2953.95 | 2986 | 988 | 33.80 | 33.80 | 34.04 | 33.99 | 0.02 | 0.01 | 66.19 | 0.00 |
| 2017 | 6669.35 | 6820 | 988 | 76.91 | 77.54 | 77.06 | 77.85 | 0.08 | 0.06 | 22.40 | 0.63 |
| 2018 | 4643.92 | 4714 | 988 | 53.42 | 53.54 | 53.66 | 53.81 | 0.00 | 0.00 | 46.46 | 0.11 |
| 2019 | 7473.09 | 7657 | 988 | 86.23 | 87.13 | 86.35 | 87.41 | 0.01 | 6.20 | 6.67 | 0.90 |
| 2020 | 6603.94 | 6722 | 988 | 75.93 | 76.11 | 76.09 | 76.53 | 0.00 | 0.00 | 23.89 | 0.19 |
| 2021 | 8475.06 | 8700 | 988 | 97.85 | 98.66 | 97.92 | 99.32 | 1.19 | 1.19 | 0.15 | 0.81 |
| 2022 | 5348.60 | 5495 | 988 | 61.68 | 62.30 | 61.80 | 62.73 | 0.03 | 0.02 | 37.68 | 0.62 |
| 2023 | 5835.89 | 5967 | 988 | 67.28 | 68.10 | 67.43 | 68.12 | 4.66 | 3.33 | 28.57 | 0.82 |

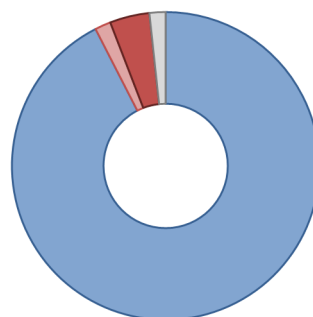
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 308 | | | 57 | |
| C. Inspection, maintenance or repair combined with refuelling | 2486 | | | 1315 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 69 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 6 |
| L. Human factor related | | | | | 17 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| Subtotal | 2486 | 308 | | 1384 | 74 | 6 |
| Total | | 2794 | | | 1464 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 1 |
| 15. Reactor Cooling Systems | | 15 |
| 16. Steam generation systems | | 25 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 31. Turbine and auxiliaries | | 3 |
| 32. Feedwater and Main Steam System | | 5 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 11 |
| 42. Electrical Power Supply Systems | 308 | 14 |
| Total | 308 | 74 |

Highlights (2023)

Automatic scram(S/G Low-Low Level due to Turbine trip(sps equipment operation), 23/7/24)
26th refueling and maintenance(23.09.19-24.01.19)

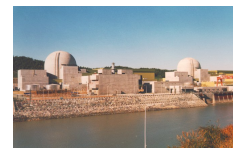
2023 Operating Experience

KR-11

HANBIT-3

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKAEC (DOOSAN HEAVY INDUSTRIES AND CONSTRUCTION CO. LTD./KOREA ATOMIC ENERGY RESEARCH INSTITUTE/COMBUSTION ENGINEERING)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)

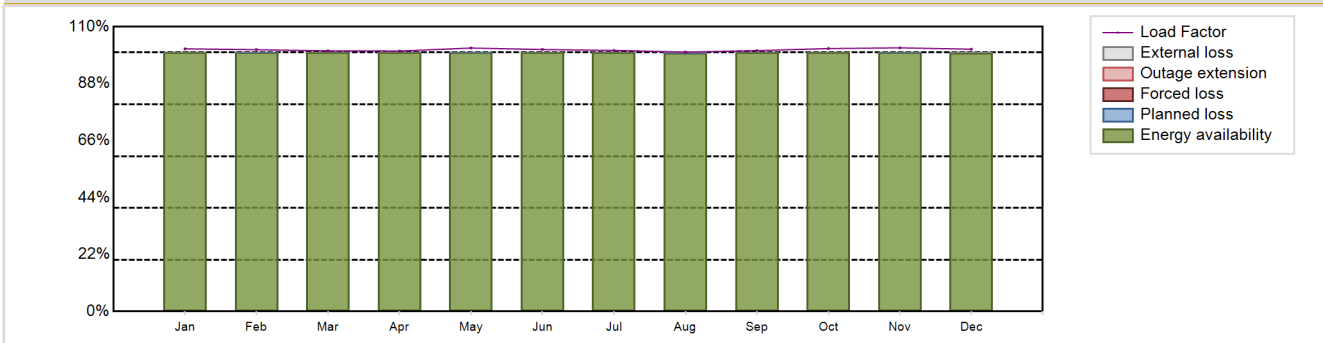


| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / OPR-1000 | Construction Date | : 1989-12-23 |
| Thermal power | : 2825 MWth | Grid Date | : 1994-10-30 |
| Gross electrical power | : 1041 MWe | Commercial Date | : 1995-03-31 |
| Reference unit power (net) | : 986 MWe | Age at end of year | : 29 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327.3 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.37 |
| Average fuel enrichment [% of U235] | : 4.2 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 4 |
| Part of the core refuelled [%] | : 36 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 42700 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.124 | HP cylinder inlet steam pressure [MPa] | : 7.14 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 177 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.26 | Number of main condensate pumps | : 4 |
| Number of control rod assemblies | : 73 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | |
| | | | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 8733.45 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.97 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 100 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 101.11 % | Externally cause unavailability (XUF) | : 0.03 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

Annual Summary

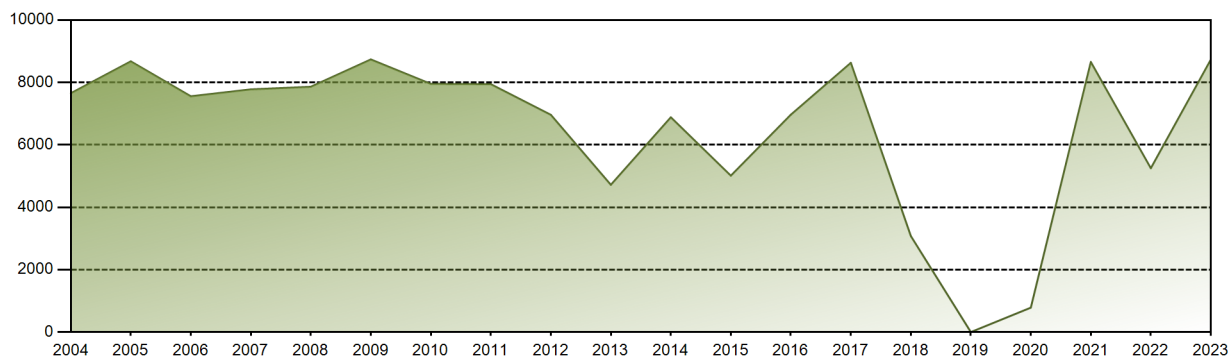


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 744.17 | 670.04 | 738.59 | 714.20 | 746.50 | 718.35 | 739.83 | 735.06 | 715.37 | 745.08 | 723.01 | 743.25 | 8733.45 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.93 | 100.00 | 100.00 | 100.00 | 99.76 | 99.97 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| LF [%] | 101.44 | 101.12 | 100.68 | 100.60 | 101.76 | 101.19 | 100.85 | 100.20 | 100.77 | 101.57 | 101.84 | 101.32 | 101.11 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.24 | 0.03 |

Historical Summary

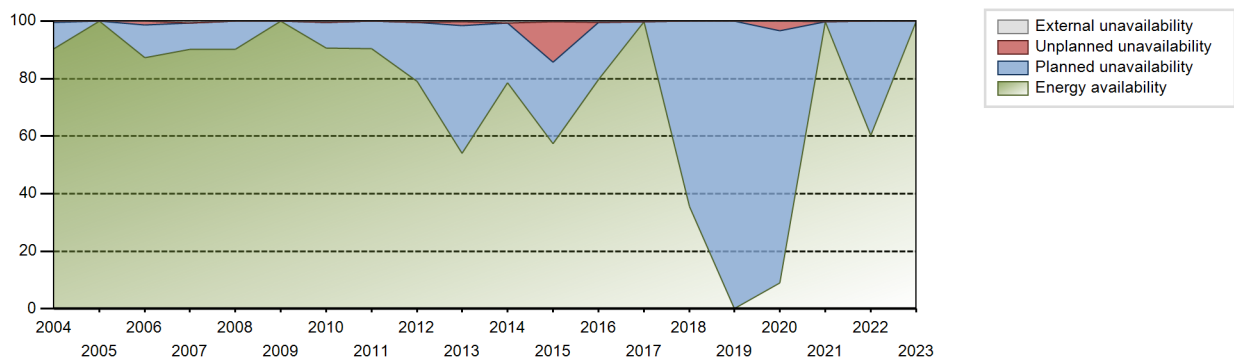
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 197771.14 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.03 % |
| Cumulative Energy Availability Factor (EAF) | : 78.51 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.82 % |
| Cumulative Unit Capability Factor (UCF) | : 78.65 % | Cumulative Planned Unavailability Factor (PUF) | : 20.53 % |
| Cumulative Load Factor (LF) | : 79.69 % | Cumulative Externally cause unavailability (XUF) | : 0.14 % |
| Cumulative Operating Factor (OF) | : 79.18 % | | |

Electricity Production (net) [GWh]

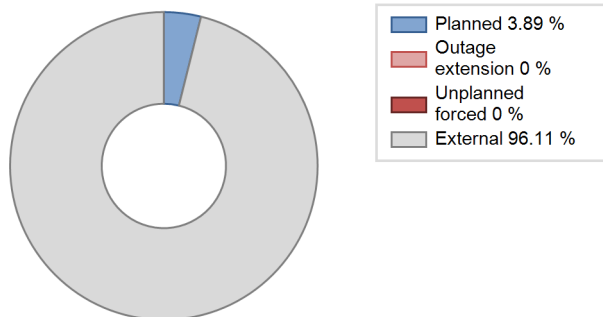


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1995 | 6430.28 | 6573 | 950 | 99.19 | 99.19 | 102.56 | 99.59 | 0.77 | 0.77 | 0.04 | 0.00 |
| 1996 | 6366.17 | 6589 | 950 | 73.97 | 73.98 | 76.29 | 75.01 | 0.22 | 0.17 | 25.85 | 0.01 |
| 1997 | 7229.61 | 7443 | 950 | 84.03 | 84.03 | 86.87 | 84.97 | 0.53 | 0.45 | 15.52 | 0.00 |
| 1998 | 7400.78 | 7566 | 950 | 85.47 | 85.47 | 88.93 | 86.37 | 0.00 | 0.00 | 14.53 | 0.00 |
| 1999 | 7395.31 | 7678 | 950 | 86.70 | 86.70 | 88.86 | 87.65 | 0.83 | 0.73 | 12.57 | 0.00 |
| 2000 | 7262.02 | 7568 | 950 | 85.62 | 85.62 | 87.02 | 86.16 | 0.17 | 0.15 | 14.23 | 0.00 |
| 2001 | 8629.13 | 8760 | 950 | 99.96 | 99.96 | 103.69 | 100.00 | 0.04 | 0.04 | 0.00 | 0.00 |
| 2002 | 7658.18 | 7831 | 950 | 89.09 | 89.09 | 92.02 | 89.39 | 0.08 | 0.07 | 10.84 | 0.00 |
| 2003 | 7818.09 | 7971 | 950 | 90.08 | 90.08 | 93.94 | 90.99 | 0.51 | 0.46 | 9.46 | 0.00 |
| 2004 | 7654.72 | 7801 | 950 | 90.35 | 90.35 | 91.73 | 88.81 | 0.48 | 0.43 | 9.22 | 0.00 |
| 2005 | 8675.55 | 8760 | 950 | 99.98 | 99.98 | 104.25 | 100.00 | 0.02 | 0.02 | 0.00 | 0.01 |
| 2006 | 7556.77 | 7800 | 985 | 87.34 | 87.40 | 87.58 | 89.04 | 1.44 | 1.27 | 11.32 | 0.06 |
| 2007 | 7778.30 | 7916 | 987 | 90.18 | 90.81 | 89.96 | 90.37 | 0.00 | 0.00 | 9.19 | 0.63 |
| 2008 | 7861.88 | 7967 | 997 | 90.11 | 90.21 | 89.77 | 90.70 | 0.00 | 0.00 | 9.79 | 0.10 |
| 2009 | 8737.18 | 8760 | 997 | 100.00 | 100.00 | 100.04 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 7953.95 | 8014 | 997 | 90.68 | 91.13 | 91.07 | 91.48 | 0.00 | 0.00 | 8.87 | 0.46 |
| 2011 | 7944.10 | 7973 | 997 | 90.45 | 90.52 | 90.96 | 91.02 | 0.06 | 0.05 | 9.43 | 0.07 |
| 2012 | 6961.94 | 6994 | 1000 | 79.02 | 79.49 | 79.26 | 79.62 | 0.00 | 0.00 | 20.51 | 0.47 |
| 2013 | 4719.06 | 4809 | 997 | 53.98 | 54.28 | 54.03 | 54.90 | 2.28 | 1.27 | 44.45 | 0.30 |
| 2014 | 6882.52 | 6938 | 1000 | 78.55 | 79.16 | 78.57 | 79.20 | 0.00 | 0.00 | 20.84 | 0.61 |
| 2015 | 5012.19 | 5125 | 994 | 57.44 | 57.63 | 57.56 | 58.50 | 19.65 | 14.10 | 28.27 | 0.19 |
| 2016 | 6965.40 | 7091 | 994 | 79.59 | 80.08 | 79.78 | 80.73 | 0.00 | 0.00 | 19.92 | 0.49 |
| 2017 | 8628.46 | 8760 | 986 | 99.69 | 99.99 | 99.90 | 100.00 | 0.00 | 0.00 | 0.01 | 0.30 |
| 2018 | 3078.30 | 3130 | 986 | 35.54 | 35.54 | 35.64 | 35.73 | 0.00 | 0.00 | 64.46 | 0.00 |
| 2019 | 0.00 | 0 | 986 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2020 | 783.33 | 903 | 986 | 9.00 | 9.00 | 9.04 | 10.28 | 27.50 | 3.41 | 87.59 | 0.00 |
| 2021 | 8655.69 | 8760 | 986 | 99.75 | 99.94 | 100.21 | 100.00 | 0.06 | 0.06 | 0.01 | 0.19 |
| 2022 | 5249.90 | 5343 | 986 | 60.27 | 60.28 | 60.78 | 60.99 | 0.00 | 0.00 | 39.72 | 0.00 |
| 2023 | 8733.45 | 8760 | 986 | 99.97 | 100.00 | 101.11 | 100.00 | 0.00 | 0.00 | 0.00 | 0.03 |

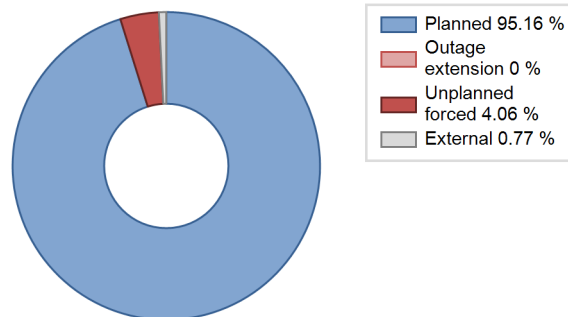
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1995 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 60 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1761 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 4 | | |
| E. Testing of plant systems or components | | | | | 0 | |
| L. Human factor related | | | | | 0 | |
| Subtotal | | | | 1765 | 60 | |
| Total | | 0 | | | 1825 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1995 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 1 |
| 15. Reactor Cooling Systems | | | | 42 |
| 31. Turbine and auxiliaries | | | | 2 |
| 32. Feedwater and Main Steam System | | | | 2 |
| 35. All other I&C Systems | | | | 1 |
| 41. Main Generator Systems | | | | 0 |
| 42. Electrical Power Supply Systems | | | | 13 |
| Total | | | | 61 |

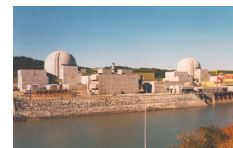
2023 Operating Experience

KR-12

HANBIT-4

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKAEC (DOOSAN HEAVY INDUSTRIES AND CONSTRUCTION CO. LTD./KOREA ATOMIC ENERGY RESEARCH INSTITUTE/COMBUSTION ENGINEERING)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / OPR-1000
 Thermal power : 2825 MWth
 Gross electrical power : 1041 MWe
 Reference unit power (net) : 970 MWe

Key Dates

Construction Date : 1990-05-26
 Grid Date : 1995-07-18
 Commercial Date : 1996-01-01
 Age at end of year : 28 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.2
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 36
 Average discharge burnup [MWd/t] : 42700
 Active core diameter [m] : 3.124
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 17.26
 Number of control rod assemblies : 73
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.3
 Number of SG : 2
 Containment type : Double
 Containment design pressure [MPa] : 0.37

Secondary systems

Number of turbine-generators per unit/reactor : 4
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 7.14
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

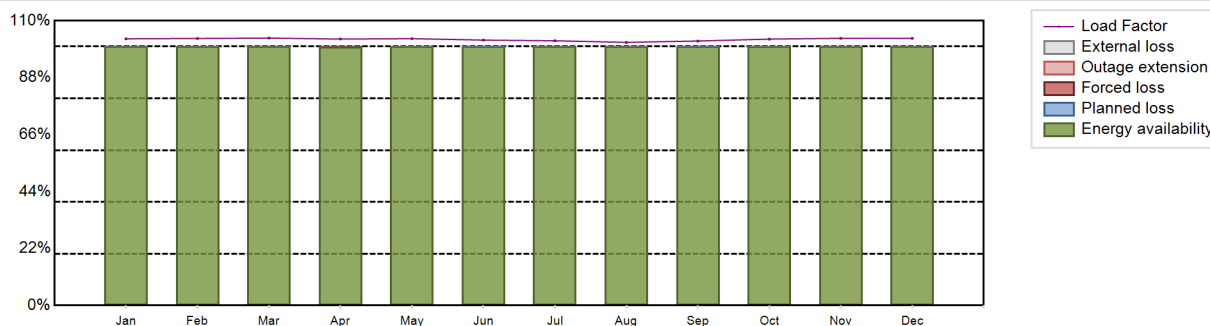
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8732.26 GW(e).h
 Energy Availability Factor (EAF) : 99.98 %
 Unit Capability Factor (UCF) : 99.98 %
 Load Factor (LF) : 102.77 %
 Operating Factor (OF) : 100 %
 Forced Loss Rate (FLR) : 0.02 %
 Unplanned Capability Loss Factor (UCL) : 0.02 %
 Planned Unavailability Factor (PUF) : 0 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

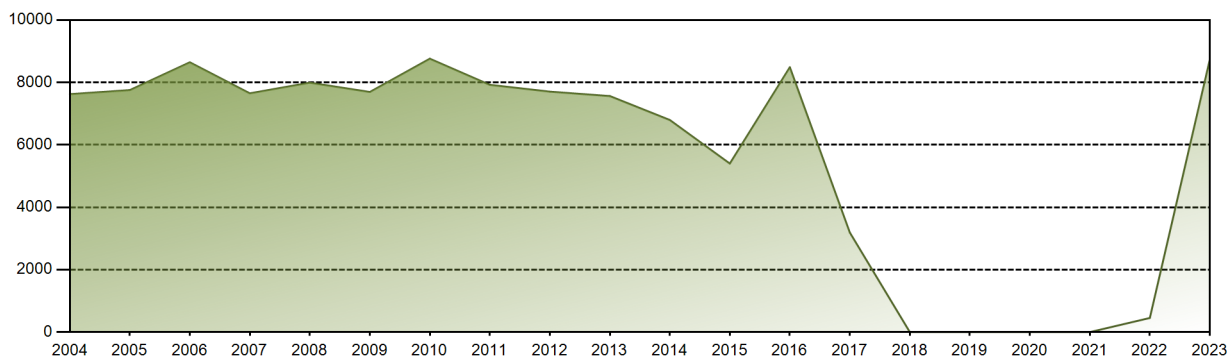


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 743.43 | 672.31 | 745.36 | 718.71 | 743.81 | 715.90 | 737.83 | 733.45 | 713.38 | 742.61 | 720.81 | 744.66 | 8732.26 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 99.75 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.98 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 99.75 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.98 |
| LF [%] | 103.01 | 103.14 | 103.28 | 102.91 | 103.07 | 102.51 | 102.24 | 101.63 | 102.14 | 102.90 | 103.21 | 103.18 | 102.77 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

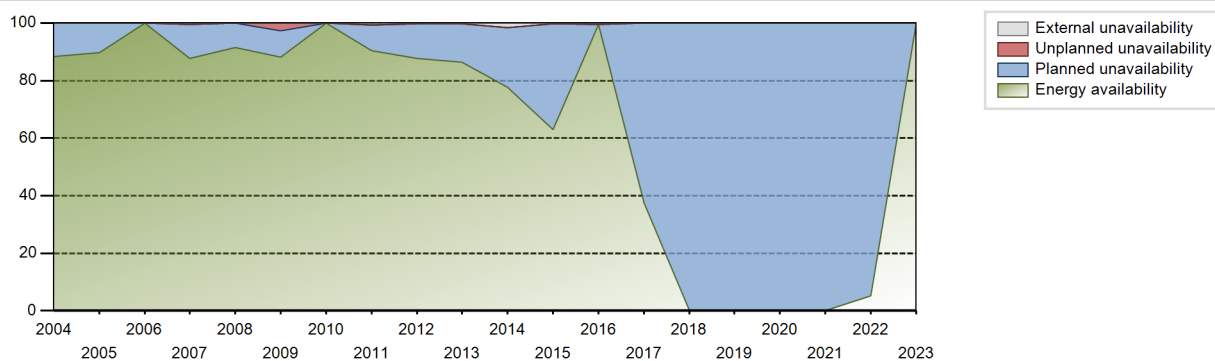
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 175057.86 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.36 % |
| Cumulative Energy Availability Factor (EAF) | : 71.36 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.31 % |
| Cumulative Unit Capability Factor (UCF) | : 71.52 % | Cumulative Planned Unavailability Factor (PUF) | : 28.18 % |
| Cumulative Load Factor (LF) | : 72.65 % | Cumulative Externally cause unavailability (XUF) | : 0.15 % |
| Cumulative Operating Factor (OF) | : 71.96 % | | |

Electricity Production (net) [GWh]

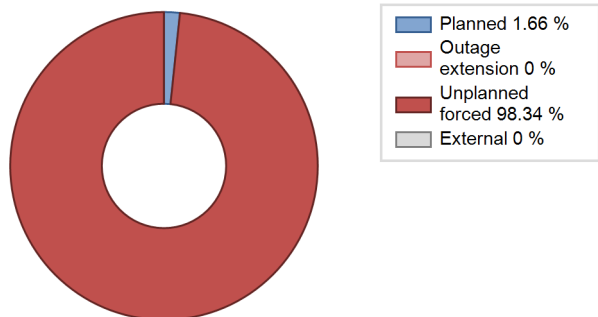


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|------|------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1996 | 7197.47 | 7565 | 950 | 83.49 | 83.50 | 86.25 | 86.12 | 1.71 | 1.45 | 15.05 | 0.00 |
| 1997 | 6767.71 | 7125 | 950 | 78.80 | 78.80 | 81.32 | 81.34 | 3.24 | 2.64 | 18.56 | 0.00 |
| 1998 | 8427.31 | 8591 | 950 | 97.14 | 97.14 | 101.27 | 98.07 | 0.09 | 0.08 | 2.78 | 0.00 |
| 1999 | 7627.93 | 7883 | 950 | 89.03 | 89.03 | 91.66 | 89.99 | 0.37 | 0.33 | 10.64 | 0.00 |
| 2000 | 7252.26 | 7441 | 950 | 84.65 | 84.65 | 86.91 | 84.71 | 0.25 | 0.21 | 15.14 | 0.00 |
| 2001 | 7237.24 | 7424 | 950 | 84.76 | 84.76 | 86.97 | 84.75 | 0.00 | 0.00 | 15.24 | 0.00 |
| 2002 | 7653.46 | 7808 | 950 | 88.65 | 88.65 | 91.97 | 89.13 | 0.00 | 0.00 | 11.35 | 0.00 |
| 2003 | 8576.76 | 8652 | 950 | 98.68 | 98.68 | 103.06 | 98.77 | 1.22 | 1.22 | 0.10 | 0.00 |
| 2004 | 7624.86 | 7782 | 950 | 88.28 | 88.28 | 91.37 | 88.59 | 0.00 | 0.00 | 11.72 | 0.00 |
| 2005 | 7754.98 | 7879 | 950 | 89.80 | 89.80 | 93.19 | 89.94 | 0.00 | 0.00 | 10.20 | 0.01 |
| 2006 | 8646.19 | 8760 | 988 | 99.99 | 99.99 | 99.90 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2007 | 7651.07 | 7790 | 987 | 87.78 | 88.37 | 88.49 | 88.93 | 0.00 | 0.00 | 11.63 | 0.59 |
| 2008 | 7992.63 | 8084 | 994 | 91.42 | 91.44 | 91.54 | 92.03 | 0.04 | 0.04 | 8.52 | 0.02 |
| 2009 | 7694.28 | 7768 | 994 | 88.07 | 88.07 | 88.36 | 88.68 | 1.51 | 2.68 | 9.25 | 0.00 |
| 2010 | 8760.58 | 8760 | 994 | 99.91 | 99.97 | 100.61 | 100.00 | 0.03 | 0.03 | 0.00 | 0.06 |
| 2011 | 7923.20 | 8005 | 994 | 90.37 | 91.00 | 90.99 | 91.38 | 0.00 | 0.00 | 9.00 | 0.64 |
| 2012 | 7705.11 | 7765 | 996 | 87.65 | 87.83 | 88.07 | 88.40 | 0.00 | 0.00 | 12.17 | 0.17 |
| 2013 | 7563.57 | 7618 | 997 | 86.44 | 86.80 | 86.60 | 86.96 | 0.00 | 0.00 | 13.20 | 0.36 |
| 2014 | 6796.58 | 6989 | 998 | 77.74 | 79.30 | 77.74 | 79.78 | 0.00 | 0.00 | 20.70 | 1.56 |
| 2015 | 5400.06 | 5584 | 980 | 62.89 | 63.18 | 62.90 | 63.74 | 0.00 | 0.00 | 36.82 | 0.29 |
| 2016 | 8487.73 | 8784 | 970 | 99.54 | 99.99 | 99.62 | 100.00 | 0.00 | 0.00 | 0.01 | 0.45 |
| 2017 | 3188.64 | 3298 | 970 | 37.48 | 37.49 | 37.53 | 37.65 | 0.00 | 0.00 | 62.51 | 0.01 |
| 2018 | 0.00 | 0 | 970 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2019 | 0.00 | 0 | 970 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2020 | 0.00 | 0 | 970 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2021 | 0.00 | 0 | 970 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2022 | 452.16 | 505 | 970 | 5.19 | 5.19 | 5.32 | 5.76 | 0.00 | 0.00 | 94.81 | 0.00 |
| 2023 | 8732.26 | 8760 | 970 | 99.98 | 99.98 | 102.77 | 100.00 | 0.02 | 0.02 | 0.00 | 0.00 |

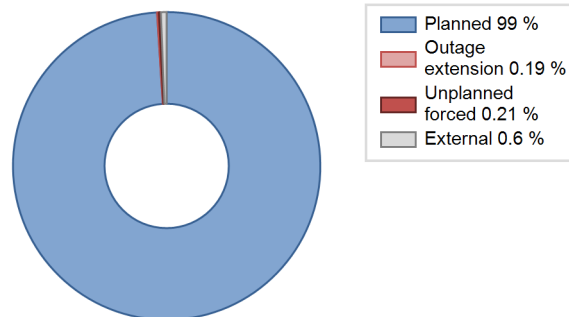
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1996 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 21 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 2436 | | |
| L. Human factor related | | | | | 0 | |
| Subtotal | | | | 2436 | 21 | |
| Total | | 0 | | | 2457 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1996 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 3 |
| 14. Safety Systems | | 4 |
| 31. Turbine and auxiliaries | | 2 |
| 32. Feedwater and Main Steam System | | 2 |
| 41. Main Generator Systems | | 4 |
| 42. Electrical Power Supply Systems | | 7 |
| Total | | 22 |

2023 Operating Experience

KR-17

HANBIT-5

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



Reactor Unit Details

Reactor type and model : PWR / OPR-1000
 Thermal power : 2825 MWth
 Gross electrical power : 1051 MWe
 Reference unit power (net) : 992 MWe

Key Dates

Construction Date : 1997-06-29
 Grid Date : 2001-12-19
 Commercial Date : 2002-05-21
 Age at end of year : 22 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 36
 Average discharge burnup [MWd/t] : 13820
 Active core diameter [m] : 3.124
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 19.68
 Number of control rod assemblies : 73
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.3
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.39

Secondary systems

Number of turbine-generators per unit/reactor : 4
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 4
 HP cylinder inlet steam pressure [MPa] : 7.14
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

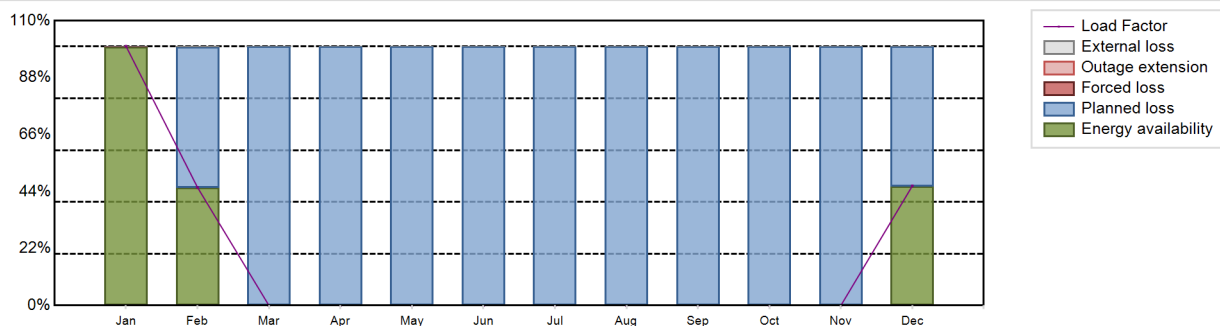
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 1384.55 GW(e).h
 Energy Availability Factor (EAF) : 15.89 %
 Unit Capability Factor (UCF) : 15.9 %
 Load Factor (LF) : 15.93 %
 Operating Factor (OF) : 16.47 %
 Forced Loss Rate (FLR) : 0.03 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 84.09 %
 Externally cause unavailability (XUF) : 0.01 %
 Total off-line time : 7317 hours

Annual Summary

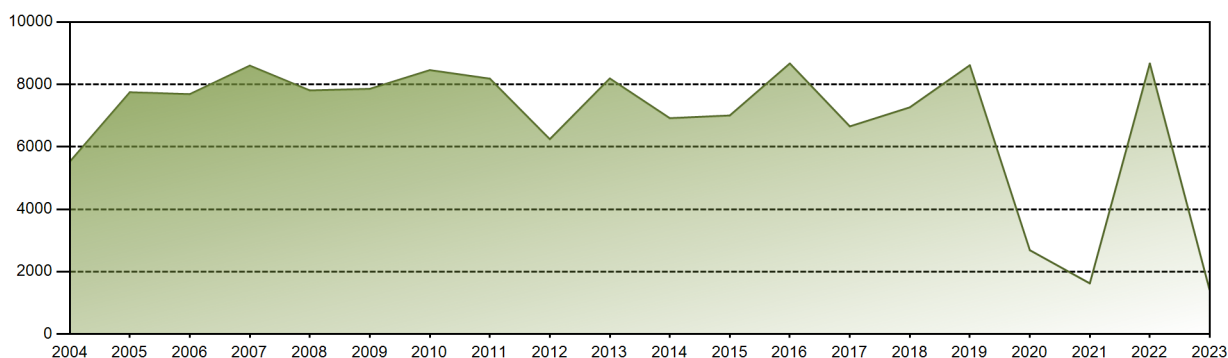


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 739.28 | 304.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 341.06 | 1384.55 |
| EAF [%] | 99.94 | 45.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 45.95 | 15.89 |
| UCF [%] | 99.94 | 45.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 45.95 | 15.90 |
| LF [%] | 100.17 | 45.63 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 46.21 | 15.93 |
| OF [%] | 100.00 | 47.92 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 50.67 | 16.47 |
| FLR [%] | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| UCL [%] | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 54.20 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 54.05 | 84.09 |
| XUF [%] | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 149376.77 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.53 % |
| Cumulative Energy Availability Factor (EAF) | : 78.47 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.85 % |
| Cumulative Unit Capability Factor (UCF) | : 78.65 % | Cumulative Planned Unavailability Factor (PUF) | : 15.5 % |
| Cumulative Load Factor (LF) | : 79.17 % | Cumulative Externally cause unavailability (XUF) | : 0.18 % |
| Cumulative Operating Factor (OF) | : 79.29 % | | |

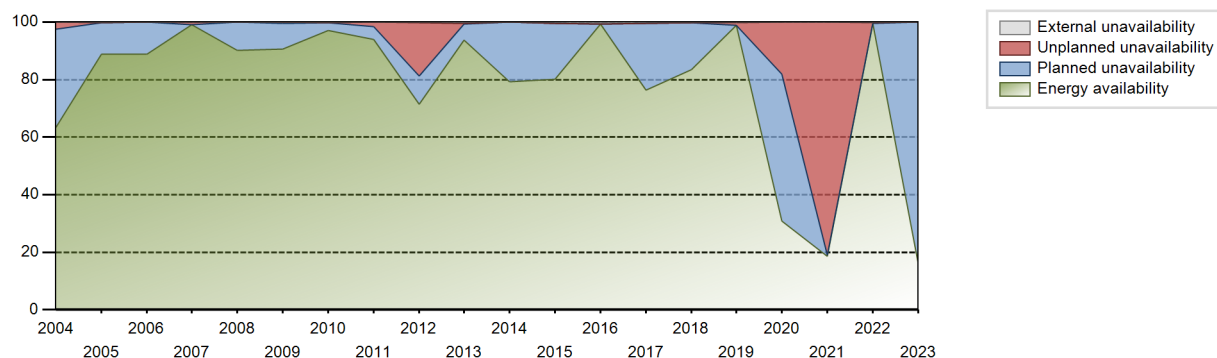
Electricity Production (net) [GWh]



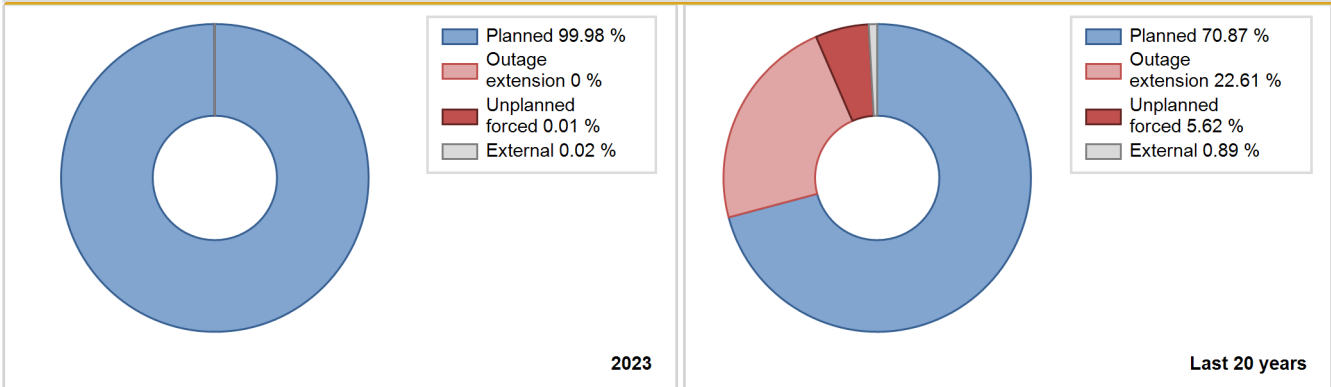
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|--------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2002 | 5006.77 | 5095 | 950 | 98.71 | 98.71 | 102.59 | 99.18 | 1.25 | 1.25 | 0.03 | 0.00 |
| 2003 | 6694.37 | 6856 | 950 | 77.12 | 77.12 | 80.44 | 78.26 | 1.14 | 0.89 | 22.00 | 0.00 |
| 2004 | 5524.51 | 5611 | 950 | 63.34 | 63.34 | 66.20 | 63.88 | 3.63 | 2.39 | 34.27 | 0.00 |
| 2005 | 7748.43 | 7873 | 950 | 88.80 | 89.00 | 93.11 | 89.87 | 0.00 | 0.00 | 11.00 | 0.20 |
| 2006 | 7688.25 | 7859 | 987 | 88.80 | 88.83 | 88.92 | 89.71 | 0.00 | 0.00 | 11.17 | 0.04 |
| 2007 | 8601.74 | 8725 | 990 | 99.11 | 99.12 | 99.19 | 99.60 | 0.88 | 0.88 | 0.00 | 0.01 |
| 2008 | 7807.37 | 7972 | 988 | 90.21 | 90.24 | 89.96 | 90.76 | 0.00 | 0.00 | 9.76 | 0.03 |
| 2009 | 7857.49 | 7987 | 988 | 90.56 | 90.58 | 90.79 | 91.18 | 0.46 | 0.42 | 9.00 | 0.02 |
| 2010 | 8457.74 | 8528 | 988 | 97.12 | 97.27 | 97.72 | 97.35 | 0.00 | 0.00 | 2.73 | 0.15 |
| 2011 | 8183.75 | 8283 | 988 | 93.90 | 93.94 | 94.56 | 94.55 | 1.65 | 1.58 | 4.48 | 0.04 |
| 2012 | 6244.61 | 6428 | 993 | 71.41 | 71.60 | 71.59 | 73.18 | 20.53 | 18.50 | 9.89 | 0.19 |
| 2013 | 8191.47 | 8290 | 997 | 93.81 | 94.29 | 93.79 | 94.63 | 0.19 | 0.18 | 5.53 | 0.47 |
| 2014 | 6918.10 | 6984 | 994 | 79.19 | 79.30 | 79.45 | 79.73 | 0.00 | 0.00 | 20.70 | 0.12 |
| 2015 | 7004.72 | 7122 | 994 | 80.16 | 80.74 | 80.45 | 81.30 | 0.00 | 0.00 | 19.26 | 0.57 |
| 2016 | 8671.06 | 8784 | 994 | 99.31 | 100.00 | 99.31 | 100.00 | 0.00 | 0.00 | 0.00 | 0.69 |
| 2017 | 6655.11 | 6783 | 994 | 76.41 | 76.79 | 76.43 | 77.43 | 0.00 | 0.00 | 23.21 | 0.38 |
| 2018 | 7265.08 | 7387 | 992 | 83.43 | 83.76 | 83.60 | 84.33 | 0.00 | 0.00 | 16.24 | 0.33 |
| 2019 | 8613.69 | 8709 | 992 | 98.95 | 99.30 | 99.12 | 99.42 | 0.69 | 0.69 | 0.00 | 0.35 |
| 2020 | 2688.51 | 2882 | 992 | 30.76 | 30.76 | 30.85 | 32.81 | 0.00 | 18.19 | 51.05 | 0.00 |
| 2021 | 1624.65 | 1660 | 992 | 18.59 | 18.59 | 18.70 | 18.95 | 0.00 | 81.04 | 0.37 | 0.00 |
| 2022 | 8671.23 | 8760 | 992 | 99.62 | 99.94 | 99.78 | 100.00 | 0.05 | 0.05 | 0.00 | 0.33 |
| 2023 | 1384.55 | 1443 | 992 | 15.89 | 15.90 | 15.93 | 16.47 | 0.03 | 0.00 | 84.09 | 0.01 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2002 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 170 | |
| C. Inspection, maintenance or repair combined with refuelling | 7316 | | | 1297 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 19 | | |
| E. Testing of plant systems or components | | | | | 331 | |
| Subtotal | 7316 | | | 1316 | 501 | |
| Total | | 7316 | | | 1817 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2002 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 4 |
| 12. Reactor I&C Systems | | 399 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 2 |
| 16. Steam generation systems | | 10 |
| 35. All other I&C Systems | | 12 |
| 42. Electrical Power Supply Systems | | 63 |
| Total | | 492 |

Highlights (2023)

The 14th Refueling & maintenance from 2023-02-14 to 2023-12-16.

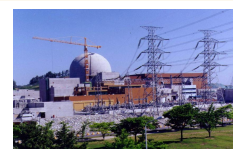
2023 Operating Experience

KR-18

HANBIT-6

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



Reactor Unit Details

Reactor type and model : PWR / OPR-1000
 Thermal power : 2825 MWth
 Gross electrical power : 1053 MWe
 Reference unit power (net) : 993 MWe

Key Dates

Construction Date : 1997-11-20
 Grid Date : 2002-09-16
 Commercial Date : 2002-12-24
 Age at end of year : 21 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 36
 Average discharge burnup [MWd/t] : 13450
 Active core diameter [m] : 3.124
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 19.68
 Number of control rod assemblies : 73
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.3
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.39

Secondary systems

Number of turbine-generators per unit/reactor : 4
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 7.14
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

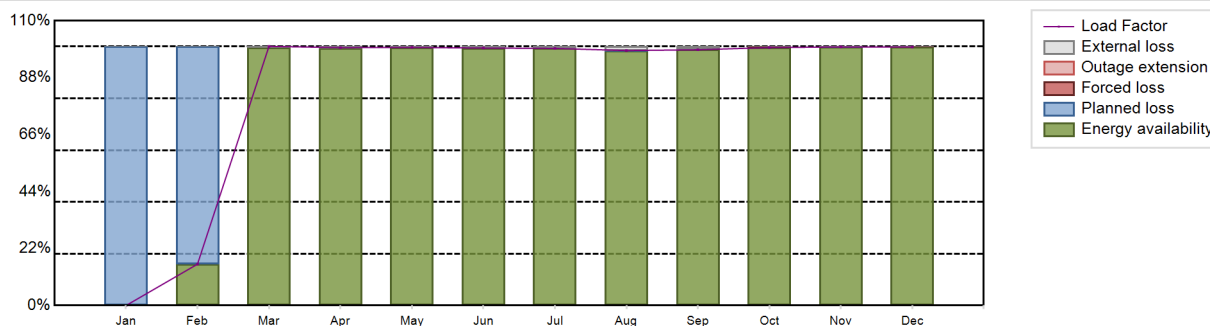
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7360.22 GW(e).h
 Energy Availability Factor (EAF) : 84.54 %
 Unit Capability Factor (UCF) : 85 %
 Load Factor (LF) : 84.61 %
 Operating Factor (OF) : 85.5 %
 Forced Loss Rate (FLR) : 0.07 %
 Unplanned Capability Loss Factor (UCL) : 0.06 %
 Planned Unavailability Factor (PUF) : 14.94 %
 Externally cause unavailability (XUF) : 0.46 %
 Total off-line time : 1270 hours

Annual Summary

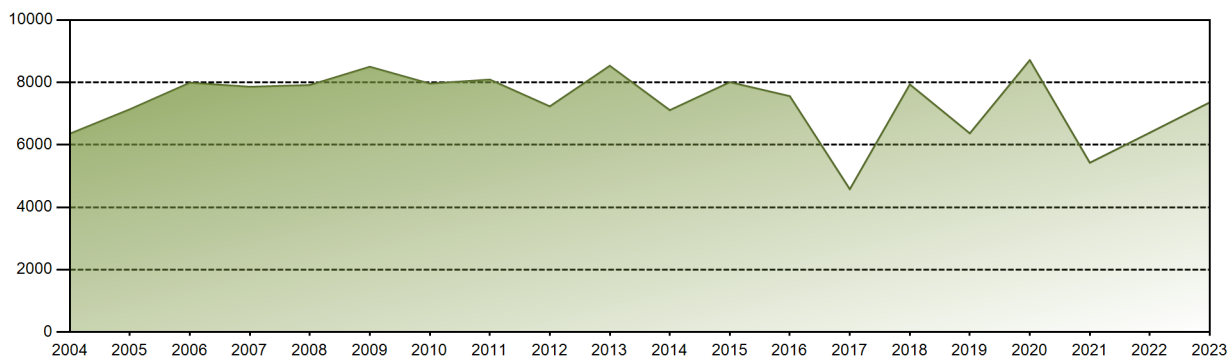


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 106.57 | 739.38 | 712.15 | 736.50 | 710.88 | 733.53 | 727.46 | 706.15 | 736.03 | 714.01 | 737.57 | 7360.22 |
| EAF [%] | 0.00 | 15.96 | 99.55 | 99.34 | 99.67 | 99.43 | 99.29 | 98.47 | 98.77 | 99.63 | 99.85 | 99.83 | 84.54 |
| UCF [%] | 0.00 | 15.96 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.98 | 100.00 | 99.63 | 99.85 | 99.83 | 85.00 |
| LF [%] | 0.00 | 15.97 | 100.08 | 99.61 | 99.69 | 99.43 | 99.29 | 98.47 | 98.77 | 99.63 | 99.87 | 99.83 | 84.61 |
| OF [%] | 0.00 | 21.73 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.50 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 0.14 | 0.17 | 0.07 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 0.14 | 0.17 | 0.06 |
| PUF [%] | 100.00 | 84.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 14.94 |
| XUF [%] | 0.00 | 0.00 | 0.45 | 0.66 | 0.33 | 0.57 | 0.71 | 1.51 | 1.23 | 0.00 | 0.00 | 0.00 | 0.46 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 156387.59 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.33 % |
| Cumulative Energy Availability Factor (EAF) | : 84.8 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.28 % |
| Cumulative Unit Capability Factor (UCF) | : 85.05 % | Cumulative Planned Unavailability Factor (PUF) | : 14.67 % |
| Cumulative Load Factor (LF) | : 85.08 % | Cumulative Externally cause unavailability (XUF) | : 0.25 % |
| Cumulative Operating Factor (OF) | : 85.5 % | | |

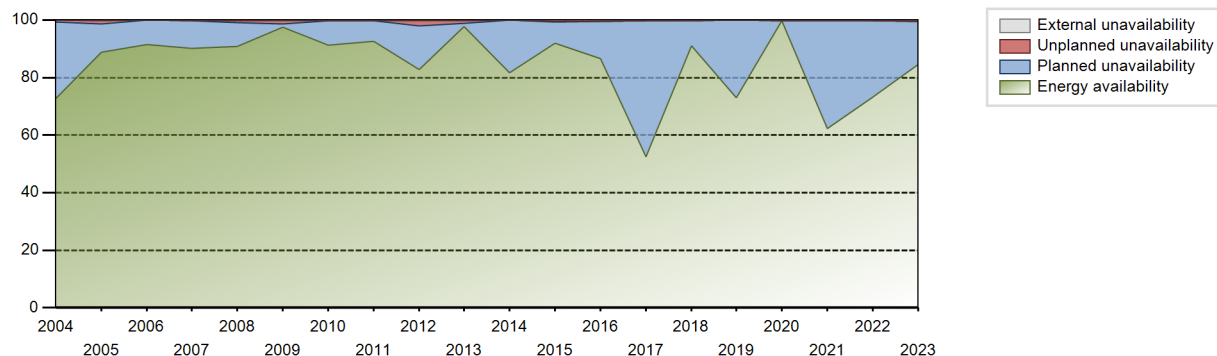
Electricity Production (net) [GWh]



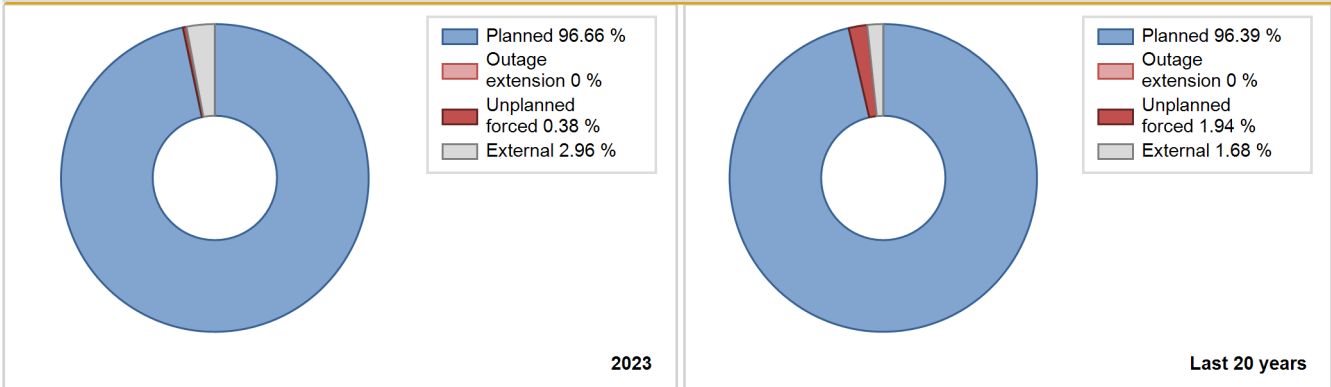
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|------------------------|------------------------------|-------|--------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2002 | 1058.41 | 1461 | 996 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 7652.19 | 7728 | 950 | 88.21 | 88.21 | 91.95 | 88.22 | 0.00 | 0.00 | 11.79 | 0.00 |
| 2004 | 6354.49 | 6449 | 950 | 72.78 | 72.78 | 76.15 | 73.42 | 0.82 | 0.60 | 26.61 | 0.00 |
| 2005 | 7137.13 | 7906 | 950 | 88.78 | 89.13 | 85.76 | 90.25 | 1.12 | 1.01 | 9.87 | 0.35 |
| 2006 | 7988.59 | 8064 | 993 | 91.48 | 91.52 | 91.84 | 92.05 | 0.00 | 0.00 | 8.48 | 0.03 |
| 2007 | 7859.23 | 7957 | 993 | 90.14 | 90.35 | 90.35 | 90.83 | 0.02 | 0.02 | 9.63 | 0.21 |
| 2008 | 7914.57 | 8073 | 996 | 90.90 | 91.13 | 90.46 | 91.91 | 0.66 | 0.61 | 8.27 | 0.23 |
| 2009 | 8501.44 | 8606 | 996 | 97.56 | 97.90 | 97.44 | 98.24 | 0.95 | 0.94 | 1.16 | 0.34 |
| 2010 | 7961.42 | 8060 | 996 | 91.19 | 91.48 | 91.25 | 92.01 | 0.00 | 0.00 | 8.52 | 0.29 |
| 2011 | 8090.64 | 8179 | 996 | 92.65 | 92.90 | 92.73 | 93.37 | 0.00 | 0.00 | 7.10 | 0.24 |
| 2012 | 7231.21 | 7325 | 993 | 82.72 | 82.96 | 82.90 | 83.39 | 2.12 | 1.80 | 15.24 | 0.24 |
| 2013 | 8531.74 | 8631 | 995 | 97.74 | 98.04 | 97.88 | 98.53 | 0.89 | 0.88 | 1.08 | 0.31 |
| 2014 | 7110.37 | 7235 | 993 | 81.59 | 81.73 | 81.74 | 82.59 | 0.00 | 0.00 | 18.27 | 0.14 |
| 2015 | 8006.79 | 8122 | 993 | 91.92 | 92.48 | 92.05 | 92.72 | 0.07 | 0.07 | 7.46 | 0.56 |
| 2016 | 7559.26 | 7667 | 993 | 86.50 | 86.88 | 86.66 | 87.28 | 0.00 | 0.00 | 13.12 | 0.38 |
| 2017 | 4576.12 | 4642 | 993 | 52.57 | 52.82 | 52.61 | 52.99 | 0.00 | 0.00 | 47.18 | 0.25 |
| 2018 | 7934.90 | 8042 | 993 | 91.06 | 91.41 | 91.22 | 91.80 | 0.00 | 0.00 | 8.59 | 0.36 |
| 2019 | 6367.31 | 6446 | 993 | 72.99 | 73.01 | 73.20 | 73.58 | 0.00 | 0.00 | 26.99 | 0.01 |
| 2020 | 8714.05 | 8784 | 993 | 99.71 | 100.00 | 99.90 | 100.00 | 0.00 | 0.00 | 0.00 | 0.29 |
| 2021 | 5425.44 | 5532 | 993 | 62.25 | 62.45 | 62.37 | 63.15 | 0.00 | 0.00 | 37.55 | 0.20 |
| 2022 | 6389.15 | 6444 | 993 | 73.27 | 73.53 | 73.45 | 73.56 | 0.00 | 0.00 | 26.47 | 0.26 |
| 2023 | 7360.22 | 7490 | 993 | 84.54 | 85.00 | 84.61 | 85.50 | 0.07 | 0.06 | 14.94 | 0.46 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2002 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 20 | |
| C. Inspection, maintenance or repair combined with refuelling | 1270 | | | 1247 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 4 | | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant , spare part delivery problems etc.) | | | | | | 0 |
| Subtotal | 1270 | | | 1251 | 20 | 0 |
| Total | | 1270 | | | 1271 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2002 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 2 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 10 |
| Total | | 20 |

2023 Operating Experience

KR-9

HANUL-1

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)



Reactor Unit Details

Reactor type and model : PWR / France CPI
 Thermal power : 2775 MWth
 Gross electrical power : 1014 MWe
 Reference unit power (net) : 966 MWe

Key Dates

Construction Date : 1983-01-26
 Grid Date : 1988-04-07
 Commercial Date : 1988-09-10
 Age at end of year : 35 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 38
 Average discharge burnup [MWd/t] : 42500
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.83
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 323.2
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.42

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.53
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

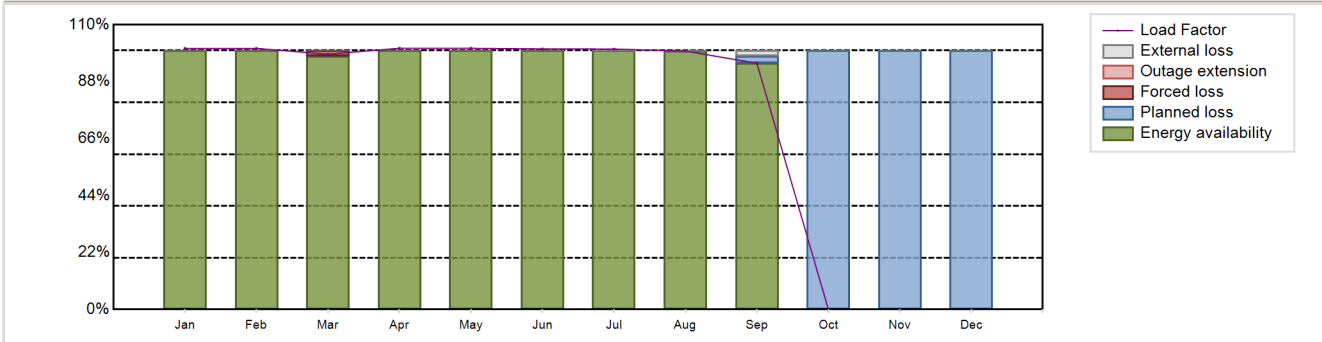
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6316.71 GW(e).h
 Energy Availability Factor (EAF) : 74.19 %
 Unit Capability Factor (UCF) : 74.39 %
 Load Factor (LF) : 74.65 %
 Operating Factor (OF) : 74.63 %
 Forced Loss Rate (FLR) : 0.25 %
 Unplanned Capability Loss Factor (UCL) : 0.18 %
 Planned Unavailability Factor (PUF) : 25.43 %
 Externally cause unavailability (XUF) : 0.2 %
 Total off-line time : 2222 hours

Annual Summary

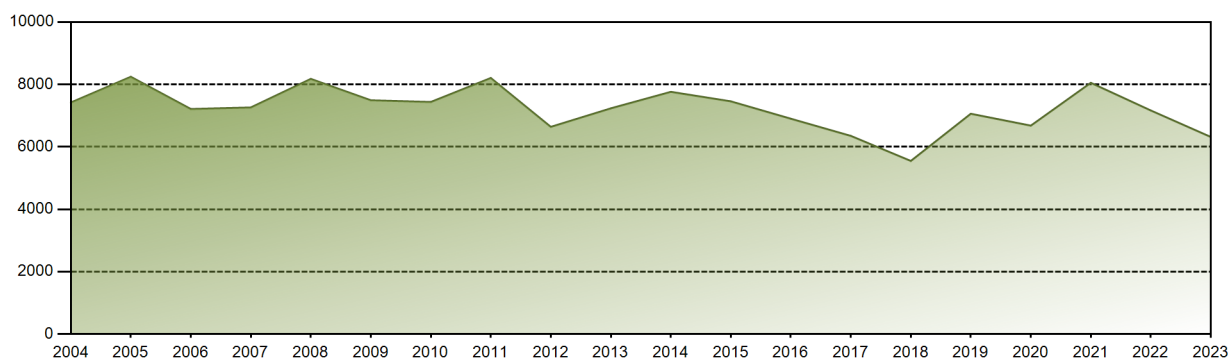


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 724.68 | 654.62 | 708.64 | 701.74 | 725.02 | 700.10 | 722.99 | 717.32 | 661.61 | 0.00 | 0.00 | 0.00 | 6316.71 |
| EAF [%] | 100.00 | 100.00 | 97.83 | 100.00 | 100.00 | 100.00 | 100.00 | 99.75 | 95.12 | 0.00 | 0.00 | 0.00 | 74.19 |
| UCF [%] | 100.00 | 100.00 | 97.83 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.28 | 0.00 | 0.00 | 0.00 | 74.39 |
| LF [%] | 100.83 | 100.84 | 98.60 | 100.89 | 100.88 | 100.66 | 100.60 | 99.81 | 95.12 | 0.00 | 0.00 | 0.00 | 74.65 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.06 | 0.00 | 0.00 | 0.00 | 74.63 |
| FLR [%] | 0.00 | 0.00 | 2.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 |
| UCL [%] | 0.00 | 0.00 | 2.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.72 | 100.00 | 100.00 | 100.00 | 25.43 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 2.16 | 0.00 | 0.00 | 0.00 | 0.20 |

Historical Summary

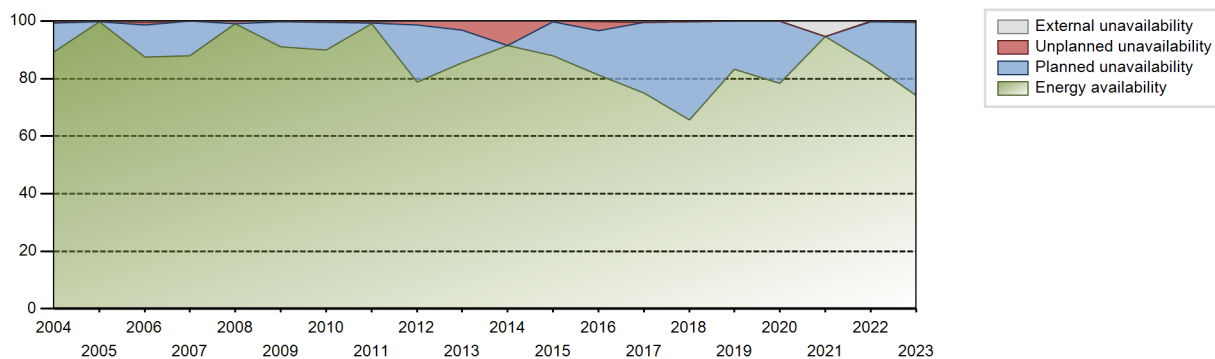
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 249258.68 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.27 % |
| Cumulative Energy Availability Factor (EAF) | : 85.22 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.98 % |
| Cumulative Unit Capability Factor (UCF) | : 85.61 % | Cumulative Planned Unavailability Factor (PUF) | : 12.41 % |
| Cumulative Load Factor (LF) | : 85.47 % | Cumulative Externally cause unavailability (XUF) | : 0.39 % |
| Cumulative Operating Factor (OF) | : 85.75 % | | |

Electricity Production (net) [GWh]

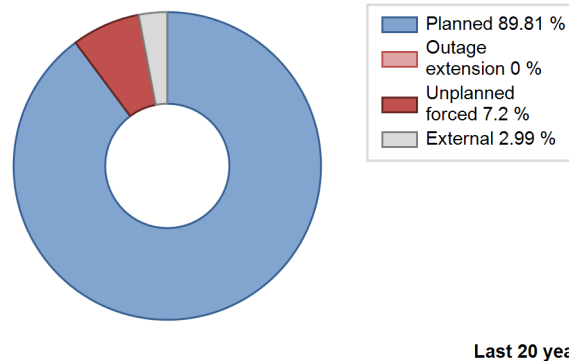
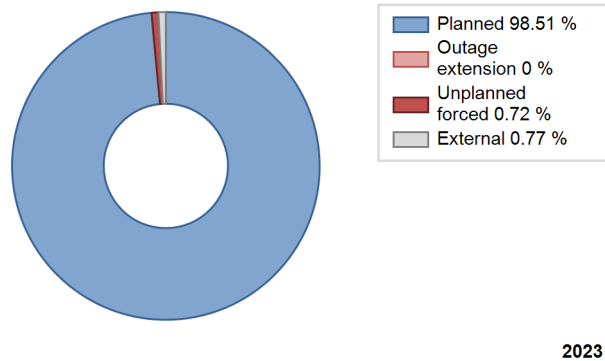


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | | | | Data not provided | | | | | | | |
| 1989 | 5205.36 | 5821 | 920 | 66.45 | 66.45 | 64.59 | 66.45 | 15.49 | 12.18 | 21.37 | 0.00 |
| 1990 | 6166.21 | 7156 | 920 | 81.69 | 81.69 | 76.51 | 81.69 | 1.16 | 0.96 | 17.35 | 0.00 |
| 1991 | 7244.32 | 7970 | 920 | 90.98 | 90.98 | 89.89 | 90.98 | 2.19 | 2.04 | 6.99 | 0.00 |
| 1992 | 7020.77 | 7675 | 920 | 87.37 | 87.37 | 86.88 | 87.37 | 0.04 | 0.03 | 12.59 | 0.00 |
| 1993 | 6977.60 | 7651 | 920 | 87.34 | 87.34 | 86.58 | 87.34 | 0.20 | 0.18 | 12.48 | 0.00 |
| 1994 | 6878.53 | 7293 | 890 | 82.02 | 82.02 | 88.23 | 83.25 | 0.01 | 0.00 | 17.97 | 0.00 |
| 1995 | 7153.82 | 7698 | 920 | 85.73 | 85.73 | 88.77 | 87.88 | 0.31 | 0.27 | 14.00 | 0.00 |
| 1996 | 7113.66 | 7631 | 920 | 85.42 | 85.63 | 88.03 | 86.87 | 0.93 | 0.81 | 13.56 | 0.21 |
| 1997 | 6801.00 | 7323 | 920 | 82.25 | 83.72 | 84.39 | 83.60 | 2.57 | 2.21 | 14.07 | 1.46 |
| 1998 | 7642.97 | 8256 | 920 | 91.45 | 94.06 | 94.84 | 94.25 | 0.00 | 0.00 | 5.94 | 2.61 |
| 1999 | 7161.55 | 7639 | 920 | 86.12 | 86.12 | 88.86 | 87.20 | 0.53 | 0.46 | 13.42 | 0.00 |
| 2000 | 7230.77 | 7736 | 920 | 86.34 | 86.75 | 89.48 | 88.07 | 0.23 | 0.20 | 13.05 | 0.41 |
| 2001 | 7022.30 | 7483 | 920 | 84.48 | 85.14 | 87.13 | 85.42 | 7.14 | 6.55 | 8.31 | 0.66 |
| 2002 | 5462.40 | 6052 | 920 | 75.98 | 75.98 | 67.78 | 69.09 | 24.01 | 24.01 | 0.01 | 0.00 |
| 2003 | 6371.56 | 7446 | 920 | 85.20 | 85.21 | 79.06 | 85.00 | 0.35 | 0.30 | 14.49 | 0.01 |
| 2004 | 7420.13 | 7970 | 920 | 89.27 | 89.48 | 91.82 | 90.73 | 0.55 | 0.50 | 10.02 | 0.21 |
| 2005 | 8245.04 | 8760 | 920 | 99.80 | 99.88 | 102.31 | 100.00 | 0.11 | 0.11 | 0.00 | 0.08 |
| 2006 | 7212.78 | 7769 | 939 | 87.50 | 88.06 | 87.69 | 88.69 | 0.82 | 0.73 | 11.21 | 0.56 |
| 2007 | 7262.21 | 7747 | 940 | 87.97 | 87.97 | 88.19 | 88.44 | 0.06 | 0.05 | 11.98 | 0.00 |
| 2008 | 8177.42 | 8747 | 945 | 99.14 | 99.19 | 98.51 | 99.58 | 0.80 | 0.80 | 0.00 | 0.06 |
| 2009 | 7493.10 | 8024 | 945 | 90.99 | 90.99 | 90.52 | 91.60 | 0.33 | 0.30 | 8.70 | 0.00 |
| 2010 | 7437.82 | 7988 | 945 | 89.84 | 90.16 | 89.85 | 91.19 | 0.06 | 0.06 | 9.78 | 0.32 |
| 2011 | 8206.10 | 8730 | 945 | 99.13 | 99.40 | 99.13 | 99.66 | 0.53 | 0.53 | 0.07 | 0.27 |
| 2012 | 6640.08 | 6988 | 960 | 78.86 | 78.90 | 79.15 | 79.55 | 1.71 | 1.37 | 19.73 | 0.04 |
| 2013 | 7233.32 | 7545 | 960 | 85.54 | 85.57 | 86.01 | 86.13 | 3.53 | 3.13 | 11.29 | 0.03 |
| 2014 | 7762.26 | 8033 | 963 | 91.49 | 91.49 | 92.01 | 91.70 | 8.51 | 8.51 | 0.00 | 0.00 |
| 2015 | 7458.09 | 7747 | 966 | 87.88 | 87.96 | 88.13 | 88.44 | 0.15 | 0.13 | 11.91 | 0.08 |
| 2016 | 6901.60 | 7171 | 968 | 81.13 | 81.34 | 81.17 | 81.64 | 3.69 | 3.12 | 15.54 | 0.21 |
| 2017 | 6351.26 | 6622 | 968 | 74.90 | 75.34 | 74.90 | 75.59 | 0.00 | 0.00 | 24.66 | 0.44 |
| 2018 | 5547.64 | 5770 | 966 | 65.55 | 65.79 | 65.56 | 65.87 | 0.00 | 0.00 | 34.21 | 0.24 |
| 2019 | 7060.57 | 7322 | 966 | 83.22 | 83.33 | 83.44 | 83.58 | 0.00 | 0.00 | 16.67 | 0.11 |
| 2020 | 6679.80 | 6921 | 966 | 78.38 | 78.44 | 78.72 | 78.79 | 0.05 | 0.04 | 21.52 | 0.06 |
| 2021 | 8051.79 | 8364 | 966 | 94.70 | 100.00 | 95.15 | 95.48 | 0.00 | 0.00 | 0.00 | 5.30 |
| 2022 | 7165.36 | 7488 | 966 | 85.00 | 85.03 | 84.68 | 85.48 | 0.32 | 0.28 | 14.69 | 0.03 |
| 2023 | 6316.71 | 6538 | 966 | 74.19 | 74.39 | 74.65 | 74.63 | 0.25 | 0.18 | 25.43 | 0.20 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 139 | |
| C. Inspection, maintenance or repair combined with refuelling | 2222 | | | 1042 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 77 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 13 |
| Z. Other | | | | | | 2 |
| Subtotal | 2222 | | | 1119 | 145 | 15 |
| Total | | 2222 | | | 1279 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 28 |
| 15. Reactor Cooling Systems | | 2 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 8 |
| 31. Turbine and auxiliaries | | 12 |
| 32. Feedwater and Main Steam System | | 4 |
| 33. Circulating Water System | | 4 |
| 41. Main Generator Systems | | 90 |
| 42. Electrical Power Supply Systems | | 5 |
| Total | | 153 |

Highlights (2023)

Power reduction due to Maintenance of First Stage Moisture Separator Reheater(GSS 001ZZ)
 Dry Air Injection Line Flange in Moisture Separator and Reheater System(3.1 ~ 3.2)
 Power reduction due to Maintenance of Second Stage Condensate Recovery Tank Normal Drain Valve(GSS 042VL) in Steam Leakage of Moisture Separator and Reheater System(3.2 ~ 3.4)
 25rd Refueling(2023. 9.30. ~ 2024. 1. 18.)

2023 Operating Experience

KR-10

HANUL-2

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : ALSTOM (ALSTOM)



Reactor Unit Details

Reactor type and model : PWR / France CPI
 Thermal power : 2775 MWth
 Gross electrical power : 1011 MWe
 Reference unit power (net) : 967 MWe

Key Dates

Construction Date : 1983-07-05
 Grid Date : 1989-04-14
 Commercial Date : 1989-09-30
 Age at end of year : 34 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 38
 Average discharge burnup [MWd/t] : 42500
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.83
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 323.2
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.42

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.53
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

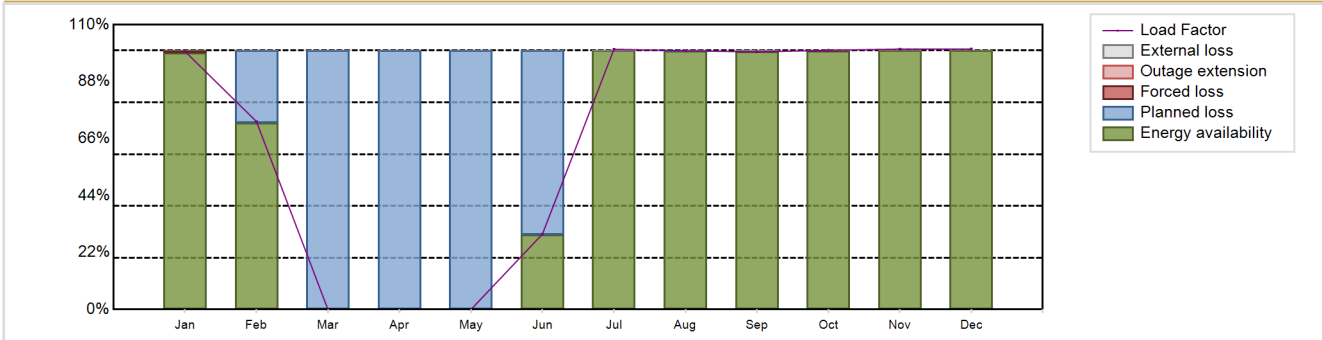
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5670.91 GW(e).h
 Energy Availability Factor (EAF) : 66.69 %
 Unit Capability Factor (UCF) : 66.75 %
 Load Factor (LF) : 66.95 %
 Operating Factor (OF) : 67.11 %
 Forced Loss Rate (FLR) : 0.11 %
 Unplanned Capability Loss Factor (UCL) : 0.08 %
 Planned Unavailability Factor (PUF) : 33.18 %
 Externally cause unavailability (XUF) : 0.05 %
 Total off-line time : 2881 hours

Annual Summary

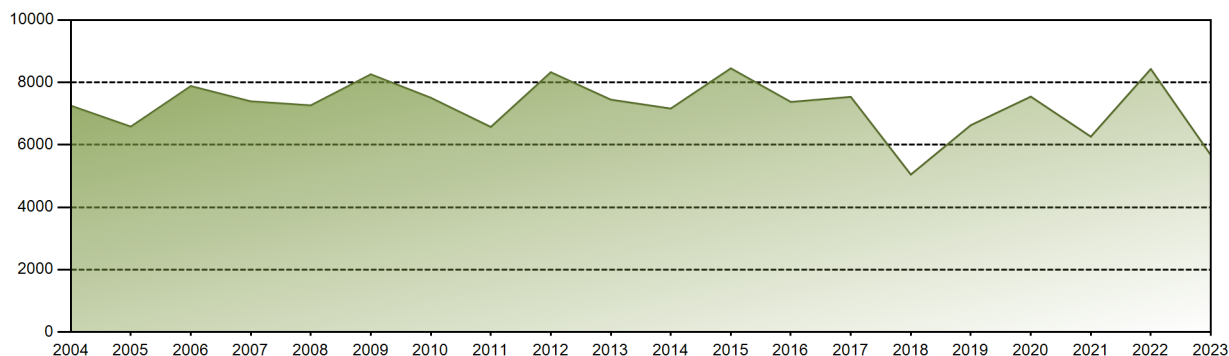


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 717.21 | 471.74 | 0.00 | 0.00 | 0.00 | 202.77 | 723.07 | 718.90 | 692.83 | 720.29 | 700.28 | 723.82 | 5670.91 |
| EAF [%] | 99.12 | 72.17 | 0.00 | 0.00 | 0.00 | 28.98 | 100.00 | 99.85 | 99.51 | 99.96 | 100.00 | 100.00 | 66.69 |
| UCF [%] | 99.12 | 72.17 | 0.00 | 0.00 | 0.00 | 28.98 | 100.00 | 99.99 | 99.98 | 99.99 | 100.00 | 100.00 | 66.75 |
| LF [%] | 99.69 | 72.59 | 0.00 | 0.00 | 0.00 | 29.12 | 100.50 | 99.92 | 99.51 | 100.12 | 100.58 | 100.61 | 66.95 |
| OF [%] | 100.00 | 72.92 | 0.00 | 0.00 | 0.00 | 31.81 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 67.11 |
| FLR [%] | 0.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 |
| UCL [%] | 0.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 |
| PUF [%] | 0.00 | 27.83 | 100.00 | 100.00 | 100.00 | 71.02 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 33.18 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.47 | 0.03 | 0.00 | 0.00 | 0.05 |

Historical Summary

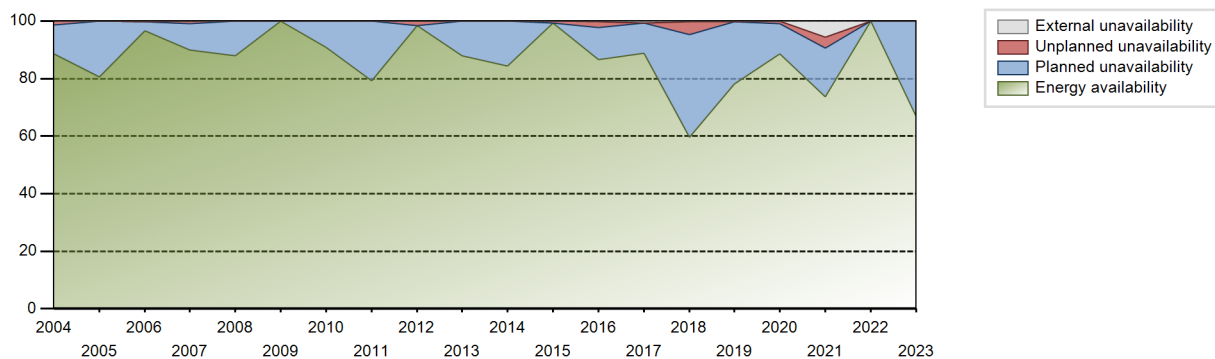
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 245819.37 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.02 % |
| Cumulative Energy Availability Factor (EAF) | : 86.2 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.07 % |
| Cumulative Unit Capability Factor (UCF) | : 86.53 % | Cumulative Planned Unavailability Factor (PUF) | : 12.4 % |
| Cumulative Load Factor (LF) | : 87.05 % | Cumulative Externally cause unavailability (XUF) | : 0.33 % |
| Cumulative Operating Factor (OF) | : 87.08 % | | |

Electricity Production (net) [GWh]

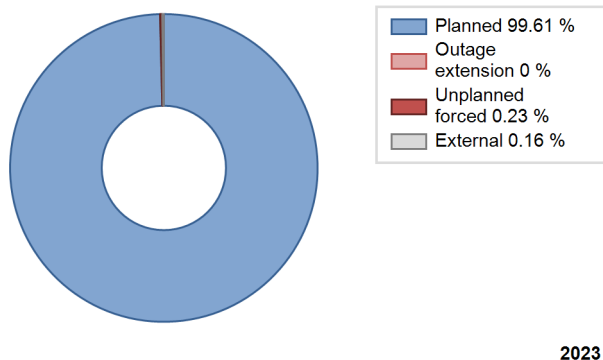


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | | | | Data not provided | | | | | | | |
| 1990 | 5547.29 | 6395 | 920 | 73.00 | 73.00 | 68.83 | 73.00 | 0.27 | 0.19 | 26.80 | 0.00 |
| 1991 | 6671.16 | 7603 | 920 | 86.79 | 86.79 | 82.78 | 86.79 | 0.05 | 0.05 | 13.16 | 0.00 |
| 1992 | 7076.88 | 7686 | 920 | 87.50 | 87.50 | 87.57 | 87.50 | 0.00 | 0.00 | 12.50 | 0.00 |
| 1993 | 7230.22 | 7693 | 920 | 87.82 | 87.82 | 89.71 | 87.82 | 0.16 | 0.14 | 12.04 | 0.00 |
| 1994 | 6889.67 | 7315 | 890 | 81.47 | 81.47 | 88.37 | 83.50 | 0.18 | 0.15 | 18.38 | 0.00 |
| 1995 | 7810.26 | 8223 | 920 | 93.39 | 93.42 | 96.91 | 93.87 | 0.34 | 0.32 | 6.26 | 0.03 |
| 1996 | 7696.38 | 8151 | 920 | 91.05 | 91.27 | 95.24 | 92.79 | 0.45 | 0.41 | 8.32 | 0.22 |
| 1997 | 7055.18 | 7534 | 920 | 84.27 | 85.99 | 87.54 | 86.00 | 0.52 | 0.45 | 13.56 | 1.72 |
| 1998 | 7388.87 | 7947 | 920 | 88.33 | 88.48 | 91.68 | 90.72 | 0.00 | 0.00 | 11.52 | 0.15 |
| 1999 | 7815.17 | 8748 | 920 | 94.53 | 94.58 | 96.97 | 99.86 | 5.17 | 5.16 | 0.27 | 0.05 |
| 2000 | 6836.81 | 7330 | 920 | 82.34 | 82.49 | 84.60 | 83.45 | 0.00 | 0.00 | 17.51 | 0.15 |
| 2001 | 7268.56 | 7848 | 920 | 89.18 | 90.16 | 90.19 | 89.59 | 0.94 | 0.85 | 8.99 | 0.97 |
| 2002 | 6485.83 | 6939 | 920 | 78.26 | 78.26 | 80.48 | 79.21 | 0.01 | 0.01 | 21.73 | 0.00 |
| 2003 | 7253.75 | 7686 | 920 | 87.12 | 87.12 | 90.01 | 87.74 | 12.87 | 12.87 | 0.00 | 0.00 |
| 2004 | 7253.74 | 7888 | 920 | 88.64 | 88.64 | 89.76 | 89.80 | 1.53 | 1.38 | 9.98 | 0.00 |
| 2005 | 6582.35 | 7218 | 920 | 80.66 | 80.75 | 81.68 | 82.40 | 0.00 | 0.00 | 19.25 | 0.09 |
| 2006 | 7882.51 | 8510 | 937 | 96.69 | 97.03 | 96.03 | 97.15 | 0.03 | 0.03 | 2.94 | 0.33 |
| 2007 | 7391.65 | 7946 | 937 | 90.02 | 90.02 | 90.05 | 90.71 | 1.06 | 0.96 | 9.01 | 0.00 |
| 2008 | 7264.19 | 7752 | 942 | 87.94 | 87.95 | 87.79 | 88.25 | 0.00 | 0.00 | 12.05 | 0.01 |
| 2009 | 8258.31 | 8760 | 942 | 100.00 | 100.00 | 100.08 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 7506.86 | 7991 | 942 | 90.81 | 90.86 | 90.97 | 91.22 | 0.00 | 0.00 | 9.14 | 0.05 |
| 2011 | 6571.07 | 7003 | 942 | 79.26 | 79.30 | 79.63 | 79.94 | 0.00 | 0.00 | 20.70 | 0.04 |
| 2012 | 8325.47 | 8661 | 961 | 98.33 | 98.36 | 98.63 | 98.60 | 1.64 | 1.64 | 0.00 | 0.03 |
| 2013 | 7446.49 | 7740 | 962 | 87.98 | 87.98 | 88.36 | 88.36 | 0.01 | 0.01 | 12.01 | 0.00 |
| 2014 | 7161.63 | 7430 | 965 | 84.39 | 84.41 | 84.72 | 84.82 | 0.10 | 0.09 | 15.50 | 0.02 |
| 2015 | 8449.96 | 8760 | 967 | 99.35 | 99.38 | 99.75 | 100.00 | 0.62 | 0.62 | 0.00 | 0.03 |
| 2016 | 7373.63 | 7665 | 969 | 86.55 | 86.84 | 86.63 | 87.26 | 0.00 | 2.00 | 11.16 | 0.29 |
| 2017 | 7535.86 | 7858 | 969 | 88.78 | 89.39 | 88.78 | 89.70 | 0.00 | 0.00 | 10.61 | 0.60 |
| 2018 | 5046.21 | 5271 | 967 | 59.55 | 59.71 | 59.57 | 60.17 | 6.97 | 4.47 | 35.82 | 0.16 |
| 2019 | 6629.49 | 6874 | 967 | 78.13 | 78.38 | 78.26 | 78.47 | 0.00 | 0.00 | 21.62 | 0.25 |
| 2020 | 7544.08 | 7849 | 967 | 88.69 | 88.82 | 88.82 | 89.36 | 0.90 | 0.81 | 10.37 | 0.13 |
| 2021 | 6260.94 | 6606 | 967 | 73.77 | 79.39 | 73.91 | 75.41 | 0.00 | 3.82 | 16.78 | 5.62 |
| 2022 | 8427.91 | 8760 | 967 | 99.93 | 100.00 | 99.49 | 100.00 | 0.00 | 0.00 | 0.00 | 0.06 |
| 2023 | 5670.91 | 5879 | 967 | 66.69 | 66.75 | 66.95 | 67.11 | 0.11 | 0.08 | 33.18 | 0.05 |

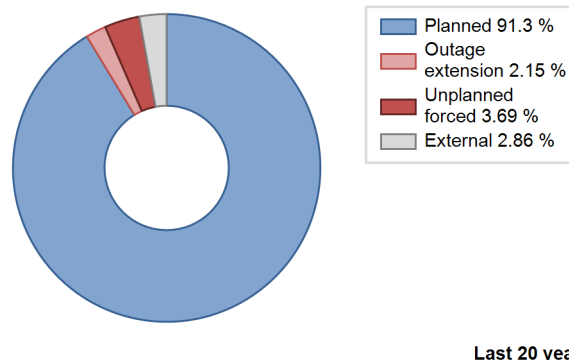
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 102 | |
| C. Inspection, maintenance or repair combined with refuelling | 2881 | | | 1045 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 38 | | |
| E. Testing of plant systems or components | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 15 |
| Z. Other | | | | | | 3 |
| Subtotal | 2881 | | | 1083 | 103 | 18 |
| Total | | 2881 | | | 1204 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 0 |
| 14. Safety Systems | | 10 |
| 16. Steam generation systems | | 1 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 31. Turbine and auxiliaries | | 55 |
| 32. Feedwater and Main Steam System | | 1 |
| 33. Circulating Water System | | 5 |
| 41. Main Generator Systems | | 31 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 105 |

Highlights (2023)

Power Reduction due to Maintenance for Drum Screen Gear off course(1.18)
 24rd Refueling(2.21 ~ 6. 21)
 Control Rod Operation and Slip from Reactor Head Replacement(7.7, 8.7, 8.16, 8.21, 8.28, 9.4, 9.14, 9.18, 10.16)

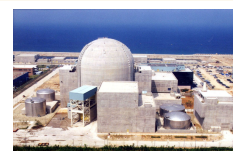
2023 Operating Experience

KR-13

HANUL-3

KOREA, REPUBLIC OF

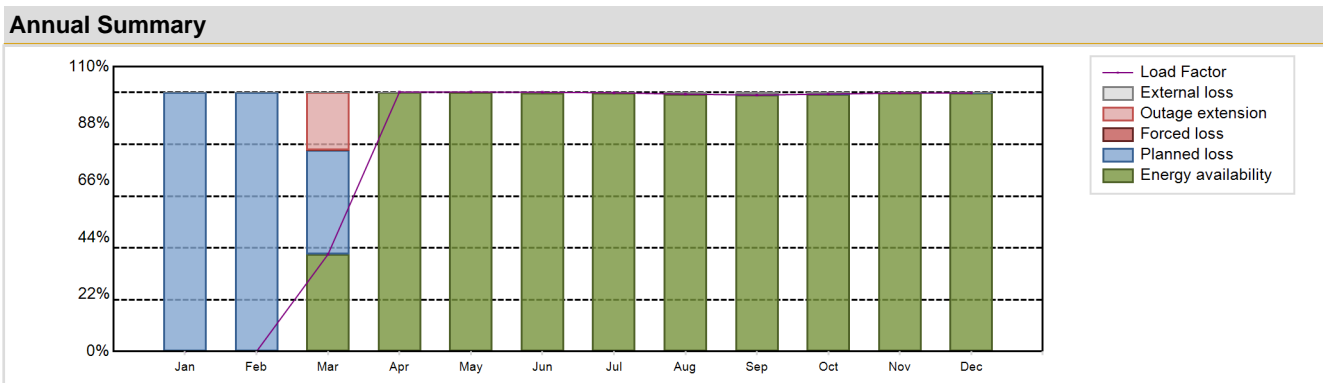
Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / OPR-1000 | Construction Date | : 1993-07-21 |
| Thermal power | : 2825 MWth | Grid Date | : 1998-01-06 |
| Gross electrical power | : 1051 MWe | Commercial Date | : 1998-08-11 |
| Reference unit power (net) | : 997 MWe | Age at end of year | : 25 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327.3 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.39 |
| Average fuel enrichment [% of U235] | : 4 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 4 |
| Part of the core refuelled [%] | : 36.7 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 45800 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.122 | HP cylinder inlet steam pressure [MPa] | : 7.136 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 177 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.24 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 73 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | |
| | | | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|------------------|--|--------------|
| Net Energy Production | : 6843.5 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 78.31 % | Unplanned Capability Loss Factor (UCL) | : 1.88 % |
| Unit Capability Factor (UCF) | : 78.53 % | Planned Unavailability Factor (PUF) | : 19.59 % |
| Load Factor (LF) | : 78.36 % | Externally cause unavailability (XUF) | : 0.21 % |
| Operating Factor (OF) | : 79.01 % | Total off-line time | : 1839 hours |

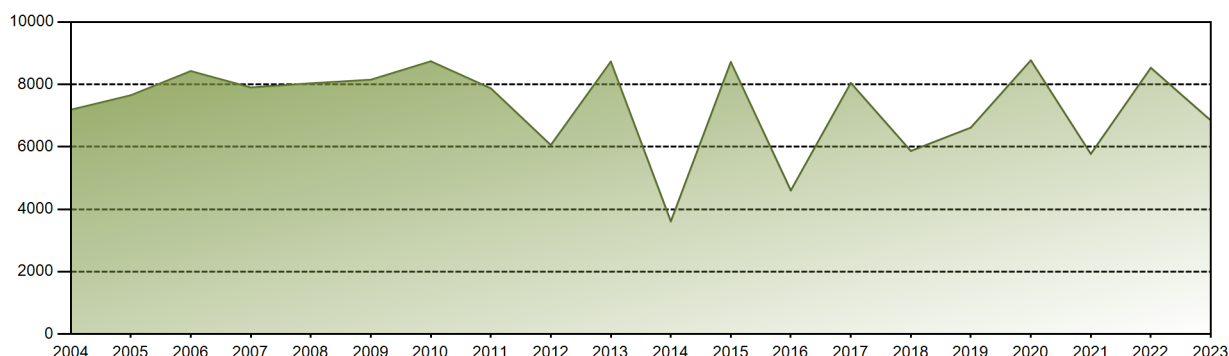


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 278.16 | 719.16 | 743.38 | 718.69 | 741.18 | 737.23 | 710.84 | 737.47 | 716.64 | 740.73 | 6843.50 |
| EAF [%] | 0.00 | 0.00 | 37.55 | 100.00 | 100.00 | 99.98 | 99.90 | 99.39 | 99.03 | 99.42 | 99.84 | 99.86 | 78.31 |
| UCF [%] | 0.00 | 0.00 | 37.56 | 100.00 | 100.00 | 99.98 | 100.00 | 100.00 | 99.96 | 100.00 | 100.00 | 99.99 | 78.53 |
| LF [%] | 0.00 | 0.00 | 37.50 | 100.18 | 100.22 | 100.12 | 99.92 | 99.39 | 99.03 | 99.42 | 99.83 | 99.86 | 78.36 |
| OF [%] | 0.00 | 0.00 | 43.15 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 79.01 |
| FLR [%] | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 22.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.88 |
| PUF [%] | 100.00 | 100.00 | 40.29 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.01 | 19.59 |
| XUF [%] | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.10 | 0.61 | 0.94 | 0.58 | 0.16 | 0.13 | 0.21 |

Historical Summary

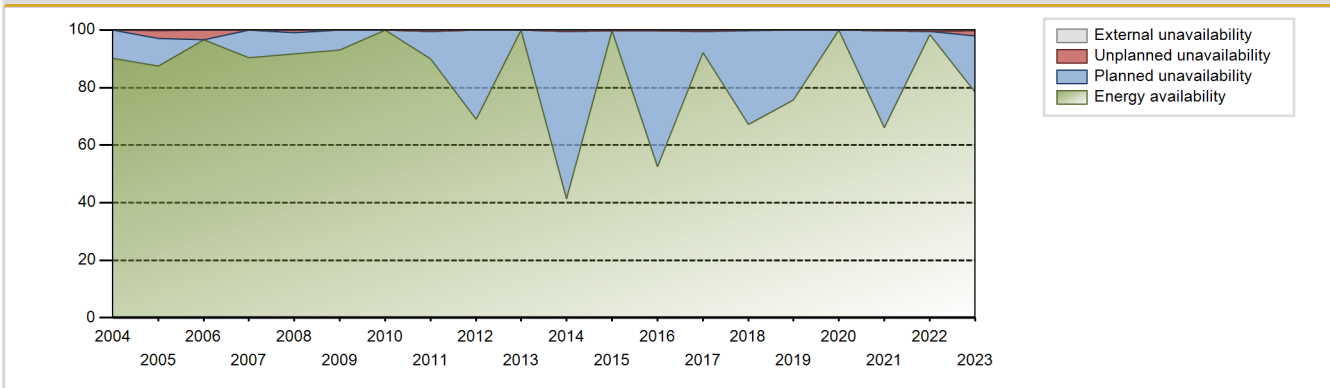
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 190351.13 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.39 % |
| Cumulative Energy Availability Factor (EAF) | : 85.23 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.42 % |
| Cumulative Unit Capability Factor (UCF) | : 85.43 % | Cumulative Planned Unavailability Factor (PUF) | : 14.15 % |
| Cumulative Load Factor (LF) | : 85.17 % | Cumulative Externally cause unavailability (XUF) | : 0.2 % |
| Cumulative Operating Factor (OF) | : 85.96 % | | |

Electricity Production (net) [GWh]

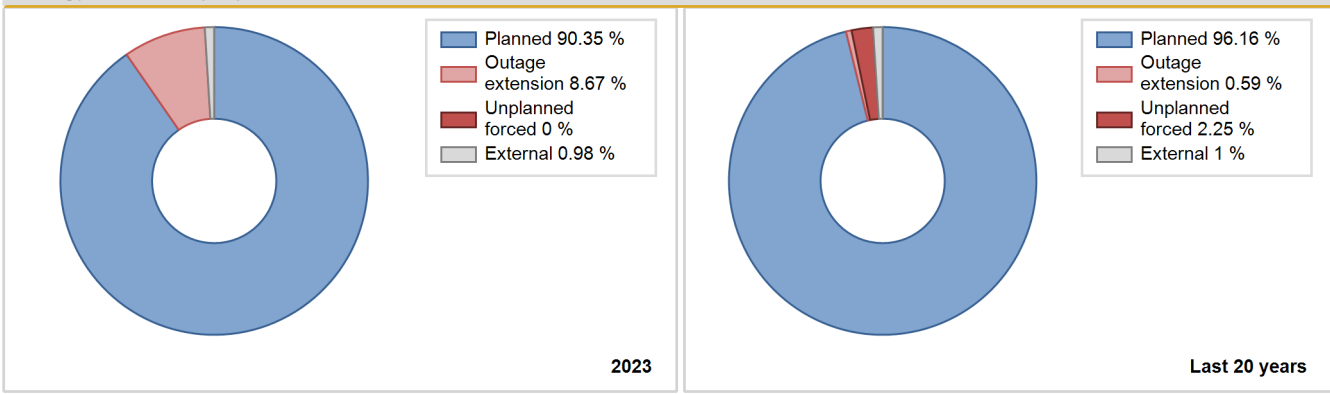


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1998 | 4822.23 | 5872 | 960 | 99.98 | 99.98 | 99.17 | 97.74 | 0.00 | 0.00 | 0.02 | 0.00 |
| 1999 | 6918.04 | 7149 | 960 | 79.67 | 81.45 | 82.26 | 81.61 | 0.68 | 0.56 | 17.99 | 1.78 |
| 2000 | 7489.09 | 7734 | 960 | 86.99 | 86.99 | 88.81 | 88.05 | 0.65 | 0.57 | 12.44 | 0.00 |
| 2001 | 7922.21 | 8025 | 960 | 91.25 | 91.25 | 94.20 | 91.61 | 0.00 | 0.00 | 8.75 | 0.00 |
| 2002 | 7031.29 | 7824 | 960 | 88.96 | 88.96 | 83.61 | 89.32 | 0.13 | 0.11 | 10.93 | 0.00 |
| 2003 | 7984.26 | 8758 | 960 | 99.56 | 99.56 | 94.94 | 99.98 | 0.00 | 0.43 | 0.01 | 0.00 |
| 2004 | 7187.59 | 7986 | 960 | 90.05 | 90.05 | 85.24 | 90.92 | 0.00 | 0.00 | 9.95 | 0.00 |
| 2005 | 7651.74 | 7834 | 960 | 87.58 | 87.73 | 90.99 | 89.43 | 2.99 | 2.70 | 9.57 | 0.15 |
| 2006 | 8425.90 | 8501 | 994 | 96.60 | 96.60 | 96.77 | 97.04 | 3.38 | 3.38 | 0.01 | 0.00 |
| 2007 | 7901.94 | 7970 | 995 | 90.35 | 90.35 | 90.66 | 90.98 | 0.12 | 0.11 | 9.54 | 0.00 |
| 2008 | 8034.73 | 8122 | 994 | 91.67 | 91.69 | 92.02 | 92.46 | 0.98 | 0.91 | 7.40 | 0.02 |
| 2009 | 8149.75 | 8225 | 994 | 93.15 | 93.26 | 93.60 | 93.89 | 0.00 | 0.00 | 6.74 | 0.10 |
| 2010 | 8740.74 | 8760 | 994 | 99.93 | 99.94 | 100.38 | 100.00 | 0.06 | 0.06 | 0.00 | 0.01 |
| 2011 | 7873.04 | 7960 | 994 | 90.04 | 90.45 | 90.42 | 90.87 | 0.00 | 0.00 | 9.55 | 0.41 |
| 2012 | 6056.35 | 6130 | 994 | 69.08 | 69.17 | 69.36 | 69.79 | 0.00 | 0.00 | 30.83 | 0.09 |
| 2013 | 8731.76 | 8760 | 994 | 99.94 | 99.99 | 100.28 | 100.00 | 0.00 | 0.00 | 0.01 | 0.06 |
| 2014 | 3609.51 | 3739 | 997 | 41.31 | 41.77 | 41.33 | 42.68 | 0.00 | 0.00 | 58.23 | 0.46 |
| 2015 | 8717.66 | 8760 | 997 | 99.80 | 100.00 | 99.82 | 100.00 | 0.00 | 0.00 | 0.00 | 0.20 |
| 2016 | 4601.49 | 4708 | 997 | 52.54 | 52.74 | 52.54 | 53.60 | 0.00 | 0.00 | 47.26 | 0.20 |
| 2017 | 8047.45 | 8122 | 997 | 92.14 | 92.52 | 92.14 | 92.72 | 0.03 | 0.02 | 7.46 | 0.38 |
| 2018 | 5868.02 | 5935 | 997 | 67.11 | 67.21 | 67.19 | 67.75 | 0.15 | 0.10 | 32.69 | 0.10 |
| 2019 | 6616.04 | 6687 | 997 | 75.70 | 75.76 | 75.75 | 76.34 | 0.00 | 0.00 | 24.24 | 0.06 |
| 2020 | 8772.41 | 8784 | 997 | 99.98 | 99.99 | 100.17 | 100.00 | 0.00 | 0.00 | 0.01 | 0.02 |
| 2021 | 5773.46 | 5868 | 997 | 66.03 | 66.36 | 66.11 | 66.99 | 0.00 | 0.00 | 33.64 | 0.33 |
| 2022 | 8531.57 | 8674 | 997 | 98.40 | 98.82 | 97.69 | 99.02 | 0.00 | 0.00 | 1.18 | 0.42 |
| 2023 | 6843.50 | 6921 | 997 | 78.31 | 78.53 | 78.36 | 79.01 | 0.00 | 1.88 | 19.59 | 0.21 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1998 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | | 23 |
| C. Inspection, maintenance or repair combined with refuelling | 1678 | | | 1220 | | |
| H. Nuclear regulatory requirements | | 165 | | | 7 | |
| Subtotal | 1678 | 165 | | 1220 | 30 | |
| Total | | 1843 | | | 1250 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1998 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 9 |
| 31. Turbine and auxiliaries | | 1 |
| 32. Feedwater and Main Steam System | | 1 |
| 41. Main Generator Systems | | 12 |
| Total | | 23 |

2023 Operating Experience

KR-14

HANUL-4

KOREA, REPUBLIC OF

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : KHNP (Korea Hydro and Nuclear Power Co.) |
| Owner | : KHNP (Korea Hydro and Nuclear Power Co.) |
| Reactor Supplier | : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING) |
| Turbine Supplier | : DHICGE (Doosan Heavy Industries & Construction and General Electric) |

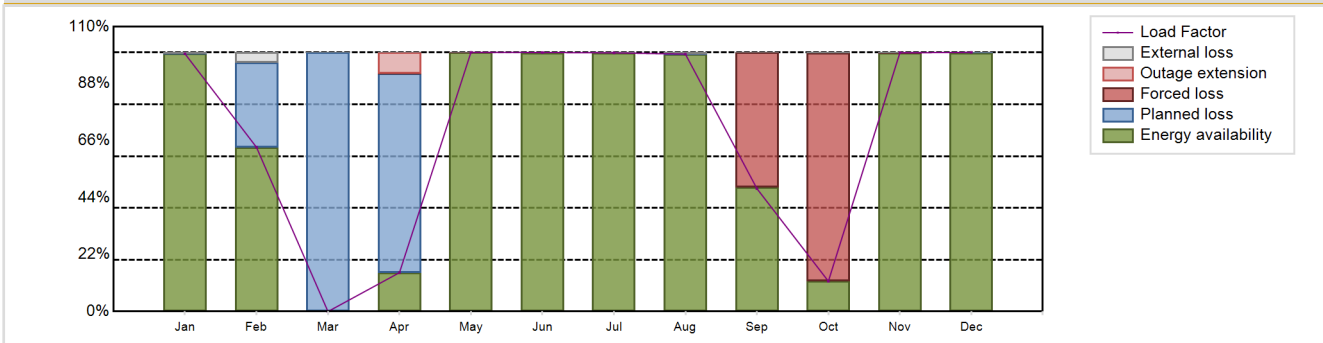


| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / OPR-1000 | Construction Date | : 1993-11-01 |
| Thermal power | : 2825 MWth | Grid Date | : 1998-12-28 |
| Gross electrical power | : 1052 MWe | Commercial Date | : 1999-12-31 |
| Reference unit power (net) | : 999 MWe | Age at end of year | : 25 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.52502 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327.3 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.39 |
| Average fuel enrichment [% of U235] | : 4 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 4 |
| Part of the core refuelled [%] | : 36 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 46603 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.122 | HP cylinder inlet steam pressure [MPa] | : 7.136 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 177 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.24 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 73 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | |
| | | | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|------------------|--|--------------|
| Net Energy Production | : 6109.9 GW(e).h | Forced Loss Rate (FLR) | : 14.37 % |
| Energy Availability Factor (EAF) | : 69.83 % | Unplanned Capability Loss Factor (UCL) | : 12.45 % |
| Unit Capability Factor (UCF) | : 70.22 % | Planned Unavailability Factor (PUF) | : 17.33 % |
| Load Factor (LF) | : 69.82 % | Externally cause unavailability (XUF) | : 0.39 % |
| Operating Factor (OF) | : 71.15 % | Total off-line time | : 2527 hours |

Annual Summary

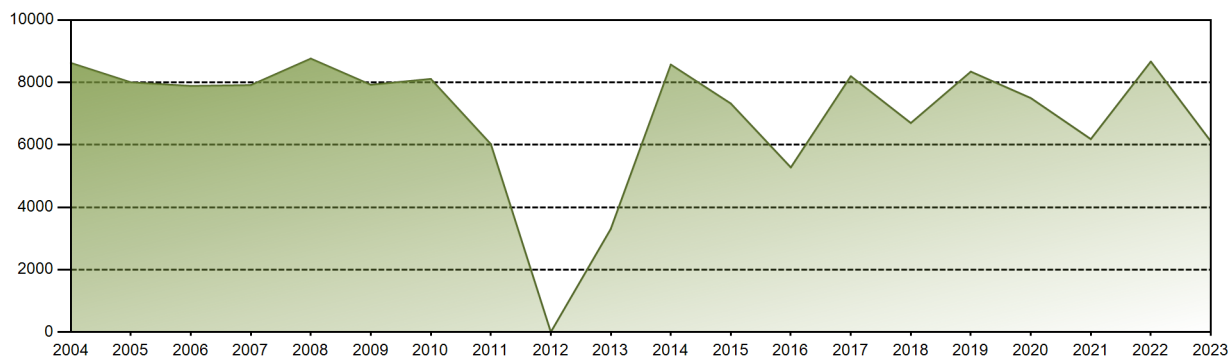


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 739.84 | 425.92 | 0.00 | 108.00 | 744.03 | 719.59 | 742.48 | 738.91 | 341.63 | 86.90 | 718.81 | 743.78 | 6109.90 |
| EAF [%] | 99.54 | 63.49 | 0.00 | 15.01 | 100.00 | 99.97 | 99.89 | 99.42 | 47.90 | 11.69 | 99.90 | 99.99 | 69.83 |
| UCF [%] | 100.00 | 67.27 | 0.00 | 15.01 | 100.00 | 99.97 | 100.00 | 99.97 | 47.90 | 11.71 | 99.97 | 99.99 | 70.22 |
| LF [%] | 99.54 | 63.44 | 0.00 | 15.02 | 100.10 | 100.04 | 99.90 | 99.42 | 47.50 | 11.69 | 99.94 | 100.07 | 69.82 |
| OF [%] | 100.00 | 69.35 | 0.00 | 20.00 | 100.00 | 100.00 | 100.00 | 100.00 | 50.14 | 13.71 | 100.00 | 100.00 | 71.15 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 52.10 | 88.29 | 0.03 | 0.00 | 14.37 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 8.10 | 0.00 | 0.00 | 0.00 | 0.00 | 52.10 | 88.29 | 0.03 | 0.00 | 12.45 |
| PUF [%] | 0.00 | 32.73 | 100.00 | 76.89 | 0.00 | 0.03 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 17.33 |
| XUF [%] | 0.46 | 3.78 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.56 | 0.00 | 0.02 | 0.07 | 0.00 | 0.39 |

Historical Summary

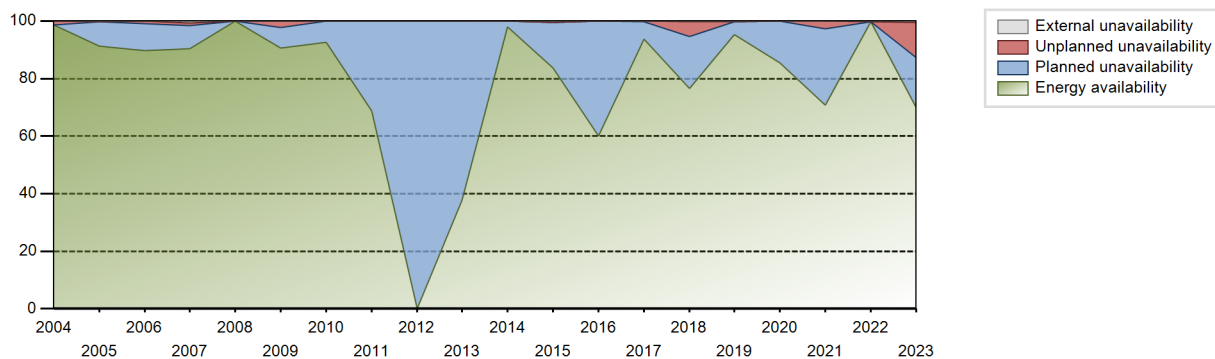
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 176512.47 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.28 % |
| Cumulative Energy Availability Factor (EAF) | : 80.71 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.17 % |
| Cumulative Unit Capability Factor (UCF) | : 80.84 % | Cumulative Planned Unavailability Factor (PUF) | : 17.99 % |
| Cumulative Load Factor (LF) | : 81.47 % | Cumulative Externally cause unavailability (XUF) | : 0.13 % |
| Cumulative Operating Factor (OF) | : 81.9 % | | |

Electricity Production (net) [GWh]

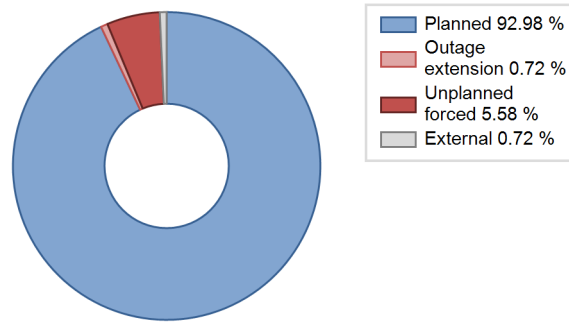
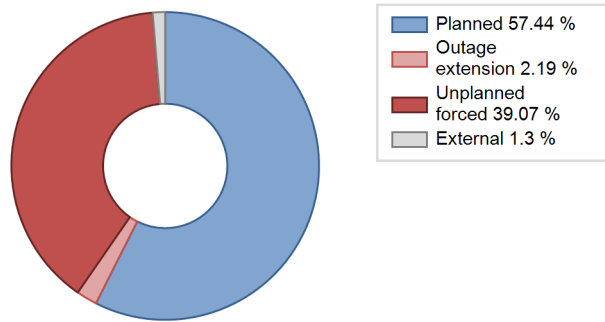


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1999 | | | | Data not provided | | | | | | | |
| 2000 | 7042.47 | 7229 | 960 | 81.26 | 81.26 | 83.51 | 82.30 | 0.50 | 0.40 | 18.33 | 0.00 |
| 2001 | 7732.33 | 7880 | 960 | 89.94 | 89.99 | 91.95 | 89.95 | 0.30 | 0.27 | 9.74 | 0.04 |
| 2002 | 7311.29 | 7448 | 960 | 83.82 | 84.02 | 86.94 | 85.02 | 0.82 | 0.70 | 15.28 | 0.20 |
| 2003 | 7922.45 | 8081 | 960 | 91.62 | 91.63 | 94.21 | 92.25 | 0.96 | 0.89 | 7.48 | 0.01 |
| 2004 | 8623.08 | 8700 | 960 | 98.66 | 98.66 | 102.26 | 99.04 | 1.33 | 1.33 | 0.01 | 0.00 |
| 2005 | 8003.01 | 8085 | 960 | 91.33 | 91.54 | 95.17 | 92.29 | 0.00 | 0.00 | 8.46 | 0.21 |
| 2006 | 7886.16 | 7938 | 993 | 89.80 | 89.80 | 90.66 | 90.62 | 1.00 | 0.90 | 9.30 | 0.00 |
| 2007 | 7912.85 | 7998 | 992 | 90.34 | 90.97 | 91.06 | 91.30 | 0.99 | 0.91 | 8.12 | 0.63 |
| 2008 | 8762.75 | 8784 | 998 | 99.99 | 99.99 | 99.96 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| 2009 | 7924.37 | 8047 | 998 | 90.61 | 90.61 | 90.64 | 91.86 | 2.36 | 2.19 | 7.20 | 0.00 |
| 2010 | 8110.60 | 8149 | 998 | 92.59 | 92.61 | 92.77 | 93.03 | 0.00 | 0.00 | 7.39 | 0.02 |
| 2011 | 6023.71 | 6034 | 998 | 68.73 | 68.75 | 68.90 | 68.88 | 0.00 | 0.00 | 31.25 | 0.02 |
| 2012 | 0.00 | 0 | 998 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2013 | 3307.10 | 3362 | 998 | 37.77 | 37.78 | 37.83 | 38.38 | 0.00 | 0.00 | 62.22 | 0.01 |
| 2014 | 8570.94 | 8606 | 999 | 97.87 | 98.00 | 97.94 | 98.24 | 0.00 | 0.00 | 2.00 | 0.13 |
| 2015 | 7322.33 | 7412 | 999 | 83.64 | 84.16 | 83.67 | 84.61 | 0.01 | 0.01 | 15.83 | 0.53 |
| 2016 | 5274.95 | 6298 | 999 | 60.11 | 60.12 | 60.11 | 71.70 | 0.22 | 0.13 | 39.75 | 0.01 |
| 2017 | 8198.68 | 8266 | 999 | 93.62 | 93.76 | 93.69 | 94.36 | 0.10 | 0.10 | 6.14 | 0.14 |
| 2018 | 6698.25 | 6802 | 999 | 76.53 | 76.72 | 76.54 | 77.65 | 6.27 | 5.14 | 18.14 | 0.19 |
| 2019 | 8344.45 | 8386 | 999 | 95.31 | 95.54 | 95.35 | 95.73 | 0.02 | 0.02 | 4.44 | 0.24 |
| 2020 | 7497.57 | 7548 | 999 | 85.41 | 85.50 | 85.44 | 85.93 | 0.04 | 0.03 | 14.47 | 0.09 |
| 2021 | 6182.87 | 6256 | 999 | 70.65 | 70.75 | 70.65 | 71.42 | 0.36 | 2.51 | 26.74 | 0.10 |
| 2022 | 8667.91 | 8760 | 999 | 99.79 | 99.99 | 99.05 | 100.00 | 0.01 | 0.01 | 0.01 | 0.20 |
| 2023 | 6109.90 | 6233 | 999 | 69.83 | 70.22 | 69.82 | 71.15 | 14.37 | 12.45 | 17.33 | 0.39 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1999 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1059 | | | 89 | |
| C. Inspection, maintenance or repair combined with refuelling | 1468 | | | 785 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 6 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 704 | | |
| L. Human factor related | | | | | 0 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| Subtotal | 1468 | 1059 | | 1495 | 89 | 2 |
| Total | | 2527 | | | 1586 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1999 to 2023 |
|-------------------------------------|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 4 |
| 15. Reactor Cooling Systems | | 8 |
| 31. Turbine and auxiliaries | | 1 |
| 32. Feedwater and Main Steam System | | 20 |
| 34. Miscellaneous Systems | 1001 | 42 |
| 41. Main Generator Systems | 58 | 6 |
| 42. Electrical Power Supply Systems | | 10 |
| Total | 1059 | 91 |

Highlights (2023)

The 16th refueling (2023-02-20 ~ 2023-04-25)
 Shutdown due to leakage of TBCCW (2023-09-16 ~ 2023-10-27)

2023 Operating Experience

KR-19

HANUL-5

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



Reactor Unit Details

Reactor type and model : PWR / OPR-1000
 Thermal power : 2825 MWth
 Gross electrical power : 1049 MWe
 Reference unit power (net) : 998 MWe

Key Dates

Construction Date : 1999-10-01
 Grid Date : 2003-12-18
 Commercial Date : 2004-07-29
 Age at end of year : 20 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 5
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 36.15
 Average discharge burnup [MWd/t] : 38723
 Active core diameter [m] : 3.12
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 17.69
 Number of control rod assemblies : 180
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.3
 Number of SG : 2
 Containment type : Double
 Containment design pressure [MPa] : 0.39

Secondary systems

Number of turbine-generators per unit/reactor : 4
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 7.14
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

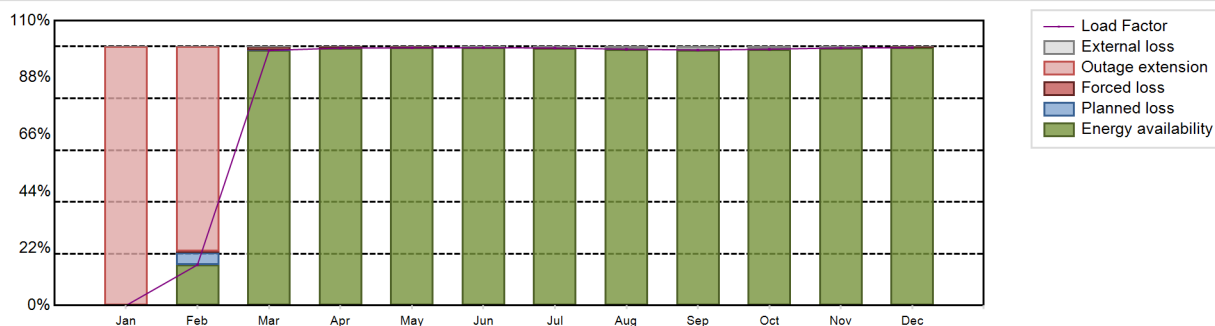
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7376.79 GW(e).h
 Energy Availability Factor (EAF) : 84.38 %
 Unit Capability Factor (UCF) : 84.78 %
 Load Factor (LF) : 84.38 %
 Operating Factor (OF) : 85.48 %
 Forced Loss Rate (FLR) : 0.33 %
 Unplanned Capability Loss Factor (UCL) : 14.84 %
 Planned Unavailability Factor (PUF) : 0.38 %
 Externally cause unavailability (XUF) : 0.4 %
 Total off-line time : 1272 hours

Annual Summary

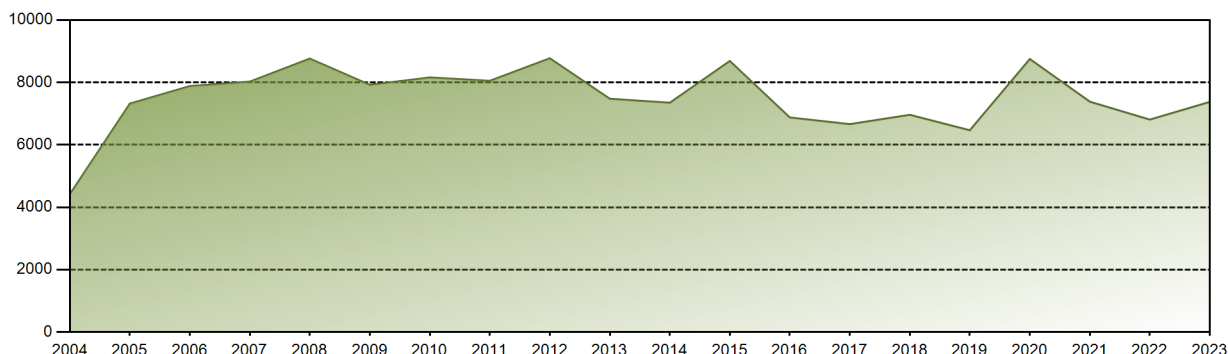


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 105.35 | 731.42 | 714.37 | 738.91 | 715.34 | 738.38 | 734.86 | 708.95 | 734.96 | 714.87 | 739.38 | 7376.79 |
| EAF [%] | 0.00 | 15.71 | 98.51 | 99.42 | 99.51 | 99.55 | 99.44 | 98.97 | 98.66 | 98.98 | 99.49 | 99.58 | 84.38 |
| UCF [%] | 0.00 | 15.71 | 98.51 | 99.42 | 99.51 | 99.97 | 100.00 | 99.96 | 100.00 | 100.00 | 99.98 | 99.58 | 84.78 |
| LF [%] | 0.00 | 15.71 | 98.51 | 99.42 | 99.51 | 99.55 | 99.44 | 98.97 | 98.66 | 98.98 | 99.49 | 99.58 | 84.38 |
| OF [%] | 0.00 | 21.43 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.48 |
| FLR [%] | 0.00 | 2.43 | 1.49 | 0.58 | 0.46 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.42 | 0.33 |
| UCL [%] | 100.00 | 79.48 | 1.49 | 0.58 | 0.46 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.42 | 14.84 |
| PUF [%] | 0.00 | 4.81 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.02 | 0.00 | 0.38 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.42 | 0.56 | 0.99 | 1.34 | 1.02 | 0.49 | 0.00 | 0.40 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 150415.73 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.93 % |
| Cumulative Energy Availability Factor (EAF) | : 88.22 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.68 % |
| Cumulative Unit Capability Factor (UCF) | : 88.43 % | Cumulative Planned Unavailability Factor (PUF) | : 8.9 % |
| Cumulative Load Factor (LF) | : 88.15 % | Cumulative Externally cause unavailability (XUF) | : 0.21 % |
| Cumulative Operating Factor (OF) | : 88.53 % | | |

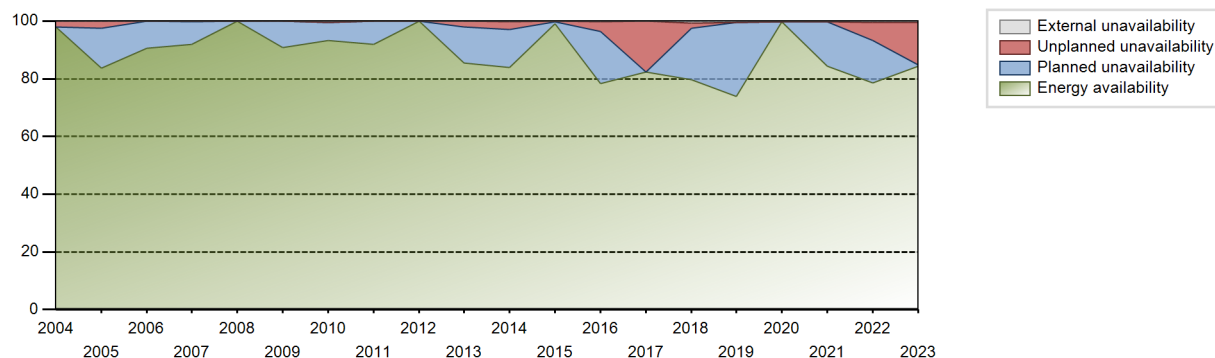
Electricity Production (net) [GWh]



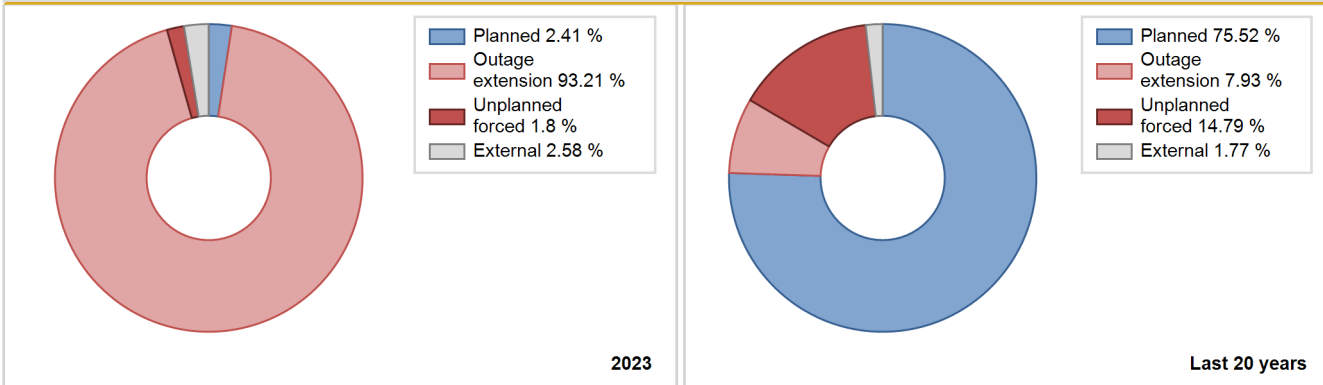
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2004 | 4415.65 | 4963 | 960 | 97.88 | 97.88 | 101.42 | 97.93 | 2.11 | 2.11 | 0.01 | 0.00 |
| 2005 | 7321.60 | 7409 | 960 | 83.79 | 83.79 | 87.06 | 84.58 | 2.77 | 2.39 | 13.82 | 0.00 |
| 2006 | 7882.81 | 7925 | 994 | 90.56 | 90.56 | 90.53 | 90.47 | 0.00 | 0.00 | 9.44 | 0.00 |
| 2007 | 8025.93 | 8115 | 995 | 91.87 | 91.87 | 92.08 | 92.64 | 0.27 | 0.25 | 7.88 | 0.00 |
| 2008 | 8763.82 | 8784 | 1001 | 99.93 | 99.96 | 99.67 | 100.00 | 0.04 | 0.04 | 0.01 | 0.03 |
| 2009 | 7924.16 | 7988 | 1001 | 90.75 | 90.75 | 90.37 | 91.19 | 0.00 | 0.00 | 9.25 | 0.00 |
| 2010 | 8160.25 | 8245 | 997 | 93.24 | 93.70 | 93.43 | 94.12 | 0.00 | 0.00 | 6.30 | 0.46 |
| 2011 | 8052.72 | 8106 | 997 | 92.00 | 92.07 | 92.20 | 92.53 | 0.00 | 0.00 | 7.92 | 0.08 |
| 2012 | 8773.91 | 8784 | 998 | 99.91 | 99.96 | 100.09 | 100.00 | 0.00 | 0.00 | 0.04 | 0.05 |
| 2013 | 7476.53 | 7544 | 996 | 85.42 | 85.45 | 85.69 | 86.12 | 2.20 | 1.92 | 12.63 | 0.02 |
| 2014 | 7349.72 | 7408 | 998 | 83.98 | 84.26 | 84.07 | 84.57 | 2.95 | 2.56 | 13.17 | 0.28 |
| 2015 | 8687.64 | 8742 | 998 | 99.10 | 99.19 | 99.37 | 99.79 | 0.18 | 0.18 | 0.64 | 0.08 |
| 2016 | 6877.61 | 6961 | 998 | 78.43 | 78.72 | 78.45 | 79.25 | 3.94 | 3.23 | 18.04 | 0.29 |
| 2017 | 6663.73 | 6707 | 998 | 82.31 | 82.42 | 76.22 | 76.56 | 17.58 | 17.58 | 0.00 | 0.11 |
| 2018 | 6962.42 | 7097 | 998 | 79.62 | 80.39 | 79.64 | 81.02 | 0.12 | 1.64 | 17.97 | 0.77 |
| 2019 | 6467.68 | 6575 | 998 | 73.98 | 74.50 | 73.98 | 75.06 | 0.00 | 0.00 | 25.50 | 0.52 |
| 2020 | 8750.36 | 8784 | 998 | 99.75 | 99.96 | 99.82 | 100.00 | 0.04 | 0.04 | 0.00 | 0.21 |
| 2021 | 7383.73 | 7478 | 998 | 84.46 | 84.76 | 84.46 | 85.37 | 0.09 | 0.07 | 15.17 | 0.30 |
| 2022 | 6809.01 | 6950 | 998 | 78.51 | 78.94 | 77.88 | 79.34 | 5.21 | 6.33 | 14.73 | 0.43 |
| 2023 | 7376.79 | 7488 | 998 | 84.38 | 84.78 | 84.38 | 85.48 | 0.33 | 14.84 | 0.38 | 0.40 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2004 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1276 | | | 225 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 754 | | |
| M. Governmental requirements or court decisions | | | | | | 28 |
| Subtotal | | 1276 | | 754 | 225 | 28 |
| Total | | 1276 | | | 1007 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2004 to 2023 | |
|------------------------------|------------|------|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 1276 | | 76 |
| 12. Reactor I&C Systems | | | | 75 |
| 15. Reactor Cooling Systems | | | | 25 |
| 16. Steam generation systems | | | | 8 |
| 35. All other I&C Systems | | | | 35 |
| Total | | 1276 | | 219 |

Highlights (2023)

Refueling and Maintenance(2022.11.01 ~ 2023.02.23)

2023 Operating Experience

KR-20

HANUL-6

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



Reactor Unit Details

Reactor type and model : PWR / OPR-1000
 Thermal power : 2825 MWth
 Gross electrical power : 1049 MWe
 Reference unit power (net) : 997 MWe

Key Dates

Construction Date : 2000-09-29
 Grid Date : 2005-01-07
 Commercial Date : 2005-04-22
 Age at end of year : 18 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 5
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 36.15
 Average discharge burnup [MWd/t] : 38829
 Active core diameter [m] : 3.124
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 17.69
 Number of control rod assemblies : 180
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 327.3
 Number of SG : 2
 Containment type : Double
 Containment design pressure [MPa] : 0.39

Secondary systems

Number of turbine-generators per unit/reactor : 4
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 7.14
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

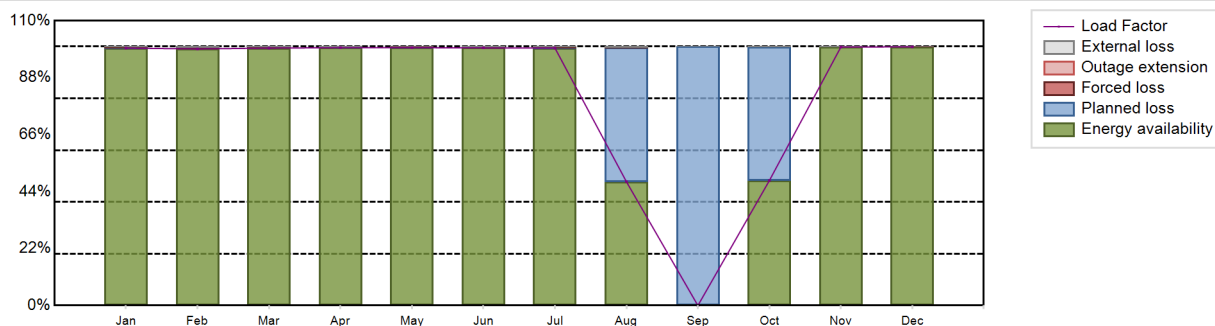
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7214.72 GW(e).h
 Energy Availability Factor (EAF) : 82.61 %
 Unit Capability Factor (UCF) : 82.73 %
 Load Factor (LF) : 82.61 %
 Operating Factor (OF) : 83.63 %
 Forced Loss Rate (FLR) : 0.34 %
 Unplanned Capability Loss Factor (UCL) : 0.28 %
 Planned Unavailability Factor (PUF) : 16.99 %
 Externally cause unavailability (XUF) : 0.12 %
 Total off-line time : 1434 hours

Annual Summary

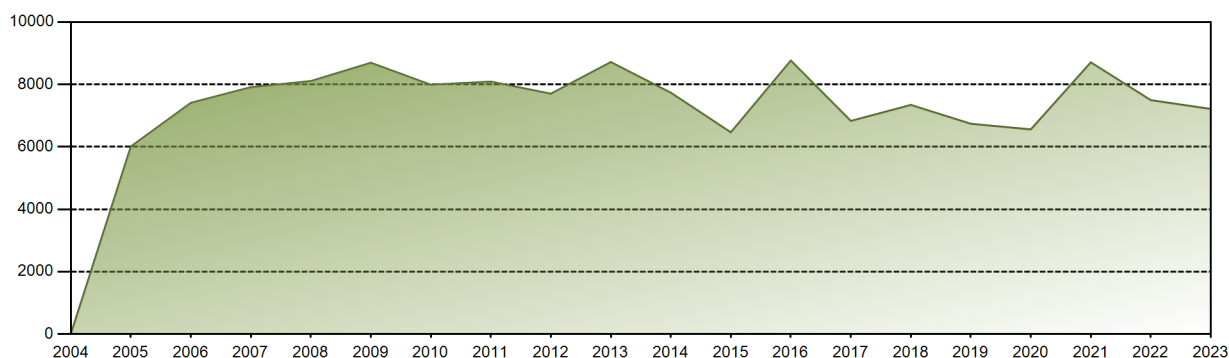


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 737.43 | 663.96 | 737.47 | 714.80 | 738.76 | 714.23 | 737.72 | 354.71 | 0.00 | 357.95 | 716.59 | 741.09 | 7214.72 |
| EAF [%] | 99.42 | 99.10 | 99.42 | 99.58 | 99.59 | 99.50 | 99.45 | 47.82 | 0.00 | 48.26 | 99.82 | 99.91 | 82.61 |
| UCF [%] | 99.45 | 99.41 | 99.50 | 99.59 | 99.59 | 99.65 | 99.63 | 48.10 | 0.00 | 48.48 | 100.00 | 99.91 | 82.73 |
| LF [%] | 99.42 | 99.10 | 99.42 | 99.58 | 99.60 | 99.50 | 99.45 | 47.82 | 0.00 | 48.26 | 99.83 | 99.91 | 82.61 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 49.73 | 0.00 | 54.30 | 100.00 | 100.00 | 83.63 |
| FLR [%] | 0.55 | 0.59 | 0.50 | 0.40 | 0.40 | 0.35 | 0.36 | 0.37 | 0.00 | 0.00 | 0.00 | 0.09 | 0.34 |
| UCL [%] | 0.55 | 0.59 | 0.50 | 0.40 | 0.40 | 0.35 | 0.36 | 0.18 | 0.00 | 0.00 | 0.00 | 0.09 | 0.28 |
| PUF [%] | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 51.72 | 100.00 | 51.52 | 0.00 | 0.00 | 16.99 |
| XUF [%] | 0.03 | 0.31 | 0.08 | 0.02 | 0.00 | 0.15 | 0.18 | 0.28 | 0.00 | 0.22 | 0.18 | 0.00 | 0.12 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 145572.61 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.74 % |
| Cumulative Energy Availability Factor (EAF) | : 88.47 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.66 % |
| Cumulative Unit Capability Factor (UCF) | : 88.63 % | Cumulative Planned Unavailability Factor (PUF) | : 10.71 % |
| Cumulative Load Factor (LF) | : 88.55 % | Cumulative Externally cause unavailability (XUF) | : 0.16 % |
| Cumulative Operating Factor (OF) | : 89.01 % | | |

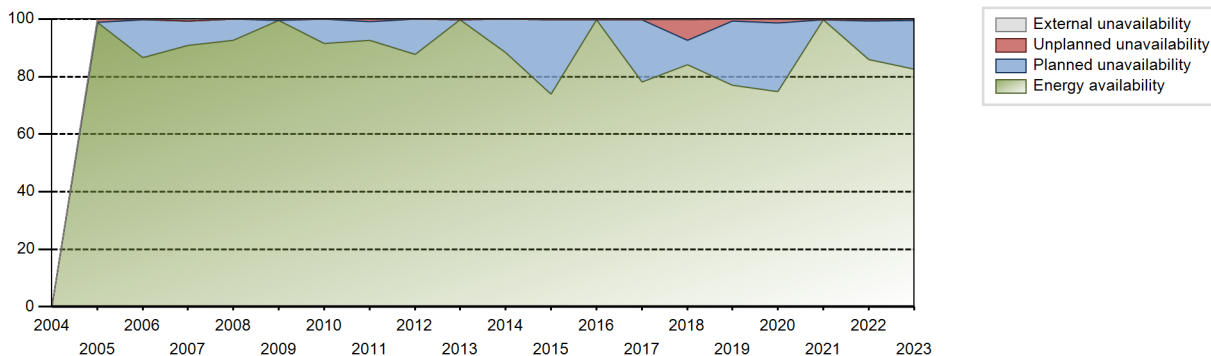
Electricity Production (net) [GWh]



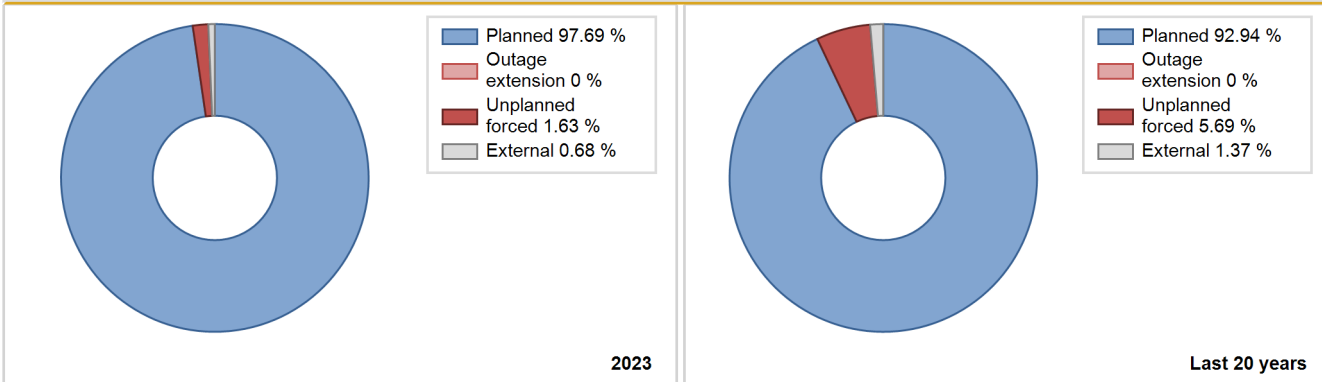
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2005 | 6010.96 | 6041 | 960 | 98.82 | 98.82 | 102.65 | 99.06 | 1.18 | 1.18 | 0.00 | 0.00 |
| 2006 | 7409.91 | 7543 | 991 | 86.65 | 86.65 | 85.36 | 86.11 | 0.38 | 0.33 | 13.02 | 0.00 |
| 2007 | 7911.30 | 8022 | 994 | 90.88 | 91.59 | 90.86 | 91.58 | 0.00 | 0.00 | 8.41 | 0.72 |
| 2008 | 8107.89 | 8168 | 1001 | 92.58 | 92.58 | 92.21 | 92.99 | 0.01 | 0.01 | 7.41 | 0.00 |
| 2009 | 8694.52 | 8724 | 1001 | 99.47 | 99.47 | 99.15 | 99.59 | 0.52 | 0.52 | 0.01 | 0.00 |
| 2010 | 7991.04 | 8055 | 997 | 91.44 | 91.54 | 91.50 | 91.95 | 0.02 | 0.02 | 8.45 | 0.10 |
| 2011 | 8090.56 | 8168 | 997 | 92.53 | 92.64 | 92.64 | 93.24 | 0.82 | 0.77 | 6.59 | 0.11 |
| 2012 | 7703.15 | 7763 | 997 | 87.81 | 87.92 | 87.96 | 88.38 | 0.00 | 0.00 | 12.08 | 0.11 |
| 2013 | 8716.35 | 8760 | 996 | 99.78 | 99.94 | 99.90 | 100.00 | 0.06 | 0.06 | 0.00 | 0.16 |
| 2014 | 7734.99 | 7810 | 997 | 88.47 | 88.57 | 88.56 | 89.16 | 0.00 | 0.00 | 11.43 | 0.10 |
| 2015 | 6465.70 | 6545 | 997 | 73.98 | 74.16 | 74.03 | 74.71 | 0.00 | 0.00 | 25.84 | 0.18 |
| 2016 | 8765.47 | 8784 | 997 | 99.85 | 100.00 | 100.09 | 100.00 | 0.00 | 0.00 | 0.00 | 0.14 |
| 2017 | 6830.58 | 6928 | 997 | 78.19 | 78.55 | 78.21 | 79.09 | 0.00 | 0.00 | 21.45 | 0.36 |
| 2018 | 7343.97 | 7419 | 997 | 84.08 | 84.40 | 84.09 | 84.69 | 7.76 | 7.10 | 8.51 | 0.31 |
| 2019 | 6739.28 | 6843 | 997 | 77.09 | 77.20 | 77.16 | 78.12 | 0.67 | 0.52 | 22.28 | 0.11 |
| 2020 | 6559.04 | 6607 | 997 | 74.81 | 74.83 | 74.89 | 75.22 | 1.76 | 1.34 | 23.83 | 0.02 |
| 2021 | 8708.44 | 8760 | 997 | 99.69 | 99.94 | 99.71 | 100.00 | 0.06 | 0.06 | 0.00 | 0.26 |
| 2022 | 7496.12 | 7620 | 997 | 85.84 | 85.99 | 85.83 | 86.99 | 0.55 | 0.48 | 13.53 | 0.16 |
| 2023 | 7214.72 | 7326 | 997 | 82.61 | 82.73 | 82.61 | 83.63 | 0.34 | 0.28 | 16.99 | 0.12 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2005 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 44 | |
| C. Inspection, maintenance or repair combined with refuelling | 1437 | | | 911 | | |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 3 |
| Subtotal | 1437 | | | 911 | 50 | 3 |
| Total | | 1437 | | | 964 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2005 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 3 |
| 15. Reactor Cooling Systems | | | | 3 |
| 35. All other I&C Systems | | | | 38 |
| 41. Main Generator Systems | | | | 4 |
| 42. Electrical Power Supply Systems | | | | 5 |
| Total | | | | 53 |

Highlights (2023)

Refueling and Maintenance(2023.08.16. ~ 2023.10.15)

2023 Operating Experience

KR-2

KORI-2

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))



Reactor Unit Details

Reactor type and model : PWR / WH F
 Thermal power : 1882 MWth
 Gross electrical power : 681 MWe
 Reference unit power (net) : 640 MWe

Key Dates

Construction Date : 1977-12-23
 Grid Date : 1983-04-22
 Commercial Date : 1983-07-25
 Age at end of year : 40 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.8
 Refuelling frequency [month] : 13
 Part of the core refuelled [%] : 40
 Average discharge burnup [MWd/t] : 36946
 Active core diameter [m] : 2.46
 Active core height/length [m] : 3.658
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 18.04
 Number of control rod assemblies : 33
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 324.5
 Number of SG : 2
 Containment type : Double
 Containment design pressure [MPa] : 0.31

Secondary systems

Number of turbine-generators per unit/reactor : 3
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.35
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

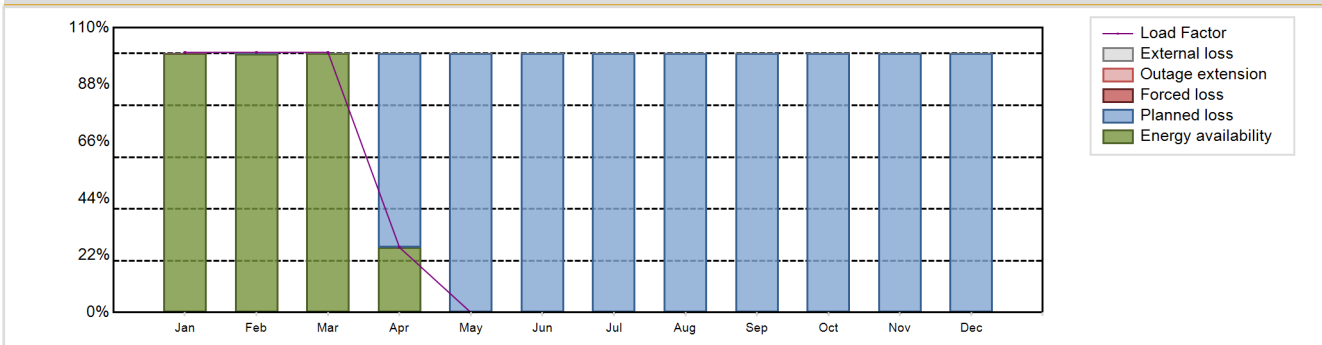
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 1504.5 GW(e).h
 Energy Availability Factor (EAF) : 26.71 %
 Unit Capability Factor (UCF) : 26.71 %
 Load Factor (LF) : 26.84 %
 Operating Factor (OF) : 26.83 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 73.29 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 6410 hours

Annual Summary

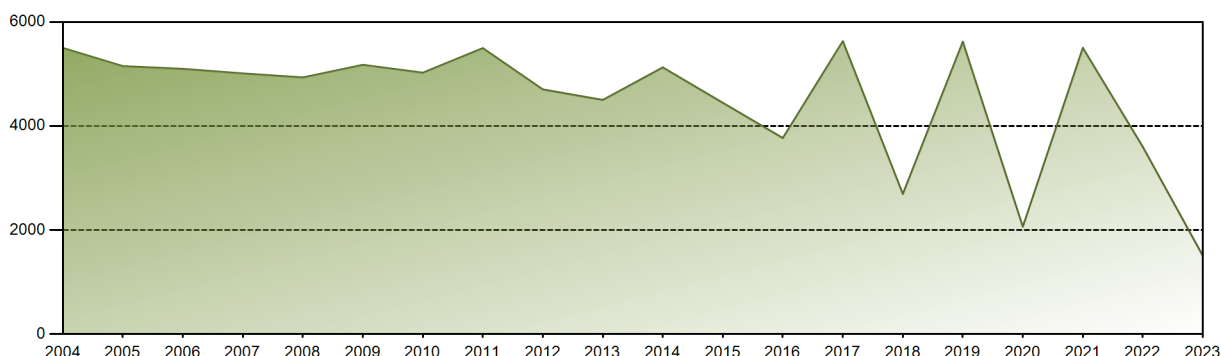


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 478.17 | 431.93 | 478.44 | 115.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1504.50 |
| EAF [%] | 100.00 | 99.98 | 100.00 | 25.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.71 |
| UCF [%] | 100.00 | 99.98 | 100.00 | 25.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.71 |
| LF [%] | 100.42 | 100.43 | 100.48 | 25.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.84 |
| OF [%] | 100.00 | 100.00 | 100.00 | 26.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.83 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.02 | 0.00 | 74.96 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 73.29 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 185221.57 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.96 % |
| Cumulative Energy Availability Factor (EAF) | : 82.49 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.65 % |
| Cumulative Unit Capability Factor (UCF) | : 82.82 % | Cumulative Planned Unavailability Factor (PUF) | : 15.53 % |
| Cumulative Load Factor (LF) | : 83.62 % | Cumulative Externally cause unavailability (XUF) | : 0.33 % |
| Cumulative Operating Factor (OF) | : 83.36 % | | |

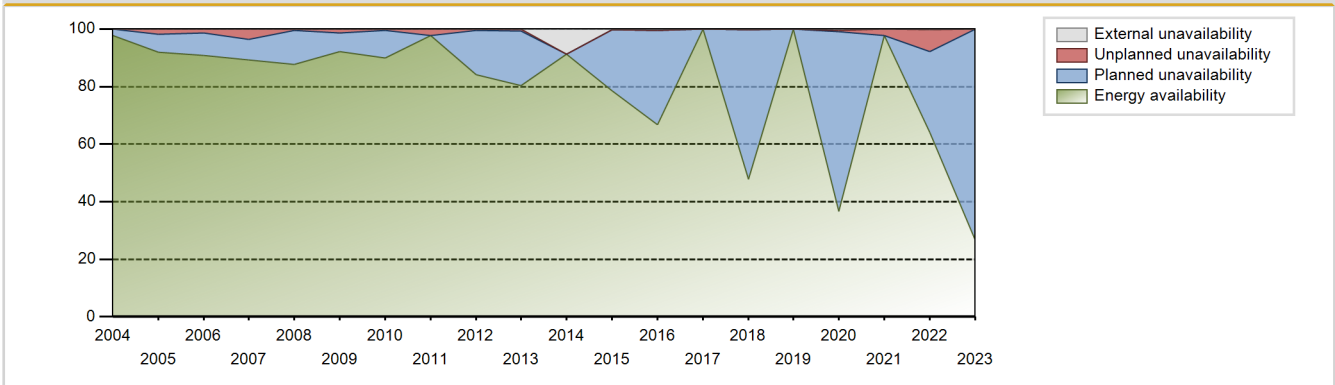
Electricity Production (net) [GWh]



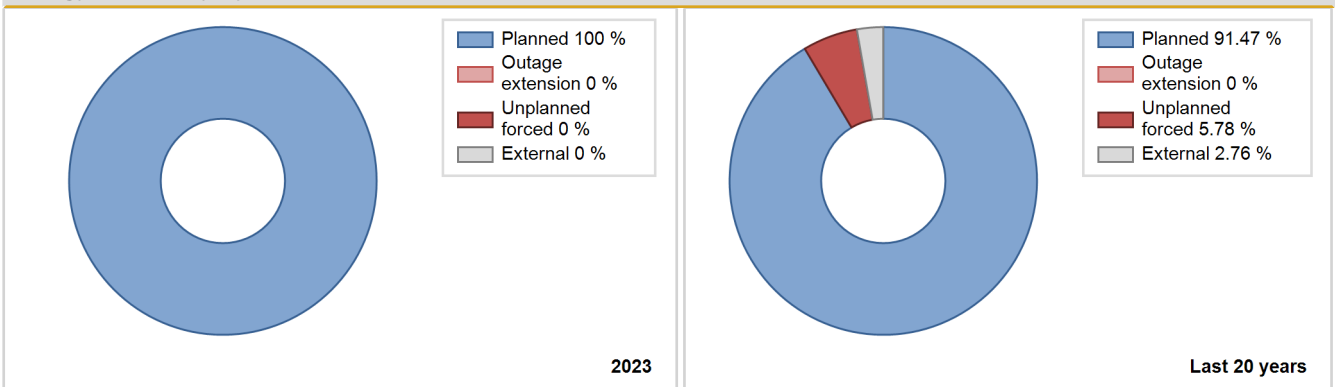
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | | | | Data not provided | | | | | | | |
| 1984 | 4086.38 | 6876 | 605 | 76.10 | 76.10 | 76.89 | 78.28 | 10.44 | 8.87 | 15.03 | 0.00 |
| 1985 | 3731.40 | 6641 | 605 | 69.83 | 69.83 | 70.41 | 75.81 | 16.53 | 13.82 | 16.35 | 0.00 |
| 1986 | 3945.20 | 6555 | 605 | 74.83 | 75.22 | 74.44 | 74.83 | 13.85 | 12.10 | 12.68 | 0.40 |
| 1987 | 4265.44 | 7251 | 605 | 81.64 | 82.07 | 80.48 | 82.77 | 0.60 | 0.49 | 17.43 | 0.43 |
| 1988 | 4504.67 | 7275 | 605 | 82.82 | 82.82 | 84.76 | 82.82 | 0.00 | 0.00 | 17.18 | 0.00 |
| 1989 | 5062.77 | 8387 | 605 | 95.74 | 95.74 | 95.53 | 95.74 | 3.94 | 3.93 | 0.33 | 0.00 |
| 1990 | 4349.88 | 7381 | 605 | 84.26 | 84.26 | 82.08 | 84.26 | 0.00 | 0.00 | 15.74 | 0.00 |
| 1991 | 4553.98 | 7512 | 605 | 85.75 | 85.75 | 85.93 | 85.75 | 0.09 | 0.08 | 14.17 | 0.00 |
| 1992 | 4517.20 | 7469 | 605 | 85.03 | 85.03 | 85.00 | 85.03 | 0.64 | 0.55 | 14.42 | 0.00 |
| 1993 | 4186.98 | 7048 | 605 | 80.46 | 80.46 | 79.00 | 80.46 | 0.85 | 0.69 | 18.85 | 0.00 |
| 1994 | 4693.89 | 7685 | 605 | 86.50 | 86.50 | 88.57 | 87.73 | 0.35 | 0.30 | 13.20 | 0.00 |
| 1995 | 5106.61 | 8370 | 605 | 94.71 | 94.78 | 96.35 | 95.55 | 0.78 | 0.75 | 4.48 | 0.07 |
| 1996 | 4673.92 | 7668 | 605 | 86.03 | 86.06 | 87.95 | 87.30 | 0.29 | 0.25 | 13.69 | 0.03 |
| 1997 | 4620.33 | 7639 | 605 | 86.62 | 86.75 | 87.18 | 87.20 | 0.01 | 0.01 | 13.24 | 0.14 |
| 1998 | 4697.63 | 7541 | 605 | 84.87 | 84.87 | 88.64 | 86.08 | 1.30 | 1.12 | 14.01 | 0.00 |
| 1999 | 4672.24 | 7472 | 605 | 83.62 | 83.62 | 88.16 | 85.30 | 0.00 | 0.00 | 16.38 | 0.00 |
| 2000 | 4914.70 | 7812 | 605 | 90.14 | 90.14 | 92.48 | 88.93 | 0.00 | 0.00 | 9.85 | 0.00 |
| 2001 | 4807.76 | 7650 | 605 | 87.29 | 87.29 | 90.72 | 87.33 | 0.02 | 0.02 | 12.69 | 0.00 |
| 2002 | 5051.22 | 7982 | 605 | 90.63 | 90.63 | 95.31 | 91.12 | 0.00 | 0.01 | 9.36 | 0.00 |
| 2003 | 4844.24 | 7709 | 605 | 85.43 | 86.52 | 91.40 | 88.00 | 1.24 | 1.09 | 12.40 | 1.09 |
| 2004 | 5501.54 | 8602 | 605 | 97.84 | 97.84 | 103.52 | 97.93 | 0.00 | 0.00 | 2.16 | 0.00 |
| 2005 | 5151.51 | 8080 | 605 | 92.05 | 92.05 | 97.20 | 92.24 | 2.02 | 1.89 | 6.06 | 0.00 |
| 2006 | 5099.16 | 7984 | 637 | 90.79 | 90.79 | 91.38 | 91.14 | 1.42 | 1.31 | 7.90 | 0.00 |
| 2007 | 5011.02 | 7886 | 637 | 89.21 | 89.23 | 89.80 | 90.02 | 3.82 | 3.54 | 7.23 | 0.01 |
| 2008 | 4933.94 | 7771 | 637 | 87.64 | 87.64 | 88.18 | 88.47 | 0.60 | 0.53 | 11.83 | 0.00 |
| 2009 | 5176.87 | 8110 | 637 | 92.18 | 92.18 | 92.77 | 92.58 | 1.55 | 1.45 | 6.37 | 0.00 |
| 2010 | 5025.59 | 7921 | 637 | 90.04 | 90.04 | 90.06 | 90.42 | 0.46 | 0.42 | 9.55 | 0.00 |
| 2011 | 5497.79 | 8578 | 637 | 97.78 | 97.78 | 98.52 | 97.92 | 2.21 | 2.21 | 0.01 | 0.00 |
| 2012 | 4703.69 | 7606 | 637 | 84.03 | 84.03 | 84.06 | 86.59 | 0.57 | 0.48 | 15.49 | 0.00 |
| 2013 | 4501.64 | 7118 | 639 | 80.28 | 80.31 | 80.42 | 81.26 | 0.79 | 0.64 | 19.05 | 0.03 |
| 2014 | 5127.37 | 8035 | 640 | 91.22 | 99.99 | 91.46 | 91.72 | 0.00 | 0.00 | 0.01 | 8.77 |
| 2015 | 4446.10 | 6923 | 640 | 78.67 | 78.84 | 79.30 | 79.03 | 0.00 | 0.00 | 21.16 | 0.16 |
| 2016 | 3769.97 | 5935 | 640 | 66.84 | 67.22 | 67.06 | 67.57 | 0.00 | 0.00 | 32.78 | 0.38 |
| 2017 | 5631.94 | 8760 | 640 | 99.95 | 99.99 | 100.46 | 100.00 | 0.00 | 0.00 | 0.01 | 0.04 |
| 2018 | 2694.13 | 4356 | 640 | 47.84 | 48.12 | 48.05 | 49.73 | 0.08 | 0.04 | 51.84 | 0.28 |
| 2019 | 5620.15 | 8760 | 640 | 99.92 | 99.98 | 100.25 | 100.00 | 0.01 | 0.01 | 0.01 | 0.06 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|------|-------|------|
| 2020 | 2064.65 | 3327 | 640 | 36.59 | 37.14 | 36.73 | 37.88 | 1.14 | 0.43 | 62.44 | 0.55 |
| 2021 | 5502.38 | 8584 | 640 | 97.78 | 97.84 | 98.14 | 97.99 | 2.15 | 2.15 | 0.01 | 0.07 |
| 2022 | 3598.82 | 5677 | 640 | 63.98 | 64.31 | 64.19 | 64.81 | 10.42 | 7.48 | 28.21 | 0.33 |
| 2023 | 1504.50 | 2350 | 640 | 26.71 | 26.71 | 26.84 | 26.83 | 0.00 | 0.00 | 73.29 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 108 | |
| C. Inspection, maintenance or repair combined with refuelling | 6410 | | | 1269 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 24 | | |
| E. Testing of plant systems or components | | | | | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| L. Human factor related | | | | | 7 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 18 |
| Subtotal | 6410 | | | 1293 | 115 | 22 |
| Total | | 6410 | | | 1430 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 15 |
| 14. Safety Systems | | 0 |
| 15. Reactor Cooling Systems | | 8 |
| 16. Steam generation systems | | 2 |
| 31. Turbine and auxiliaries | | 28 |
| 32. Feedwater and Main Steam System | | 9 |
| 33. Circulating Water System | | 18 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 28 |
| 42. Electrical Power Supply Systems | | 25 |
| Total | | 133 |

Highlights (2023)

Maintenance(4.8~12.31)

2023 Operating Experience

KR-5

KORI-3

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))



Reactor Unit Details

Reactor type and model : PWR / WH F
 Thermal power : 2912 MWth
 Gross electrical power : 1046 MWe
 Reference unit power (net) : 1011 MWe

Key Dates

Construction Date : 1979-10-01
 Grid Date : 1985-01-22
 Commercial Date : 1985-09-30
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.5
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 41
 Average discharge burnup [MWd/t] : 17910
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.658
 Number of fissile fuel assemblies/bundles : 151
 Fuel linear heat generation rate [kW/m] : 17.83
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.4
 Reactor outlet temperature [°C] : 326
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.31

Secondary systems

Number of turbine-generators per unit/reactor : 4
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.53
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 2

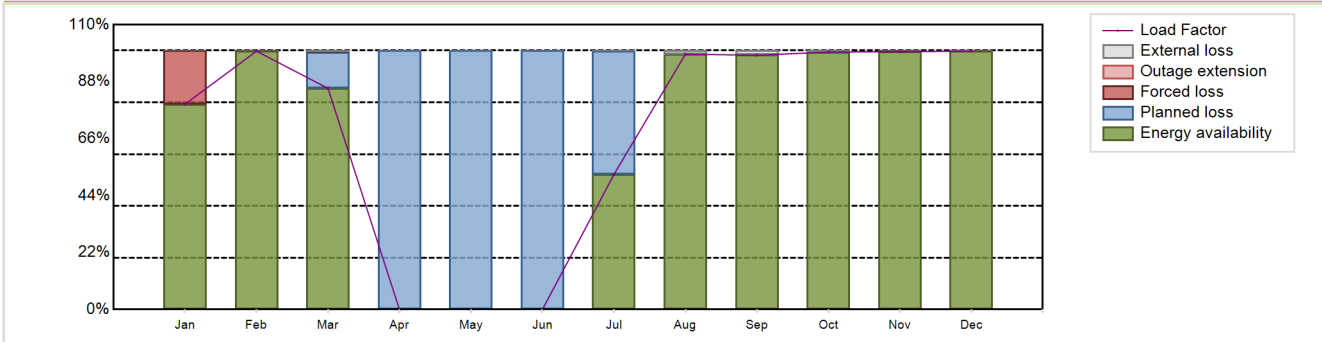
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5988.78 GW(e).h
 Energy Availability Factor (EAF) : 67.63 %
 Unit Capability Factor (UCF) : 67.97 %
 Load Factor (LF) : 67.62 %
 Operating Factor (OF) : 68.87 %
 Forced Loss Rate (FLR) : 2.64 %
 Unplanned Capability Loss Factor (UCL) : 1.84 %
 Planned Unavailability Factor (PUF) : 30.19 %
 Externally cause unavailability (XUF) : 0.34 %
 Total off-line time : 2727 hours

Annual Summary

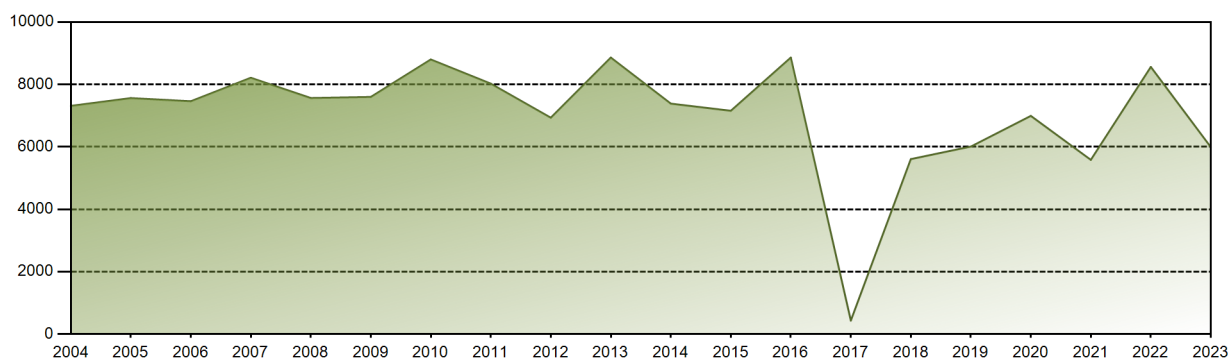


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 596.40 | 677.85 | 642.53 | 0.00 | 0.00 | 0.00 | 392.05 | 741.80 | 714.84 | 747.94 | 725.05 | 750.33 | 5988.78 |
| EAF [%] | 79.29 | 99.77 | 85.42 | 0.00 | 0.00 | 0.00 | 52.12 | 98.62 | 98.35 | 99.44 | 99.61 | 99.75 | 67.63 |
| UCF [%] | 79.29 | 99.77 | 85.80 | 0.00 | 0.00 | 0.00 | 52.19 | 100.00 | 100.00 | 99.99 | 99.61 | 99.75 | 67.97 |
| LF [%] | 79.29 | 99.77 | 85.42 | 0.00 | 0.00 | 0.00 | 52.12 | 98.62 | 98.20 | 99.44 | 99.61 | 99.75 | 67.62 |
| OF [%] | 83.74 | 100.00 | 88.44 | 0.00 | 0.00 | 0.00 | 54.84 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 68.87 |
| FLR [%] | 20.71 | 0.23 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | 0.25 | 2.64 |
| UCL [%] | 20.71 | 0.23 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | 0.25 | 1.84 |
| PUF [%] | 0.00 | 0.00 | 14.03 | 100.00 | 100.00 | 100.00 | 47.81 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 30.19 |
| XUF [%] | 0.00 | 0.00 | 0.38 | 0.00 | 0.00 | 0.00 | 0.07 | 1.38 | 1.65 | 0.55 | 0.00 | 0.00 | 0.34 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 267983.27 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.13 % |
| Cumulative Energy Availability Factor (EAF) | : 82.18 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.94 % |
| Cumulative Unit Capability Factor (UCF) | : 82.53 % | Cumulative Planned Unavailability Factor (PUF) | : 16.53 % |
| Cumulative Load Factor (LF) | : 83.84 % | Cumulative Externally cause unavailability (XUF) | : 0.35 % |
| Cumulative Operating Factor (OF) | : 82.88 % | | |

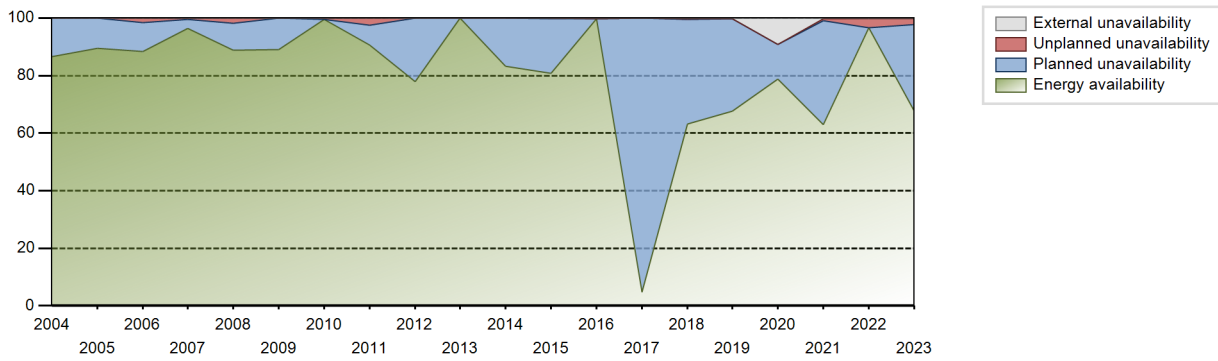
Electricity Production (net) [GWh]



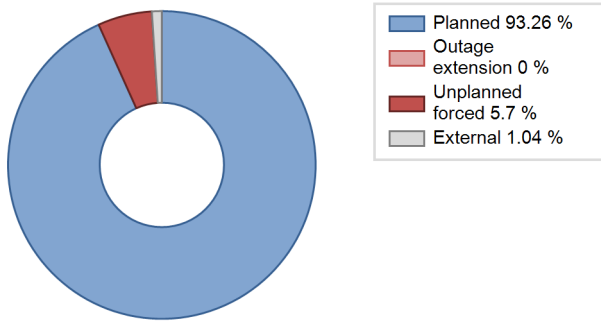
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | | | | Data not provided | | | | | | | |
| 1986 | 5611.72 | 6529 | 895 | 73.32 | 73.32 | 71.58 | 74.53 | 5.41 | 4.20 | 22.48 | 0.00 |
| 1987 | 5804.81 | 6665 | 895 | 78.78 | 79.12 | 74.04 | 76.08 | 2.13 | 1.72 | 19.16 | 0.34 |
| 1988 | 6119.71 | 7005 | 895 | 79.75 | 79.75 | 77.84 | 79.75 | 0.38 | 0.31 | 19.95 | 0.00 |
| 1989 | 6591.97 | 7206 | 895 | 82.26 | 82.26 | 84.08 | 82.26 | 1.89 | 1.59 | 16.15 | 0.00 |
| 1990 | 6838.13 | 7923 | 895 | 90.45 | 90.45 | 87.22 | 90.45 | 1.57 | 1.44 | 8.12 | 0.00 |
| 1991 | 5902.46 | 6578 | 895 | 75.09 | 75.09 | 75.28 | 75.09 | 10.59 | 8.89 | 16.02 | 0.00 |
| 1992 | 6746.17 | 7349 | 895 | 83.66 | 83.66 | 85.81 | 83.66 | 0.00 | 0.00 | 16.34 | 0.00 |
| 1993 | 7121.81 | 7721 | 895 | 88.14 | 88.14 | 90.84 | 88.14 | 1.37 | 1.22 | 10.63 | 0.00 |
| 1994 | 6545.31 | 7128 | 890 | 79.18 | 79.35 | 83.95 | 81.37 | 0.00 | 0.00 | 20.65 | 0.16 |
| 1995 | 6015.47 | 6863 | 895 | 73.75 | 73.75 | 76.73 | 78.34 | 0.66 | 0.49 | 25.76 | 0.00 |
| 1996 | 7939.72 | 8431 | 895 | 95.42 | 95.42 | 100.99 | 95.98 | 0.00 | 0.00 | 4.58 | 0.00 |
| 1997 | 6051.91 | 6503 | 895 | 73.82 | 73.82 | 77.19 | 74.24 | 0.00 | 0.00 | 26.18 | 0.00 |
| 1998 | 6902.53 | 7325 | 895 | 82.78 | 82.86 | 88.04 | 83.62 | 3.30 | 2.83 | 14.32 | 0.08 |
| 1999 | 7231.82 | 7615 | 895 | 86.30 | 86.30 | 92.24 | 86.93 | 0.21 | 0.18 | 13.52 | 0.00 |
| 2000 | 8094.33 | 8399 | 895 | 95.59 | 95.59 | 102.96 | 95.62 | 0.32 | 0.31 | 4.10 | 0.00 |
| 2001 | 7570.25 | 7881 | 895 | 89.41 | 89.41 | 96.56 | 89.97 | 0.00 | 0.00 | 10.59 | 0.00 |
| 2002 | 7684.80 | 8062 | 895 | 90.93 | 90.93 | 98.02 | 92.03 | 0.00 | 0.00 | 9.07 | 0.00 |
| 2003 | 8387.43 | 8689 | 895 | 99.05 | 100.00 | 106.98 | 99.19 | 0.00 | 0.00 | 0.00 | 0.95 |
| 2004 | 7312.46 | 7630 | 895 | 86.55 | 86.55 | 93.01 | 86.86 | 0.00 | 0.00 | 13.45 | 0.00 |
| 2005 | 7562.17 | 7885 | 895 | 89.44 | 89.44 | 96.45 | 90.01 | 0.00 | 0.00 | 10.56 | 0.00 |
| 2006 | 7461.77 | 7813 | 963 | 88.28 | 88.28 | 88.45 | 89.19 | 1.82 | 1.63 | 10.08 | 0.00 |
| 2007 | 8214.16 | 8503 | 964 | 96.40 | 96.40 | 97.27 | 97.07 | 0.49 | 0.47 | 3.12 | 0.00 |
| 2008 | 7564.39 | 7854 | 979 | 88.80 | 88.88 | 87.96 | 89.41 | 2.00 | 1.82 | 9.30 | 0.08 |
| 2009 | 7599.62 | 7820 | 1007 | 88.99 | 88.99 | 88.40 | 89.27 | 0.00 | 0.00 | 11.00 | 0.00 |
| 2010 | 8799.70 | 8732 | 1007 | 99.56 | 99.56 | 99.75 | 99.68 | 0.44 | 0.44 | 0.00 | 0.00 |
| 2011 | 8025.13 | 7971 | 1011 | 90.57 | 90.57 | 90.61 | 90.99 | 2.77 | 2.58 | 6.85 | 0.00 |
| 2012 | 6933.06 | 6875 | 1011 | 77.89 | 77.97 | 78.07 | 78.27 | 0.01 | 0.01 | 22.02 | 0.09 |
| 2013 | 8861.52 | 8760 | 1011 | 99.93 | 100.00 | 100.06 | 100.00 | 0.00 | 0.00 | 0.00 | 0.07 |
| 2014 | 7384.18 | 7332 | 1011 | 83.33 | 83.39 | 83.38 | 83.70 | 0.00 | 0.00 | 16.61 | 0.07 |
| 2015 | 7155.51 | 7119 | 1011 | 80.70 | 80.74 | 80.80 | 81.27 | 0.28 | 0.23 | 19.04 | 0.04 |
| 2016 | 8860.96 | 8784 | 1011 | 99.77 | 100.00 | 99.78 | 100.00 | 0.00 | 0.00 | 0.00 | 0.23 |
| 2017 | 432.36 | 442 | 1011 | 4.88 | 4.96 | 4.88 | 5.05 | 0.00 | 0.00 | 95.04 | 0.07 |
| 2018 | 5606.18 | 5610 | 1011 | 63.27 | 63.43 | 63.30 | 64.04 | 0.61 | 0.39 | 36.17 | 0.17 |
| 2019 | 6008.10 | 5962 | 1011 | 67.75 | 67.93 | 67.84 | 68.06 | 0.02 | 0.02 | 32.05 | 0.19 |
| 2020 | 6991.45 | 6953 | 1011 | 78.68 | 87.91 | 78.73 | 79.16 | 0.01 | 0.01 | 12.08 | 9.23 |
| 2021 | 5582.70 | 5576 | 1011 | 63.02 | 63.18 | 63.04 | 63.65 | 1.22 | 0.78 | 36.04 | 0.16 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 8560.23 | 8528 | 1011 | 96.66 | 97.01 | 96.66 | 97.35 | 2.99 | 2.99 | 0.00 | 0.36 |
| 2023 | 5988.78 | 6033 | 1011 | 67.63 | 67.97 | 67.62 | 68.87 | 2.64 | 1.84 | 30.19 | 0.34 |

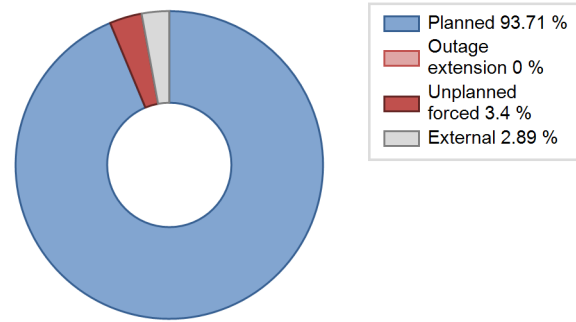
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 121 | | | 72 | |
| C. Inspection, maintenance or repair combined with refuelling | 2606 | | | 1344 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 16 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 25 | | |
| H. Nuclear regulatory requirements | | | | | 4 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 7 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 21 |
| Subtotal | 2606 | 121 | | 1385 | 83 | 24 |
| Total | | 2727 | | | 1492 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 10 |
| 13. Reactor Auxiliary Systems | | 4 |
| 15. Reactor Cooling Systems | | 2 |
| 16. Steam generation systems | | 3 |
| 31. Turbine and auxiliaries | | 11 |
| 32. Feedwater and Main Steam System | | 7 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | 121 | 36 |
| 42. Electrical Power Supply Systems | | 3 |
| Total | 121 | 80 |

Highlights (2023)

Automatic scram due to actuation of voltage ground relay (2022. 12. 22. ~ 2023. 1. 6.)
27th Refueling and Maintenance (2023. 3. 28. ~ 2023. 7. 14.)

2023 Operating Experience

KR-6

KORI-4

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))



Reactor Unit Details

Reactor type and model : PWR / WH F
 Thermal power : 2912 MWth
 Gross electrical power : 1046 MWe
 Reference unit power (net) : 1012 MWe

Key Dates

Construction Date : 1980-04-01
 Grid Date : 1985-12-31
 Commercial Date : 1986-04-29
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.5
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 41
 Average discharge burnup [MWd/t] : 18210
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.658
 Number of fissile fuel assemblies/bundles : 151
 Fuel linear heat generation rate [kW/m] : 17.83
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.2
 Reactor outlet temperature [°C] : 326
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.31

Secondary systems

Number of turbine-generators per unit/reactor : 4
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.53
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 2

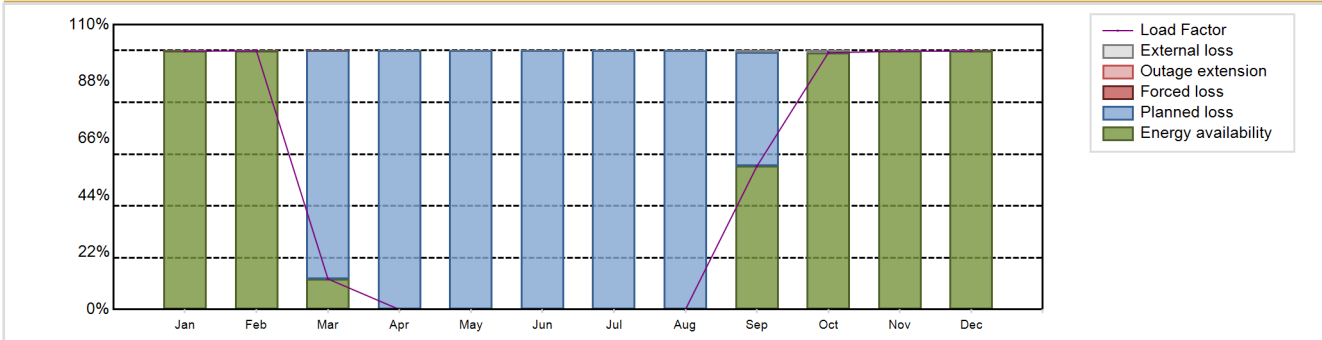
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 4147.74 GW(e).h
 Energy Availability Factor (EAF) : 46.79 %
 Unit Capability Factor (UCF) : 46.92 %
 Load Factor (LF) : 46.79 %
 Operating Factor (OF) : 48.01 %
 Forced Loss Rate (FLR) : 0.14 %
 Unplanned Capability Loss Factor (UCL) : 0.07 %
 Planned Unavailability Factor (PUF) : 53.02 %
 Externally cause unavailability (XUF) : 0.13 %
 Total off-line time : 4554 hours

Annual Summary

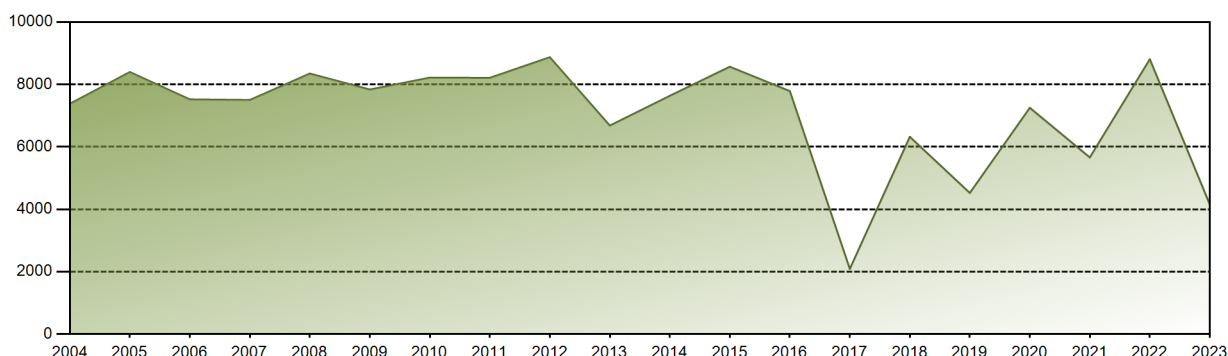


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 751.16 | 679.24 | 88.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 403.27 | 746.81 | 726.92 | 751.41 | 4147.74 |
| EAF [%] | 99.77 | 99.88 | 11.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 55.35 | 99.19 | 99.76 | 99.80 | 46.79 |
| UCF [%] | 99.77 | 99.88 | 11.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 56.10 | 100.00 | 99.76 | 99.80 | 46.92 |
| LF [%] | 99.77 | 99.88 | 11.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 55.35 | 99.19 | 99.76 | 99.80 | 46.79 |
| OF [%] | 100.00 | 100.00 | 14.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 66.11 | 100.00 | 100.00 | 100.00 | 48.01 |
| FLR [%] | 0.23 | 0.12 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.20 | 0.14 |
| UCL [%] | 0.23 | 0.12 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.20 | 0.07 |
| PUF [%] | 0.00 | 0.00 | 88.18 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 43.90 | 0.00 | 0.00 | 0.00 | 53.02 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.75 | 0.81 | 0.00 | 0.00 | 0.13 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 267178.76 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.58 % |
| Cumulative Energy Availability Factor (EAF) | : 82.96 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.49 % |
| Cumulative Unit Capability Factor (UCF) | : 83.39 % | Cumulative Planned Unavailability Factor (PUF) | : 16.13 % |
| Cumulative Load Factor (LF) | : 84.75 % | Cumulative Externally cause unavailability (XUF) | : 0.42 % |
| Cumulative Operating Factor (OF) | : 83.67 % | | |

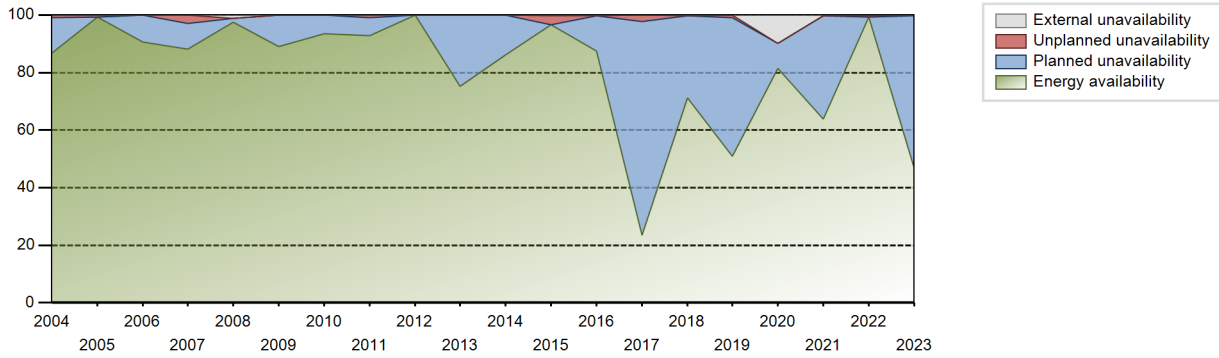
Electricity Production (net) [GWh]



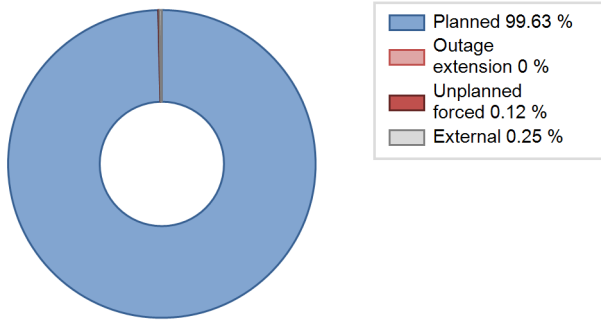
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | | | | Data not provided | | | | | | | |
| 1987 | 5860.82 | 6707 | 895 | 78.01 | 78.27 | 74.75 | 76.56 | 0.53 | 0.42 | 21.31 | 0.26 |
| 1988 | 5909.08 | 7006 | 895 | 79.76 | 80.70 | 75.16 | 79.76 | 0.34 | 0.27 | 19.02 | 0.94 |
| 1989 | 6177.37 | 6763 | 895 | 77.20 | 77.20 | 78.79 | 77.20 | 0.19 | 0.15 | 22.65 | 0.00 |
| 1990 | 6230.03 | 7140 | 895 | 81.51 | 81.51 | 79.46 | 81.51 | 1.08 | 0.89 | 17.60 | 0.00 |
| 1991 | 6353.02 | 7011 | 895 | 80.03 | 80.44 | 81.03 | 80.03 | 1.18 | 0.96 | 18.60 | 0.41 |
| 1992 | 6652.32 | 7266 | 895 | 82.72 | 82.72 | 84.62 | 82.72 | 0.68 | 0.57 | 16.71 | 0.00 |
| 1993 | 6835.92 | 7456 | 895 | 85.11 | 85.11 | 87.19 | 85.11 | 1.51 | 1.30 | 13.59 | 0.00 |
| 1994 | 7455.10 | 8160 | 890 | 90.02 | 90.05 | 95.62 | 93.15 | 0.50 | 0.46 | 9.50 | 0.03 |
| 1995 | 6950.57 | 7824 | 890 | 89.31 | 89.31 | 89.15 | 89.32 | 0.00 | 0.00 | 10.69 | 0.01 |
| 1996 | 6678.43 | 7147 | 895 | 80.04 | 80.04 | 84.95 | 81.36 | 0.00 | 0.00 | 19.96 | 0.00 |
| 1997 | 7014.21 | 7450 | 895 | 84.36 | 84.36 | 89.46 | 85.05 | 0.00 | 0.00 | 15.64 | 0.00 |
| 1998 | 8433.70 | 8760 | 895 | 100.00 | 100.00 | 107.57 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1999 | 7128.95 | 7451 | 895 | 84.56 | 84.56 | 90.93 | 85.06 | 0.00 | 0.00 | 15.44 | 0.00 |
| 2000 | 7334.35 | 7578 | 895 | 86.17 | 86.17 | 93.29 | 86.27 | 0.45 | 0.39 | 13.44 | 0.00 |
| 2001 | 7615.10 | 7929 | 895 | 89.99 | 89.99 | 97.13 | 90.51 | 0.00 | 0.00 | 10.01 | 0.00 |
| 2002 | 8495.50 | 8760 | 895 | 100.00 | 100.00 | 108.36 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 7596.96 | 7913 | 895 | 89.58 | 90.47 | 96.90 | 90.33 | 0.00 | 0.00 | 9.53 | 0.89 |
| 2004 | 7378.56 | 7669 | 895 | 86.83 | 86.83 | 93.85 | 87.31 | 0.95 | 0.83 | 12.34 | 0.00 |
| 2005 | 8397.18 | 8695 | 895 | 99.20 | 99.20 | 107.10 | 99.26 | 0.80 | 0.80 | 0.00 | 0.00 |
| 2006 | 7520.38 | 7824 | 967 | 90.67 | 90.67 | 88.78 | 89.32 | 0.15 | 0.14 | 9.19 | 0.00 |
| 2007 | 7500.92 | 7967 | 966 | 88.04 | 88.04 | 88.64 | 90.95 | 3.13 | 2.84 | 9.11 | 0.00 |
| 2008 | 8348.25 | 8674 | 977 | 97.62 | 98.76 | 97.28 | 98.75 | 0.00 | 0.00 | 1.24 | 1.14 |
| 2009 | 7836.76 | 7779 | 1007 | 89.02 | 89.02 | 89.06 | 88.80 | 0.00 | 0.00 | 10.98 | 0.00 |
| 2010 | 8218.18 | 8217 | 1007 | 93.55 | 93.56 | 93.16 | 93.80 | 0.00 | 0.00 | 6.44 | 0.01 |
| 2011 | 8210.90 | 8227 | 1009 | 92.77 | 92.83 | 92.90 | 93.92 | 0.88 | 0.82 | 6.35 | 0.06 |
| 2012 | 8871.96 | 8784 | 1007 | 99.95 | 100.00 | 100.30 | 100.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| 2013 | 6681.28 | 6680 | 1010 | 75.32 | 75.41 | 75.52 | 76.26 | 0.00 | 0.00 | 24.59 | 0.09 |
| 2014 | 7635.09 | 7579 | 1010 | 86.04 | 86.04 | 86.30 | 86.52 | 0.00 | 0.00 | 13.96 | 0.00 |
| 2015 | 8566.93 | 8488 | 1012 | 96.59 | 96.74 | 96.64 | 96.89 | 3.26 | 3.26 | 0.00 | 0.15 |
| 2016 | 7786.10 | 7746 | 1012 | 87.57 | 87.87 | 87.59 | 88.18 | 0.02 | 0.02 | 12.11 | 0.30 |
| 2017 | 2088.18 | 2069 | 1012 | 23.55 | 23.59 | 23.55 | 23.62 | 8.76 | 2.27 | 74.14 | 0.03 |
| 2018 | 6320.55 | 6279 | 1012 | 71.26 | 71.41 | 71.30 | 71.68 | 0.03 | 0.02 | 28.57 | 0.15 |
| 2019 | 4521.89 | 4546 | 1012 | 50.96 | 50.97 | 51.01 | 51.89 | 1.59 | 0.82 | 48.21 | 0.00 |
| 2020 | 7250.24 | 7222 | 1012 | 81.52 | 91.37 | 81.56 | 82.22 | 0.08 | 0.07 | 8.56 | 9.84 |
| 2021 | 5660.06 | 5649 | 1012 | 63.80 | 63.99 | 63.85 | 64.49 | 0.08 | 0.05 | 35.96 | 0.20 |
| 2022 | 8807.27 | 8760 | 1012 | 99.35 | 99.65 | 99.35 | 100.00 | 0.35 | 0.35 | 0.00 | 0.31 |

2023 4147.74 4206 1012 46.79 46.92 46.79 48.01 0.14 0.07 53.02 0.13

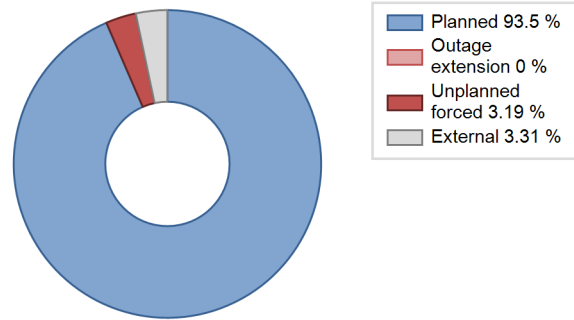
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 33 | |
| C. Inspection, maintenance or repair combined with refuelling | 4554 | | | 1304 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 15 | | |
| E. Testing of plant systems or components | | | | | 0 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 29 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 25 |
| Z. Other | | | | | | 0 |
| Subtotal | 4554 | | | 1348 | 34 | 28 |
| Total | | 4554 | | | 1410 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 0 |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 0 |
| 15. Reactor Cooling Systems | | 2 |
| 16. Steam generation systems | | 5 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 31. Turbine and auxiliaries | | 7 |
| 32. Feedwater and Main Steam System | | 4 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 1 |
| 41. Main Generator Systems | | 0 |
| 42. Electrical Power Supply Systems | | 9 |
| Total | | 37 |

Highlights (2023)

27th Refueling and Maintenance (2023. 3. 5. ~ 2023. 9. 11.)

2023 Operating Experience

KR-25

SAEUL-1

KOREA, REPUBLIC OF

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : KHNP (Korea Hydro and Nuclear Power Co.) |
| Owner | : KHNP (Korea Hydro and Nuclear Power Co.) |
| Reactor Supplier | : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING) |
| Turbine Supplier | : DHICGE (Doosan Heavy Industries & Construction and General Electric) |

Reactor Unit Details

| | |
|----------------------------|------------------|
| Reactor type and model | : PWR / APR-1400 |
| Thermal power | : 3983 MWth |
| Gross electrical power | : 1488 MWe |
| Reference unit power (net) | : 1416 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 2008-10-16 |
| Grid Date | : 2016-01-15 |
| Commercial Date | : 2016-12-20 |
| Age at end of year | : 7 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : 2.66 |
| Refuelling frequency [month] | : 18 |
| Part of the core refuelled [%] | : 41 |
| Average discharge burnup [MWd/t] | : 53073 |
| Active core diameter [m] | : 3.647 |
| Active core height/length [m] | : 3.81 |
| Number of fissile fuel assemblies/bundles | : 241 |
| Fuel linear heat generation rate [kW/m] | : 18.38 |
| Number of control rod assemblies | : 93 |
| Number of external reactor coolant loops | : 2 |
| Coolant type | : H2O |

| | |
|-----------------------------------|----------|
| Operating coolant pressure [MPa] | : 15.5 |
| Reactor outlet temperature [°C] | : 323.9 |
| Number of SG | : 2 |
| Containment type | : Single |
| Containment design pressure [MPa] | : 0.41 |

Secondary systems

| | |
|--|----------------------|
| Number of turbine-generators per unit/reactor | : 4 |
| Turbine speed [rpm] | : 1800 |
| Number of LP cylinders per turbine | : 3 |
| HP cylinder inlet steam pressure [MPa] | : 6.764 |
| Output voltage [kV] | : 24 |
| Primary means of condenser cooling | : Sea (once-through) |
| Number of main condensate pumps | : 3 |
| Number of FW pumps for full power operation | : 3 |
| Number of on-site safety related diesel generators | : 2 |

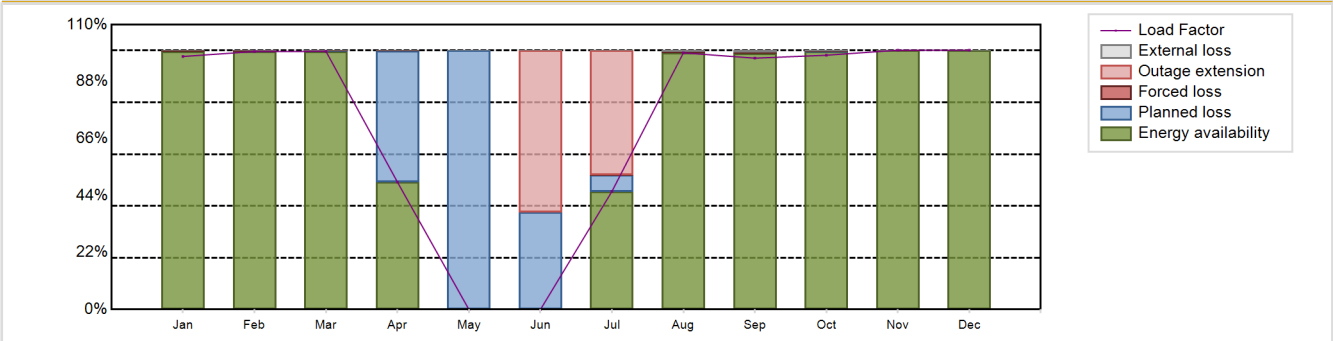
Non-electrical applications

| | |
|--|--------|
| | : none |
|--|--------|

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 9154.98 GW(e).h | Forced Loss Rate (FLR) | : 0.27 % |
| Energy Availability Factor (EAF) | : 74.21 % | Unplanned Capability Loss Factor (UCL) | : 9.43 % |
| Unit Capability Factor (UCF) | : 74.29 % | Planned Unavailability Factor (PUF) | : 16.28 % |
| Load Factor (LF) | : 73.81 % | Externally cause unavailability (XUF) | : 0.08 % |
| Operating Factor (OF) | : 75.19 % | Total off-line time | : 2173 hours |

Annual Summary

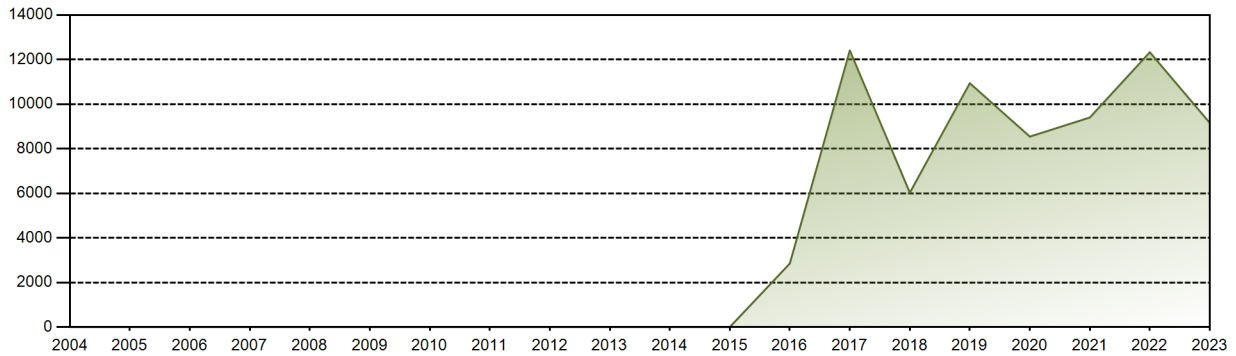


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|---------|--------|---------|--------|--------|-------|--------|---------|--------|---------|---------|---------|---------|
| GW(e)-h | 1029.57 | 948.16 | 1050.26 | 501.60 | 0.00 | 0.00 | 480.39 | 1044.29 | 989.74 | 1034.61 | 1021.04 | 1055.30 | 9154.98 |
| EAF [%] | 99.61 | 99.64 | 99.69 | 49.20 | 0.00 | 0.00 | 45.61 | 99.07 | 98.97 | 99.61 | 100.00 | 100.00 | 74.21 |
| UCF [%] | 99.61 | 99.64 | 99.69 | 49.20 | 0.00 | 0.00 | 45.61 | 99.53 | 99.48 | 99.62 | 100.00 | 100.00 | 74.29 |
| LF [%] | 97.73 | 99.64 | 99.69 | 49.20 | 0.00 | 0.00 | 45.60 | 99.13 | 97.08 | 98.21 | 100.15 | 100.17 | 73.81 |
| OF [%] | 100.00 | 100.00 | 100.00 | 51.39 | 0.00 | 0.00 | 51.75 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 75.19 |
| FLR [%] | 0.39 | 0.36 | 0.25 | 0.33 | 0.00 | 0.00 | 0.00 | 0.47 | 0.52 | 0.30 | 0.00 | 0.00 | 0.27 |
| UCL [%] | 0.39 | 0.36 | 0.25 | 0.16 | 0.00 | 62.50 | 48.12 | 0.47 | 0.52 | 0.30 | 0.00 | 0.00 | 9.43 |
| PUF [%] | 0.00 | 0.00 | 0.06 | 50.64 | 100.00 | 37.50 | 6.28 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 16.28 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.46 | 0.51 | 0.01 | 0.00 | 0.00 | 0.08 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 71652.09 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.35 % |
| Cumulative Energy Availability Factor (EAF) | : 79.21 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.4 % |
| Cumulative Unit Capability Factor (UCF) | : 79.34 % | Cumulative Planned Unavailability Factor (PUF) | : 18.26 % |
| Cumulative Load Factor (LF) | : 79.21 % | Cumulative Externally cause unavailability (XUF) | : 0.13 % |
| Cumulative Operating Factor (OF) | : 79.97 % | | |

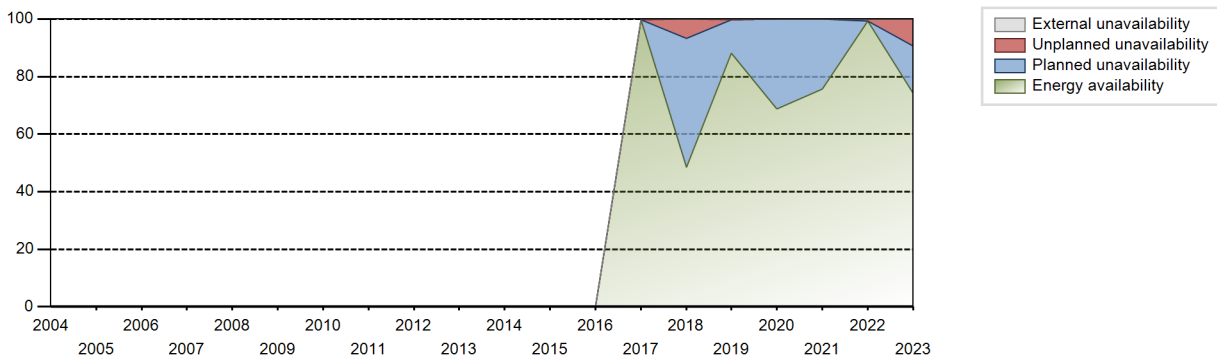
Electricity Production (net) [GWh]



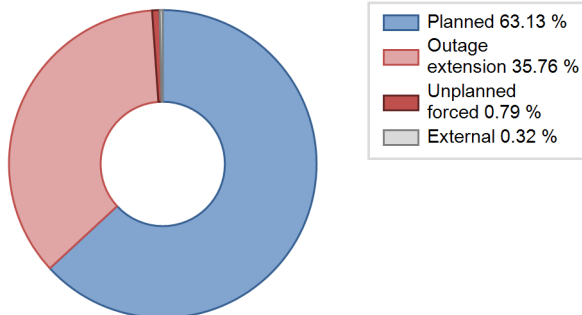
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|--------|-------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 2851.25 | 2956 | 1383 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 12405.61 | 8760 | 1416 | 99.79 | 99.99 | 100.01 | 100.00 | 0.00 | 0.00 | 0.01 | 0.21 |
| 2018 | 6027.00 | 4360 | 1416 | 48.55 | 48.64 | 48.59 | 49.77 | 12.16 | 6.74 | 44.62 | 0.10 |
| 2019 | 10939.06 | 7762 | 1416 | 88.08 | 88.44 | 88.19 | 88.61 | 0.00 | 0.00 | 11.56 | 0.35 |
| 2020 | 8544.98 | 6120 | 1416 | 68.81 | 68.82 | 68.70 | 69.67 | 0.00 | 0.00 | 31.18 | 0.02 |
| 2021 | 9400.37 | 6706 | 1416 | 75.77 | 75.87 | 75.78 | 76.55 | 0.00 | 0.00 | 24.13 | 0.10 |
| 2022 | 12328.84 | 8760 | 1416 | 99.27 | 99.32 | 99.39 | 100.00 | 0.66 | 0.65 | 0.03 | 0.05 |
| 2023 | 9154.98 | 6587 | 1416 | 74.21 | 74.29 | 73.81 | 75.19 | 0.27 | 9.43 | 16.28 | 0.08 |

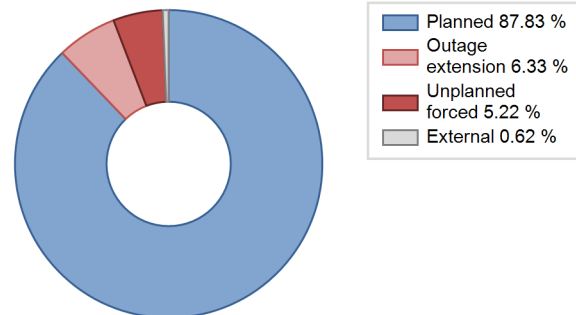
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 809 | | | 198 | |
| C. Inspection, maintenance or repair combined with refuelling | 1364 | | | 1560 | | |
| E. Testing of plant systems or components | | | | 782 | | |
| Subtotal | 1364 | 809 | | 2342 | 198 | |
| Total | | 2173 | | | 2540 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|-------------------------------------|------------|-----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 72 |
| 42. Electrical Power Supply Systems | | 809 | | 101 |
| Total | | 809 | | 173 |

2023 Operating Experience

KR-26

SAEUL-2

KOREA, REPUBLIC OF

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : KHNP (Korea Hydro and Nuclear Power Co.) |
| Owner | : KHNP (Korea Hydro and Nuclear Power Co.) |
| Reactor Supplier | : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING) |
| Turbine Supplier | : DHICGE (Doosan Heavy Industries & Construction and General Electric) |

Reactor Unit Details

| | |
|----------------------------|------------------|
| Reactor type and model | : PWR / APR-1400 |
| Thermal power | : 3983 MWth |
| Gross electrical power | : 1491 MWe |
| Reference unit power (net) | : 1418 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 2009-08-19 |
| Grid Date | : 2019-04-22 |
| Commercial Date | : 2019-08-29 |
| Age at end of year | : 4 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : 2.66 |
| Refuelling frequency [month] | : 18 |
| Part of the core refuelled [%] | : 41 |
| Average discharge burnup [MWd/t] | : 53073 |
| Active core diameter [m] | : 3.647 |
| Active core height/length [m] | : 3.81 |
| Number of fissile fuel assemblies/bundles | : 241 |
| Fuel linear heat generation rate [kW/m] | : 18.38 |
| Number of control rod assemblies | : 93 |
| Number of external reactor coolant loops | : 2 |
| Coolant type | : H2O |

| | |
|-----------------------------------|----------|
| Operating coolant pressure [MPa] | : 15.5 |
| Reactor outlet temperature [°C] | : 323.9 |
| Number of SG | : 2 |
| Containment type | : Single |
| Containment design pressure [MPa] | : 0.41 |

Secondary systems

| | |
|--|----------------------|
| Number of turbine-generators per unit/reactor | : 4 |
| Turbine speed [rpm] | : 1800 |
| Number of LP cylinders per turbine | : 3 |
| HP cylinder inlet steam pressure [MPa] | : 6.764 |
| Output voltage [kV] | : 24 |
| Primary means of condenser cooling | : Sea (once-through) |
| Number of main condensate pumps | : 3 |
| Number of FW pumps for full power operation | : 3 |
| Number of on-site safety related diesel generators | : 2 |

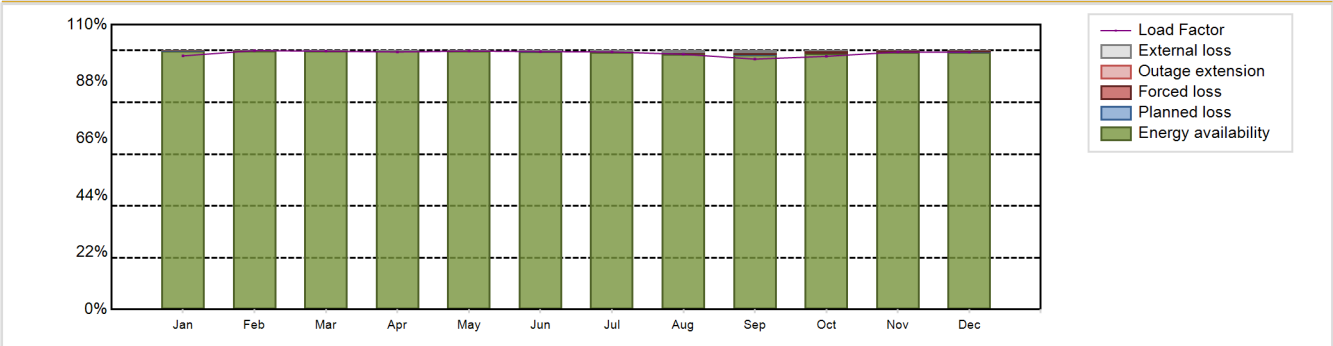
Non-electrical applications

| | |
|--|--------|
| | : none |
|--|--------|

Annual Production Results (2023)

| | | | |
|----------------------------------|--------------------|--|-----------|
| Net Energy Production | : 12295.49 GW(e).h | Forced Loss Rate (FLR) | : 0.35 % |
| Energy Availability Factor (EAF) | : 99.41 % | Unplanned Capability Loss Factor (UCL) | : 0.35 % |
| Unit Capability Factor (UCF) | : 99.62 % | Planned Unavailability Factor (PUF) | : 0.03 % |
| Load Factor (LF) | : 98.98 % | Externally cause unavailability (XUF) | : 0.21 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

Annual Summary

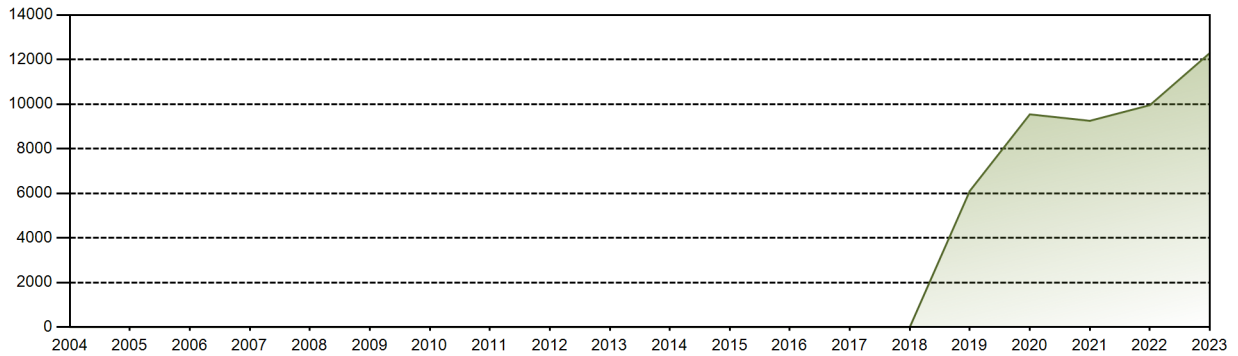


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|---------|--------|---------|---------|---------|---------|---------|---------|--------|---------|---------|---------|----------|
| GW(e)-h | 1033.41 | 952.62 | 1052.48 | 1015.55 | 1053.08 | 1016.90 | 1049.31 | 1039.89 | 987.26 | 1031.49 | 1015.20 | 1048.30 | 12295.49 |
| EAF [%] | 99.88 | 99.96 | 99.81 | 99.80 | 99.82 | 99.60 | 99.46 | 98.57 | 98.30 | 98.98 | 99.44 | 99.37 | 99.41 |
| UCF [%] | 99.88 | 99.96 | 99.81 | 99.81 | 99.82 | 99.60 | 99.85 | 99.45 | 99.25 | 99.22 | 99.44 | 99.37 | 99.62 |
| LF [%] | 97.95 | 99.97 | 99.76 | 99.47 | 99.82 | 99.60 | 99.46 | 98.57 | 96.70 | 97.77 | 99.44 | 99.37 | 98.98 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.07 | 0.04 | 0.12 | 0.19 | 0.18 | 0.33 | 0.15 | 0.55 | 0.68 | 0.78 | 0.56 | 0.55 | 0.35 |
| UCL [%] | 0.07 | 0.04 | 0.12 | 0.19 | 0.18 | 0.33 | 0.15 | 0.55 | 0.68 | 0.78 | 0.56 | 0.55 | 0.35 |
| PUF [%] | 0.05 | 0.00 | 0.07 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.08 | 0.03 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | 0.88 | 0.94 | 0.23 | 0.00 | 0.00 | 0.21 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 47154.11 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.07 % |
| Cumulative Energy Availability Factor (EAF) | : 84.11 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.58 % |
| Cumulative Unit Capability Factor (UCF) | : 84.27 % | Cumulative Planned Unavailability Factor (PUF) | : 12.15 % |
| Cumulative Load Factor (LF) | : 83.93 % | Cumulative Externally cause unavailability (XUF) | : 0.16 % |
| Cumulative Operating Factor (OF) | : 84.85 % | | |

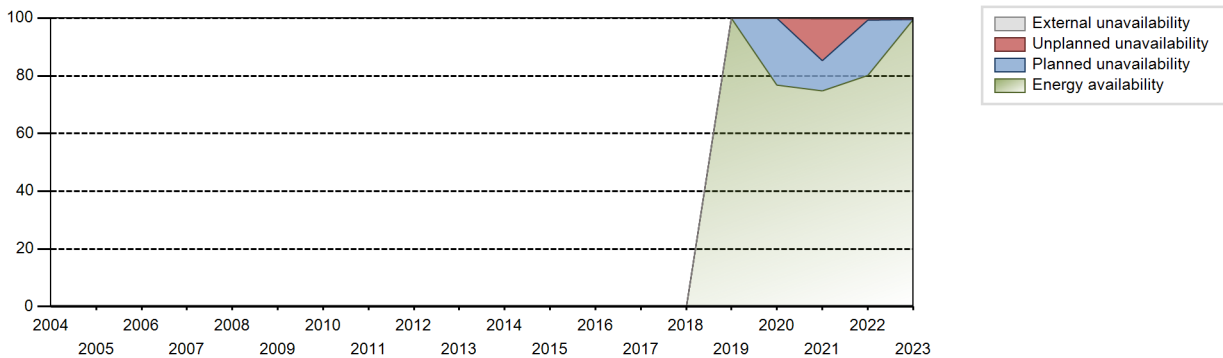
Electricity Production (net) [GWh]



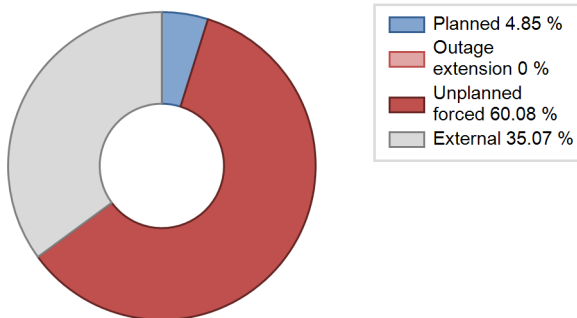
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|--------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2019 | 6107.40 | 4874 | 1418 | 99.95 | 100.00 | 100.34 | 100.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| 2020 | 9543.62 | 6778 | 1418 | 76.73 | 76.77 | 76.62 | 77.16 | 0.00 | 0.00 | 23.23 | 0.03 |
| 2021 | 9252.75 | 6635 | 1418 | 74.85 | 75.03 | 74.49 | 75.74 | 16.34 | 14.66 | 10.31 | 0.18 |
| 2022 | 9954.85 | 7135 | 1418 | 80.17 | 80.42 | 80.14 | 81.45 | 0.62 | 0.51 | 19.07 | 0.25 |
| 2023 | 12295.49 | 8760 | 1418 | 99.41 | 99.62 | 98.98 | 100.00 | 0.35 | 0.35 | 0.03 | 0.21 |

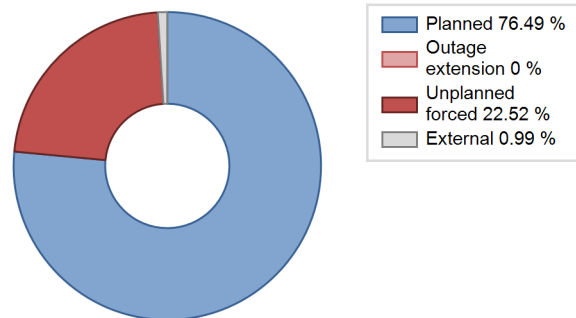
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2019 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 3 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1035 | | |
| E. Testing of plant systems or components | | | | 282 | | |
| P. Fire | | | | | 293 | |
| Subtotal | | | | 1317 | 296 | |
| Total | | 0 | | | 1613 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2019 to 2023 | |
|-----------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 31. Turbine and auxiliaries | | | | 3 |
| 41. Main Generator Systems | | | | 267 |
| Total | | | | 270 |

2023 Operating Experience

KR-27 **SHIN-HANUL-1** **KOREA, REPUBLIC OF**

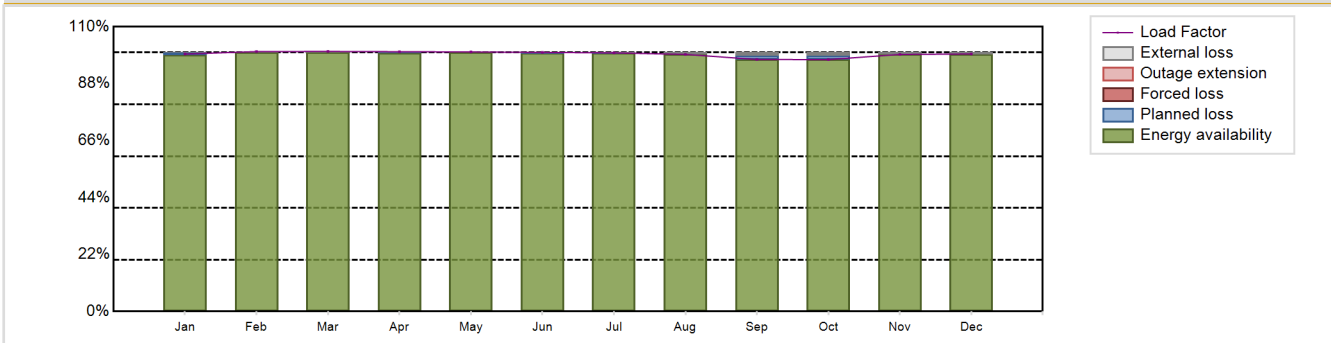
Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)

| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / APR-1400 | Construction Date | : 2012-07-10 |
| Thermal power | : 3983 MWth | Grid Date | : 2022-06-09 |
| Gross electrical power | : 1455 MWe | Commercial Date | : 2022-12-07 |
| Reference unit power (net) | : 1414 MWe | Age at end of year | : 1 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 323.9 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.41 |
| Average fuel enrichment [% of U235] | : 2.66 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 4 |
| Part of the core refuelled [%] | : 41 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 53073 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.647 | HP cylinder inlet steam pressure [MPa] | : 6.764 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : 24 |
| Number of fissile fuel assemblies/bundles | : 241 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.38 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 93 | Number of FW pumps for full power operation | : 3 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | |
| | | | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 12319.2 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.29 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 99.66 % | Planned Unavailability Factor (PUF) | : 0.34 % |
| Load Factor (LF) | : 99.46 % | Externally cause unavailability (XUF) | : 0.37 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

Annual Summary

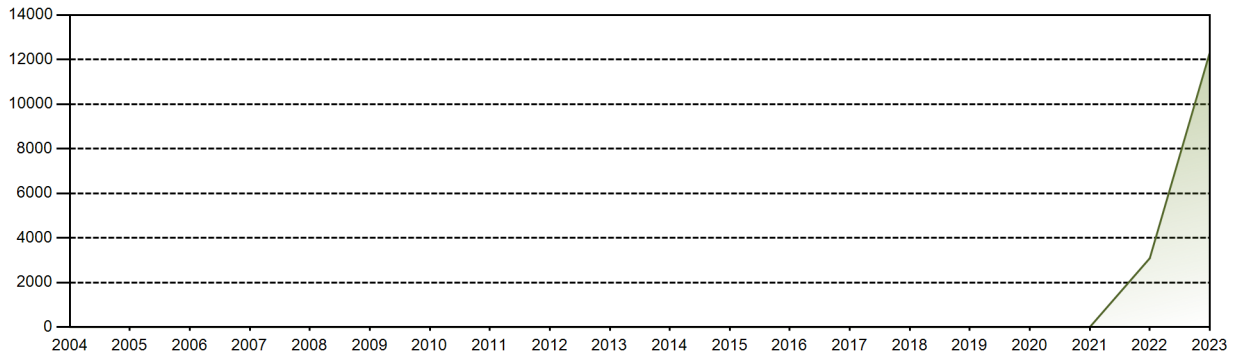


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|---------|--------|---------|---------|---------|---------|---------|---------|--------|---------|---------|---------|----------|
| GW(e)-h | 1046.05 | 953.96 | 1056.62 | 1021.68 | 1054.73 | 1018.86 | 1050.93 | 1044.62 | 991.00 | 1023.68 | 1010.72 | 1046.36 | 12319.20 |
| EAF [%] | 99.12 | 100.00 | 100.00 | 99.95 | 100.00 | 99.91 | 99.82 | 99.30 | 97.34 | 97.31 | 99.28 | 99.46 | 99.29 |
| UCF [%] | 99.12 | 100.00 | 100.00 | 99.95 | 100.00 | 99.97 | 99.89 | 100.00 | 98.56 | 98.47 | 100.00 | 100.00 | 99.66 |
| LF [%] | 99.43 | 100.39 | 100.44 | 100.35 | 100.26 | 100.08 | 99.90 | 99.30 | 97.34 | 97.31 | 99.28 | 99.46 | 99.46 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.88 | 0.00 | 0.00 | 0.05 | 0.00 | 0.03 | 0.11 | 0.00 | 1.44 | 1.53 | 0.00 | 0.00 | 0.34 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.07 | 0.70 | 1.21 | 1.16 | 0.72 | 0.54 | 0.37 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 15410.19 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0 % |
| Cumulative Energy Availability Factor (EAF) | : 99.34 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0 % |
| Cumulative Unit Capability Factor (UCF) | : 99.68 % | Cumulative Planned Unavailability Factor (PUF) | : 0.32 % |
| Cumulative Load Factor (LF) | : 99.5 % | Cumulative Externally cause unavailability (XUF) | : 0.34 % |
| Cumulative Operating Factor (OF) | : 100 % | | |

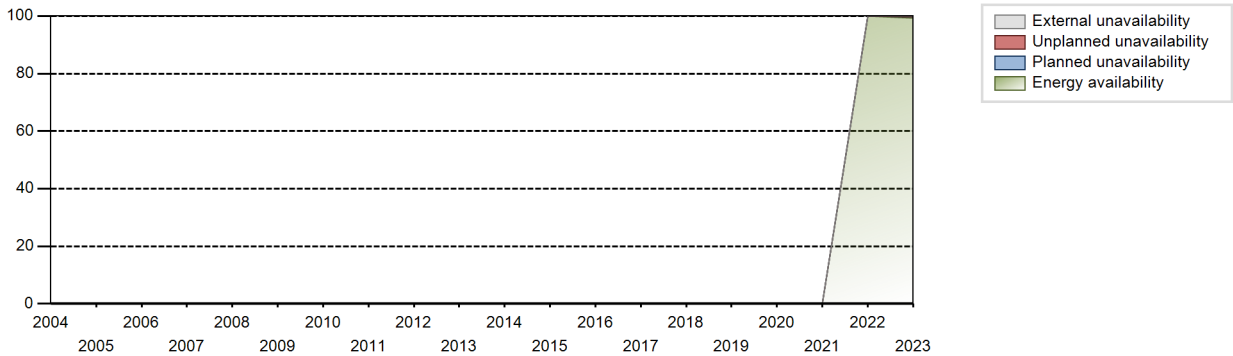
Electricity Production (net) [GWh]



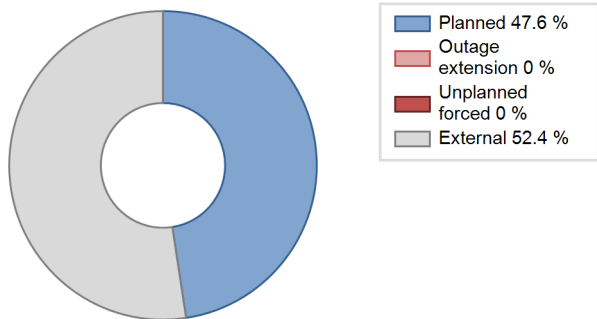
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|--------|--------|------|------|------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2022 | 3090.99 | 3144 | 1414 | 99.97 | 99.97 | 100.08 | 100.00 | 0.00 | 0.00 | 0.03 | 0.00 |
| 2023 | 12319.20 | 8760 | 1414 | 99.29 | 99.66 | 99.46 | 100.00 | 0.00 | 0.00 | 0.34 | 0.37 |

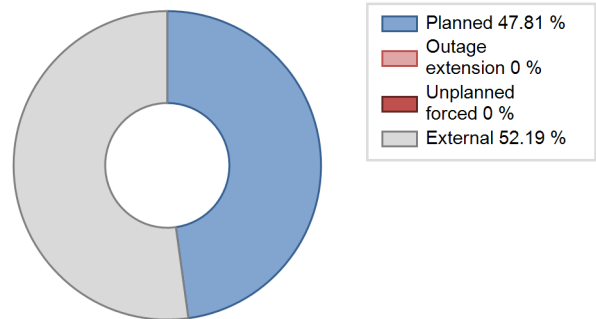
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2022 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| E. Testing of plant systems or components | 8 | | | 1679 | | |
| Subtotal | 8 | | | 1679 | | |
| Total | 8 | | | 1679 | | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2022 to 2023 | |
|--------------|------------|--|-------------------------------------|--|
| | Hours Lost | | Average hours lost per reactor-year | |
| Total | | | | |

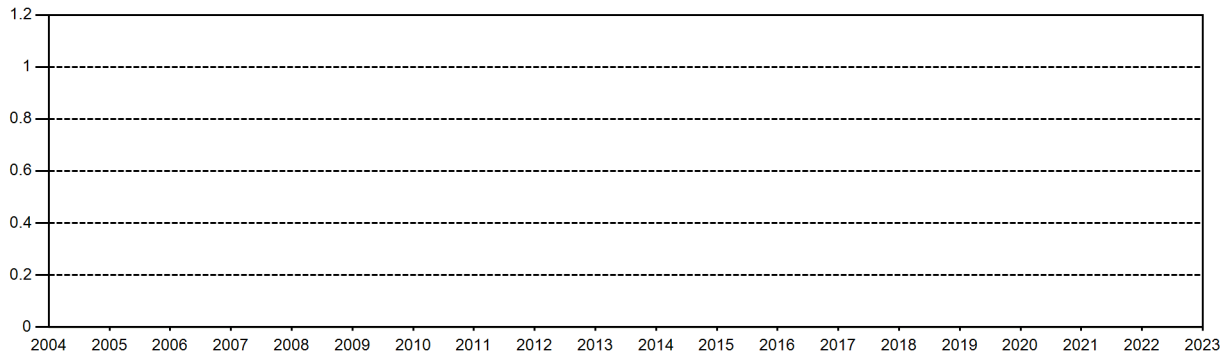
2023 Operating Experience

| KR-28 | | SHIN-HANUL-2 | | KOREA, REPUBLIC OF | | | | | | | | |
|--|---|----------------|--|--------------------|--------------------|-----|-----|-----|-----|-----|-----|-----|
| Status at end of year | : Operational | | | | | | | | | | | |
| Operator | : KHNP (Korea Hydro and Nuclear Power Co.) | | | | | | | | | | | |
| Owner | : KHNP (Korea Hydro and Nuclear Power Co.) | | | | | | | | | | | |
| Reactor Supplier | : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING) | | | | | | | | | | | |
| Turbine Supplier | : DHICGE (Doosan Heavy Industries & Construction and General Electric) | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | |
| Reactor type and model | : | PWR / APR-1400 | Construction Date | : | 2013-06-19 | | | | | | | |
| Thermal power | : | 3983 MWth | Grid Date | : | 2023-12-21 | | | | | | | |
| Gross electrical power | : | 1455 MWe | Commercial Date | : | 2024-04-05 | | | | | | | |
| Reference unit power (net) | : | 1340 MWe | Age at end of year | : | 0 years | | | | | | | |
| Design Characteristics | | | | | | | | | | | | |
| Primary Systems | | | Secondary systems | | | | | | | | | |
| Reactor vessel centreline orientation | : | Vertical | Operating coolant pressure [MPa] | : | 15.5 | | | | | | | |
| Fuel material | : | UO2 | Reactor outlet temperature [°C] | : | 323.9 | | | | | | | |
| Refuelling type | : | OFF-line | Number of SG | : | 2 | | | | | | | |
| Moderator material | : | H2O | Containment type | : | Single | | | | | | | |
| Average fuel enrichment [% of U235] | : | 2.66 | Containment design pressure [MPa] | : | 0.41 | | | | | | | |
| Refuelling frequency [month] | : | 18 | Secondary systems | | | | | | | | | |
| Part of the core refuelled [%] | : | 41 | Number of turbine-generators per unit/reactor | : | 4 | | | | | | | |
| Average discharge burnup [MWd/t] | : | 53073 | Turbine speed [rpm] | : | 1800 | | | | | | | |
| Active core diameter [m] | : | 3.647 | Number of LP cylinders per turbine | : | 3 | | | | | | | |
| Active core height/length [m] | : | 3.81 | HP cylinder inlet steam pressure [MPa] | : | 6.764 | | | | | | | |
| Number of fissile fuel assemblies/bundles | : | 241 | Output voltage [kV] | : | 24 | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : | 18.38 | Primary means of condenser cooling | : | Sea (once-through) | | | | | | | |
| Number of control rod assemblies | : | 93 | Number of main condensate pumps | : | 3 | | | | | | | |
| Number of external reactor coolant loops | : | 2 | Number of FW pumps for full power operation | : | 3 | | | | | | | |
| Coolant type | : | H2O | Number of on-site safety related diesel generators | : | 2 | | | | | | | |
| Annual Production Results (2023) | | | Non-electrical applications | | | | | | | | | |
| Net Energy Production | : | 0 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | |
| Energy Availability Factor (EAF) | : | 0 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | |
| Unit Capability Factor (UCF) | : | 0 % | Planned Unavailability Factor (PUF) | : | 0 % | | | | | | | |
| Load Factor (LF) | : | 0 % | Externally cause unavailability (XUF) | : | 0 % | | | | | | | |
| Operating Factor (OF) | : | 0 % | Total off-line time | : | 264 hours | | | | | | | |
| Annual Summary | | | | | | | | | | | | |
| No data found | | | | | | | | | | | | |
| <div style="border: 1px solid black; height: 100px; width: 100%;"></div> | | | | | | | | | | | | |
| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

| | | | | | |
|---|---|-----------|---|---|-----|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 0 % |
| Cumulative Energy Availability Factor (EAF) | : | 0 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 0 % |
| Cumulative Unit Capability Factor (UCF) | : | 0 % | Cumulative Planned Unavailability Factor (PUF) | : | 0 % |
| Cumulative Load Factor (LF) | : | 0 % | Cumulative Externally cause unavailability (XUF) | : | 0 % |
| Cumulative Operating Factor (OF) | : | 0 % | | | |

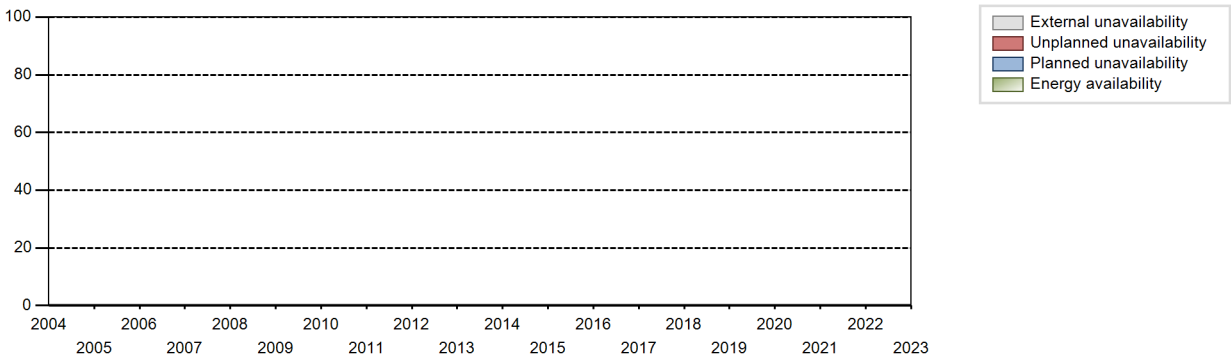
Electricity Production (net) [GWh]



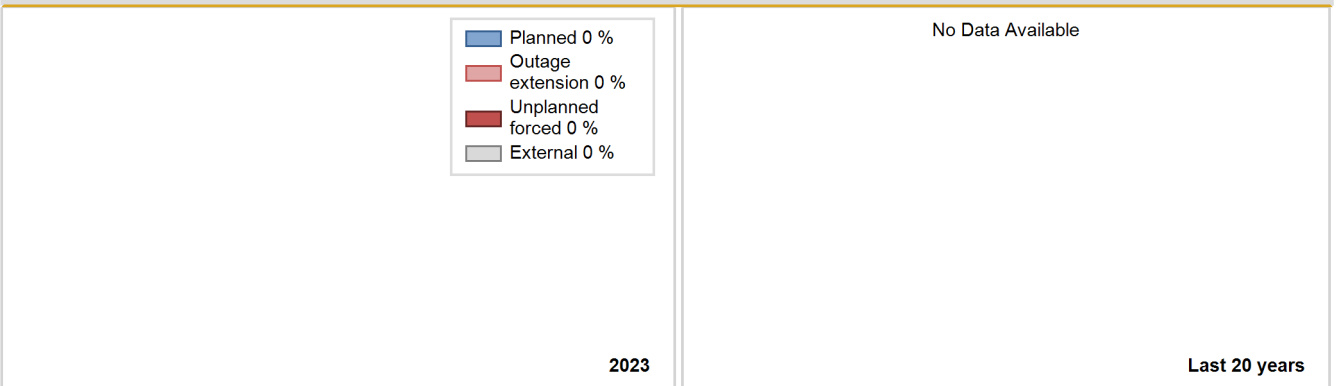
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2024 to 2023 | | |
|--------------|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| Subtotal | | | | | | |
| Total | | 0 | | | 0 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2024 to 2023 |
|---------------|-------------------|--|
| | Hours Lost | Average hours lost per reactor-year |
| Total | | |

2023 Operating Experience

KR-21

SHIN-KORI-1

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



Reactor Unit Details

Reactor type and model : PWR / OPR-1000
 Thermal power : 2825 MWth
 Gross electrical power : 1048 MWe
 Reference unit power (net) : 996 MWe

Key Dates

Construction Date : 2006-06-16
 Grid Date : 2010-08-04
 Commercial Date : 2011-02-28
 Age at end of year : 13 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.9
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 36.15
 Average discharge burnup [MWd/t] : 38829
 Active core diameter [m] : 3.81
 Active core height/length [m] : 3.124
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 17.69
 Number of control rod assemblies : 180
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 17.237
 Reactor outlet temperature [°C] : 327.3
 Number of SG : 2
 Containment type : Double
 Containment design pressure [MPa] : 0.39

Secondary systems

Number of turbine-generators per unit/reactor : 4
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 7.14
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 2

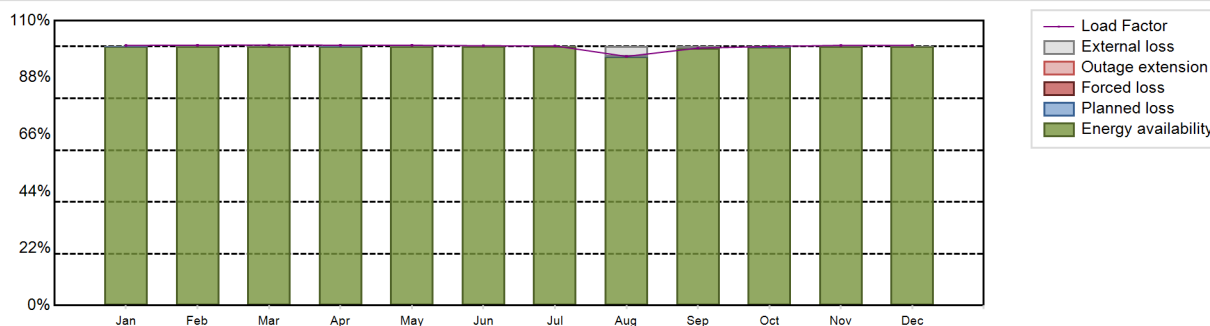
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8723.34 GW(e).h
 Energy Availability Factor (EAF) : 99.62 %
 Unit Capability Factor (UCF) : 100 %
 Load Factor (LF) : 99.98 %
 Operating Factor (OF) : 100 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0 %
 Externally cause unavailability (XUF) : 0.38 %
 Total off-line time : 0 hours

Annual Summary

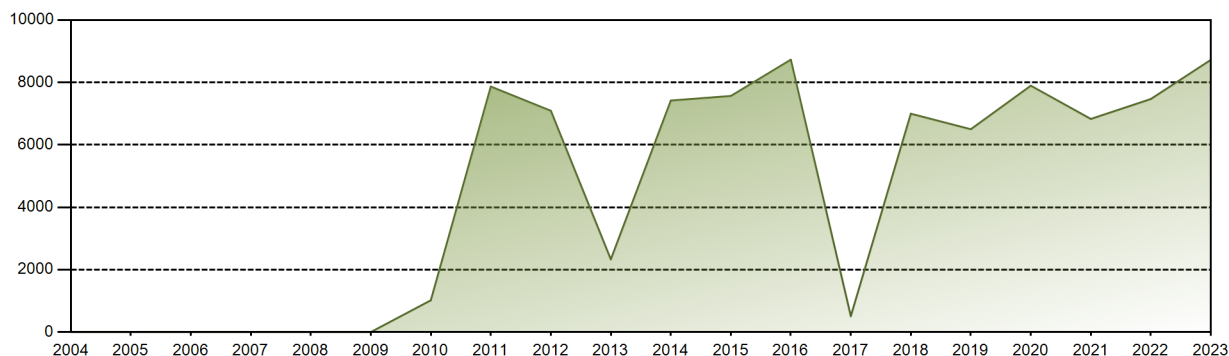


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 744.52 | 672.84 | 745.40 | 721.02 | 744.84 | 719.41 | 742.98 | 712.93 | 712.85 | 741.48 | 720.49 | 744.58 | 8723.34 |
| EAF [%] | 99.99 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 100.00 | 96.16 | 99.40 | 99.93 | 100.00 | 100.00 | 99.62 |
| UCF [%] | 99.99 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 100.00 | 99.99 | 100.00 | 99.99 | 100.00 | 100.00 | 100.00 |
| LF [%] | 100.47 | 100.53 | 100.59 | 100.54 | 100.52 | 100.32 | 100.26 | 96.21 | 99.40 | 100.06 | 100.47 | 100.48 | 99.98 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.83 | 0.60 | 0.06 | 0.00 | 0.00 | 0.38 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 86941.38 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.93 % |
| Cumulative Energy Availability Factor (EAF) | : 77.04 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.48 % |
| Cumulative Unit Capability Factor (UCF) | : 78.05 % | Cumulative Planned Unavailability Factor (PUF) | : 13.47 % |
| Cumulative Load Factor (LF) | : 76.08 % | Cumulative Externally cause unavailability (XUF) | : 1.01 % |
| Cumulative Operating Factor (OF) | : 76.69 % | | |

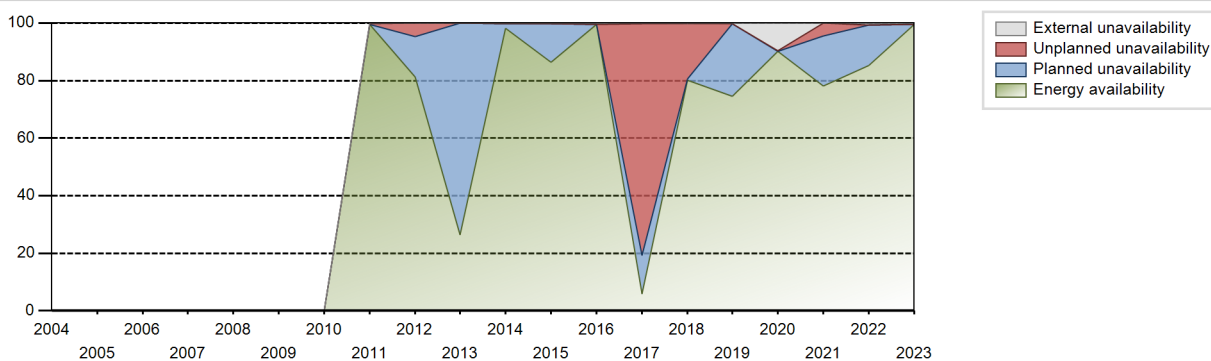
Electricity Production (net) [GWh]



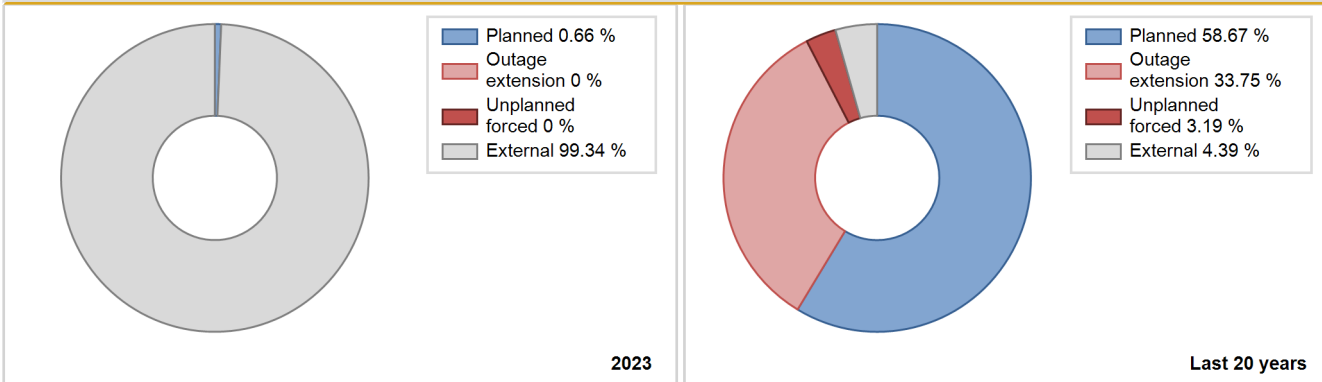
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|--------|--------|------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2011 | 7867.03 | 8008 | 985 | 99.61 | 99.98 | 100.17 | 100.00 | 0.02 | 0.02 | 0.00 | 0.37 |
| 2012 | 7091.41 | 7220 | 997 | 81.24 | 81.31 | 80.97 | 82.19 | 5.45 | 4.69 | 14.00 | 0.07 |
| 2013 | 2328.10 | 2338 | 1000 | 26.49 | 26.49 | 26.58 | 26.69 | 0.00 | 0.00 | 73.51 | 0.00 |
| 2014 | 7419.09 | 7497 | 999 | 98.23 | 98.44 | 84.78 | 85.58 | 0.00 | 0.00 | 1.56 | 0.21 |
| 2015 | 7565.55 | 7656 | 999 | 86.45 | 86.75 | 86.45 | 87.40 | 0.00 | 0.00 | 13.25 | 0.30 |
| 2016 | 8729.83 | 8784 | 997 | 99.59 | 100.00 | 99.68 | 100.00 | 0.00 | 0.00 | 0.00 | 0.41 |
| 2017 | 508.50 | 538 | 997 | 5.82 | 5.99 | 5.82 | 6.14 | 0.00 | 80.59 | 13.42 | 0.17 |
| 2018 | 6997.79 | 7107 | 996 | 80.17 | 80.49 | 80.20 | 81.13 | 0.16 | 19.03 | 0.48 | 0.32 |
| 2019 | 6500.05 | 6602 | 996 | 74.47 | 74.70 | 74.50 | 75.37 | 0.02 | 0.01 | 25.29 | 0.23 |
| 2020 | 7895.37 | 7986 | 996 | 90.24 | 99.92 | 90.24 | 90.92 | 0.07 | 0.07 | 0.00 | 9.68 |
| 2021 | 6828.96 | 6949 | 996 | 78.22 | 78.33 | 78.27 | 79.33 | 5.41 | 4.48 | 17.19 | 0.12 |
| 2022 | 7467.99 | 7519 | 996 | 85.27 | 86.00 | 85.59 | 85.83 | 0.00 | 0.00 | 14.00 | 0.74 |
| 2023 | 8723.34 | 8760 | 996 | 99.62 | 100.00 | 99.98 | 100.00 | 0.00 | 0.00 | 0.00 | 0.38 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2011 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 739 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1148 | | |
| E. Testing of plant systems or components | | | | 178 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 91 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 67 |
| Subtotal | | | | 1326 | 739 | 158 |
| Total | | 0 | | | 2223 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2011 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 29 |
| 15. Reactor Cooling Systems | | | | 650 |
| 42. Electrical Power Supply Systems | | | | 115 |
| Total | | | | 794 |

2023 Operating Experience

KR-22

SHIN-KORI-2

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / OPR-1000 | Construction Date | : 2007-06-05 |
| Thermal power | : 2825 MWth | Grid Date | : 2012-01-28 |
| Gross electrical power | : 1047 MWe | Commercial Date | : 2012-07-20 |
| Reference unit power (net) | : 996 MWe | Age at end of year | : 11 years |

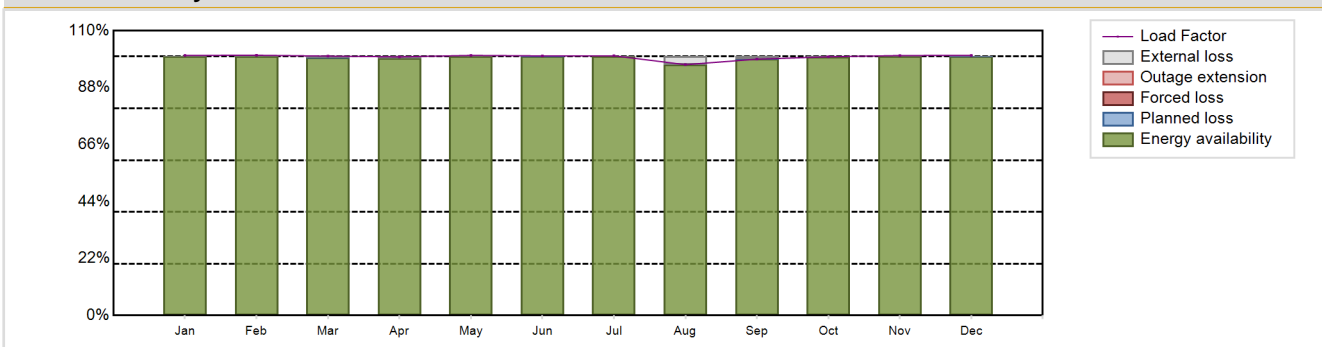
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 17.237 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 327.3 |
| Refuelling type | : OFF-line | Number of SG | : 2 |
| Moderator material | : H2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : 3.9 | Containment design pressure [MPa] | : 0.39 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 36.15 | Number of turbine-generators per unit/reactor | : 4 |
| Average discharge burnup [MWd/t] | : 38829 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 3.81 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 3.124 | HP cylinder inlet steam pressure [MPa] | : 7.14 |
| Number of fissile fuel assemblies/bundles | : 177 | Output voltage [kV] | : 22 |
| Fuel linear heat generation rate [kW/m] | : 17.69 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 180 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : 3 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 8715.76 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.56 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 100 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 99.89 % | Externally cause unavailability (XUF) | : 0.43 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

Annual Summary

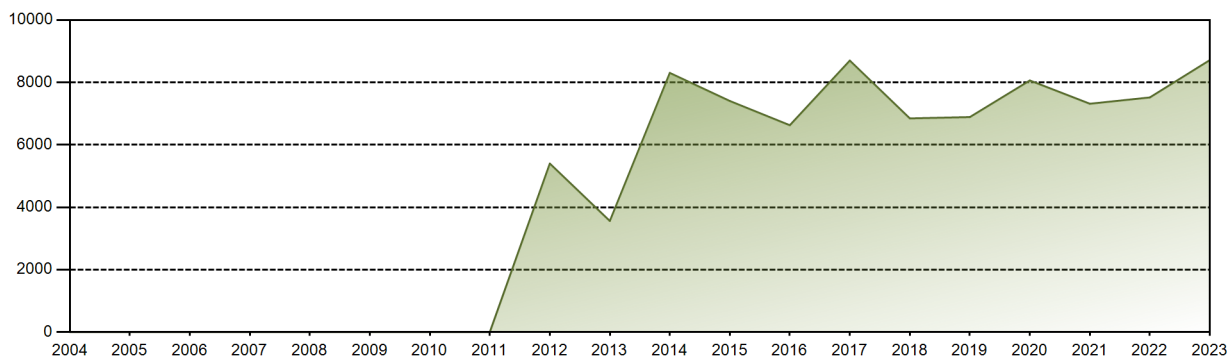


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 744.45 | 672.77 | 742.45 | 716.38 | 744.47 | 719.03 | 743.25 | 718.04 | 709.93 | 740.46 | 720.13 | 744.41 | 8715.76 |
| EAF [%] | 100.00 | 100.00 | 99.68 | 99.40 | 100.00 | 99.99 | 100.00 | 96.85 | 99.00 | 99.88 | 100.00 | 99.99 | 99.56 |
| UCF [%] | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 99.99 | 100.00 |
| LF [%] | 100.46 | 100.52 | 100.19 | 99.90 | 100.46 | 100.27 | 100.30 | 96.90 | 99.00 | 99.92 | 100.42 | 100.46 | 99.89 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.31 | 0.60 | 0.00 | 0.00 | 0.00 | 3.15 | 0.99 | 0.12 | 0.00 | 0.00 | 0.43 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 85348.32 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.25 % |
| Cumulative Energy Availability Factor (EAF) | : 83.86 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.21 % |
| Cumulative Unit Capability Factor (UCF) | : 84.85 % | Cumulative Planned Unavailability Factor (PUF) | : 14.94 % |
| Cumulative Load Factor (LF) | : 83.74 % | Cumulative Externally cause unavailability (XUF) | : 0.99 % |
| Cumulative Operating Factor (OF) | : 84.78 % | | |

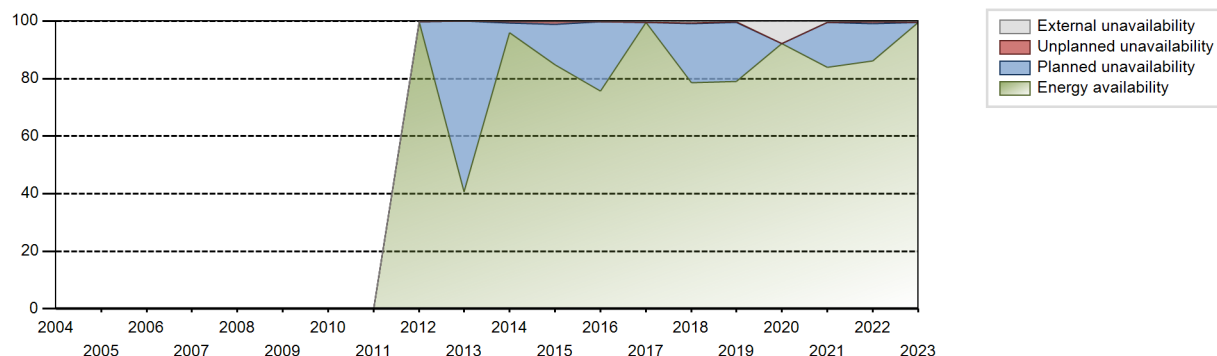
Electricity Production (net) [GWh]



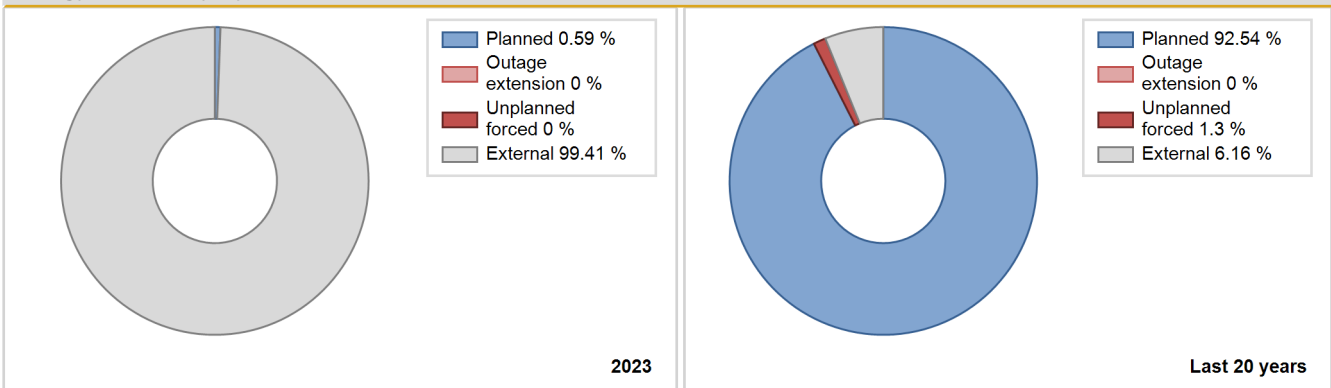
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2012 | 5400.28 | 5897 | 997 | 99.75 | 99.95 | 98.04 | 99.95 | 0.00 | 0.00 | 0.05 | 0.19 |
| 2013 | 3560.31 | 3569 | 1000 | 40.56 | 40.57 | 40.64 | 40.74 | 0.00 | 0.00 | 59.43 | 0.01 |
| 2014 | 8304.89 | 8518 | 998 | 96.01 | 96.24 | 94.99 | 97.24 | 0.52 | 0.51 | 3.26 | 0.23 |
| 2015 | 7405.24 | 7604 | 996 | 84.87 | 85.20 | 84.87 | 86.80 | 1.08 | 0.93 | 13.87 | 0.33 |
| 2016 | 6627.86 | 6718 | 997 | 75.68 | 75.87 | 75.68 | 76.48 | 0.00 | 0.00 | 24.13 | 0.19 |
| 2017 | 8699.48 | 8760 | 997 | 99.59 | 99.99 | 99.61 | 100.00 | 0.00 | 0.00 | 0.01 | 0.41 |
| 2018 | 6847.68 | 7011 | 996 | 78.48 | 79.21 | 78.48 | 80.03 | 0.25 | 0.20 | 20.60 | 0.72 |
| 2019 | 6889.15 | 7014 | 996 | 78.95 | 79.21 | 78.96 | 80.07 | 0.27 | 0.21 | 20.58 | 0.26 |
| 2020 | 8062.54 | 8127 | 996 | 92.10 | 99.99 | 92.16 | 92.52 | 0.01 | 0.01 | 0.00 | 7.89 |
| 2021 | 7316.90 | 7443 | 996 | 83.90 | 84.33 | 83.86 | 84.97 | 0.02 | 0.01 | 15.65 | 0.43 |
| 2022 | 7518.95 | 7655 | 996 | 86.20 | 86.57 | 86.18 | 87.39 | 0.62 | 0.54 | 12.90 | 0.36 |
| 2023 | 8715.76 | 8760 | 996 | 99.56 | 100.00 | 99.89 | 100.00 | 0.00 | 0.00 | 0.00 | 0.43 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2012 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 2 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1274 | | |
| E. Testing of plant systems or components | | | | 193 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 58 |
| Subtotal | | | | 1467 | 2 | 58 |
| Total | | 0 | | | 1527 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2012 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 42. Electrical Power Supply Systems | | | | 2 |
| Total | | | | 2 |

2023 Operating Experience

KR-23

SHIN-WOLSONG-1

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)

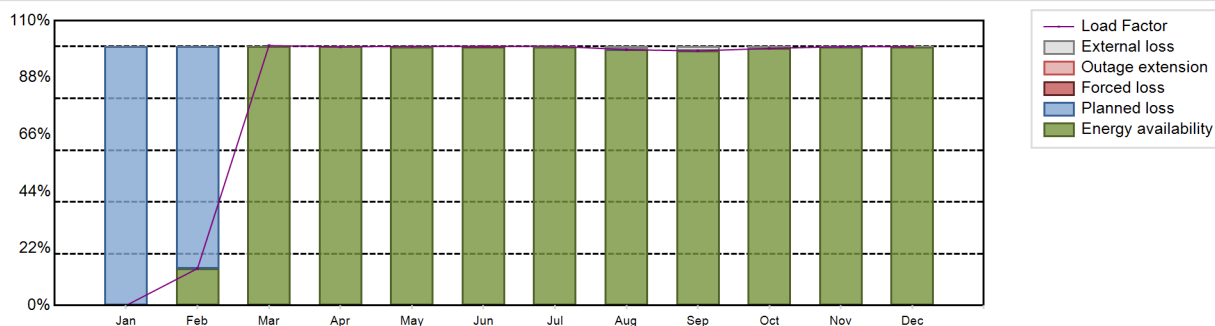


| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / OPR-1000 | Construction Date | : 2007-11-20 |
| Thermal power | : 2825 MWth | Grid Date | : 2012-01-27 |
| Gross electrical power | : 1048 MWe | Commercial Date | : 2012-07-31 |
| Reference unit power (net) | : 997 MWe | Age at end of year | : 11 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 17.237 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327.3 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.39 |
| Average fuel enrichment [% of U235] | : 3.9 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 4 |
| Part of the core refuelled [%] | : 36.15 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 38829 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.81 | HP cylinder inlet steam pressure [MPa] | : 7.14 |
| Active core height/length [m] | : 3.124 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 177 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.69 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 180 | Number of FW pumps for full power operation | : 3 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | |
| | | | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 7395.95 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 84.61 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 84.92 % | Planned Unavailability Factor (PUF) | : 15.08 % |
| Load Factor (LF) | : 84.68 % | Externally cause unavailability (XUF) | : 0.31 % |
| Operating Factor (OF) | : 85.42 % | Total off-line time | : 1277 hours |

Annual Summary

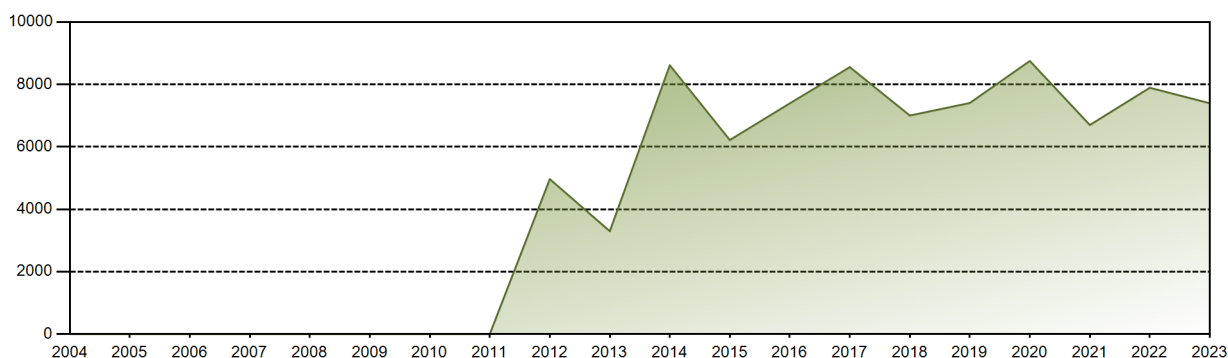


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 95.74 | 744.73 | 717.16 | 742.55 | 718.39 | 742.85 | 732.82 | 705.91 | 736.54 | 717.64 | 741.61 | 7395.95 |
| EAF [%] | 0.00 | 14.26 | 100.00 | 100.00 | 99.99 | 99.96 | 99.98 | 98.79 | 98.34 | 99.30 | 99.94 | 99.94 | 84.61 |
| UCF [%] | 0.00 | 14.26 | 100.00 | 100.00 | 99.99 | 99.99 | 100.00 | 99.98 | 100.00 | 100.00 | 99.99 | 99.95 | 84.92 |
| LF [%] | 0.00 | 14.29 | 100.40 | 99.91 | 100.11 | 100.08 | 100.15 | 98.79 | 98.34 | 99.30 | 99.97 | 99.98 | 84.68 |
| OF [%] | 0.00 | 20.68 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.42 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 100.00 | 85.74 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.01 | 0.05 | 15.08 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.02 | 1.19 | 1.66 | 0.70 | 0.04 | 0.01 | 0.31 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 84181.87 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.54 % |
| Cumulative Energy Availability Factor (EAF) | : 82.82 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.45 % |
| Cumulative Unit Capability Factor (UCF) | : 83.1 % | Cumulative Planned Unavailability Factor (PUF) | : 16.45 % |
| Cumulative Load Factor (LF) | : 82.9 % | Cumulative Externally cause unavailability (XUF) | : 0.28 % |
| Cumulative Operating Factor (OF) | : 83.66 % | | |

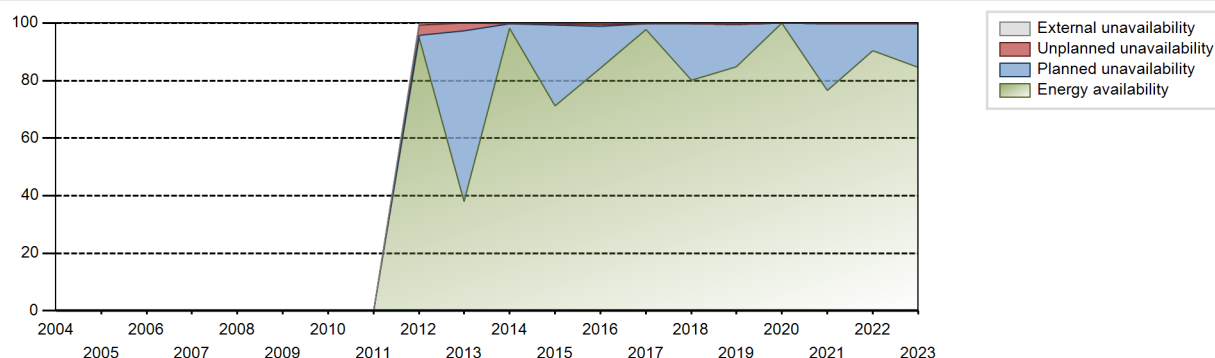
Electricity Production (net) [GWh]



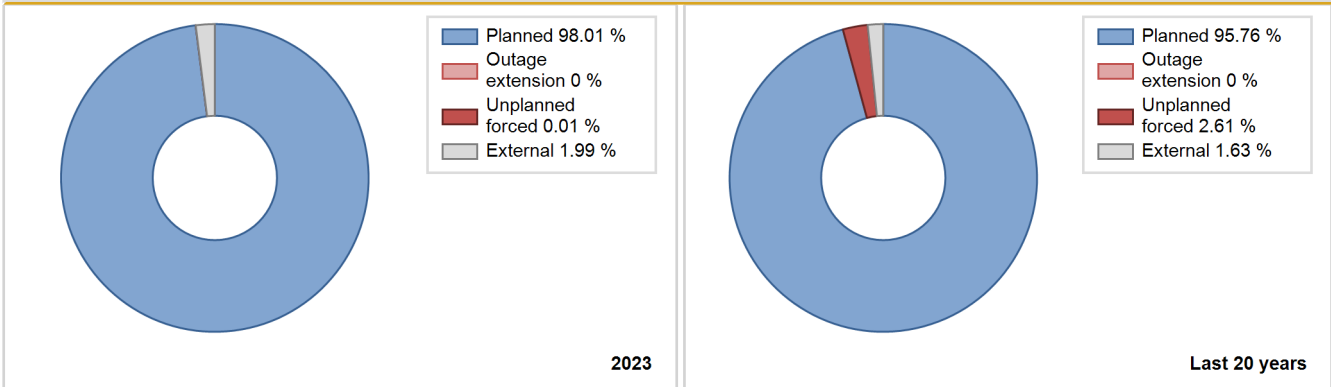
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2012 | 4964.62 | 6256 | 997 | 94.89 | 95.60 | 94.90 | 97.03 | 3.56 | 3.53 | 0.88 | 0.70 |
| 2013 | 3295.84 | 3353 | 991 | 37.93 | 37.94 | 37.97 | 38.28 | 6.51 | 2.64 | 59.42 | 0.01 |
| 2014 | 8611.78 | 8677 | 1000 | 98.27 | 98.54 | 98.31 | 99.05 | 0.00 | 0.00 | 1.46 | 0.27 |
| 2015 | 6217.67 | 6354 | 997 | 71.19 | 71.51 | 71.19 | 72.53 | 0.51 | 0.36 | 28.12 | 0.32 |
| 2016 | 7393.37 | 7522 | 997 | 84.42 | 84.81 | 84.42 | 85.63 | 0.76 | 0.65 | 14.54 | 0.39 |
| 2017 | 8553.53 | 8640 | 997 | 97.63 | 97.81 | 97.94 | 98.63 | 0.00 | 0.00 | 2.19 | 0.18 |
| 2018 | 7002.14 | 7097 | 997 | 80.08 | 80.35 | 80.17 | 81.02 | 0.00 | 0.00 | 19.65 | 0.27 |
| 2019 | 7404.26 | 7511 | 997 | 84.71 | 85.14 | 84.78 | 85.74 | 0.00 | 0.00 | 14.86 | 0.43 |
| 2020 | 8751.10 | 8784 | 997 | 99.86 | 99.99 | 99.93 | 100.00 | 0.01 | 0.01 | 0.01 | 0.13 |
| 2021 | 6699.21 | 6788 | 997 | 76.64 | 76.88 | 76.71 | 77.49 | 0.00 | 0.00 | 23.12 | 0.25 |
| 2022 | 7892.31 | 7954 | 997 | 90.27 | 90.61 | 90.37 | 90.80 | 0.00 | 0.00 | 9.39 | 0.34 |
| 2023 | 7395.95 | 7483 | 997 | 84.61 | 84.92 | 84.68 | 85.42 | 0.00 | 0.00 | 15.08 | 0.31 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2012 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 28 | |
| C. Inspection, maintenance or repair combined with refuelling | 1277 | | | 1405 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 158 | | |
| Subtotal | 1277 | | | 1563 | 28 | |
| Total | | 1277 | | | 1591 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2012 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 18 |
| 32. Feedwater and Main Steam System | | 9 |
| Total | | 27 |

Highlights (2023)

Refueling and Maintenance(~2023. 2. 23.)

2023 Operating Experience

KR-24

SHIN-WOLSONG-2

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : DHICKOPC (DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.LTD./KOREA POWER ENGINEERING COMPANY/COMBUSTIONENGINEERING)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



Reactor Unit Details

Reactor type and model : PWR / OPR-1000
 Thermal power : 2825 MWth
 Gross electrical power : 1048 MWe
 Reference unit power (net) : 993 MWe

Key Dates

Construction Date : 2008-09-23
 Grid Date : 2015-02-26
 Commercial Date : 2015-07-24
 Age at end of year : 8 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.9
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 36.15
 Average discharge burnup [MWd/t] : 38829
 Active core diameter [m] : 3.81
 Active core height/length [m] : 3.124
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 17.69
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 17.237
 Reactor outlet temperature [°C] : 327.3
 Number of SG : 2
 Containment type : Double
 Containment design pressure [MPa] : 0.39

Secondary systems

Number of turbine-generators per unit/reactor : 4
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 7.14
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 2

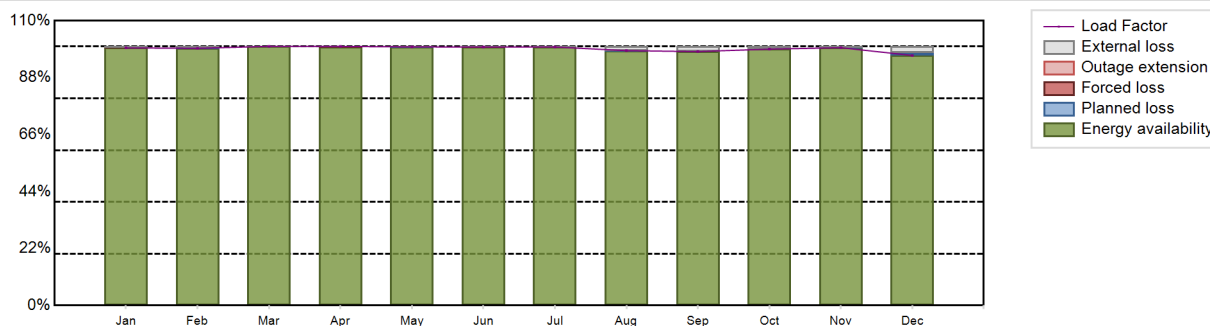
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8627.32 GW(e).h
 Energy Availability Factor (EAF) : 99.16 %
 Unit Capability Factor (UCF) : 99.9 %
 Load Factor (LF) : 99.18 %
 Operating Factor (OF) : 100 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.1 %
 Externally cause unavailability (XUF) : 0.73 %
 Total off-line time : 0 hours

Annual Summary

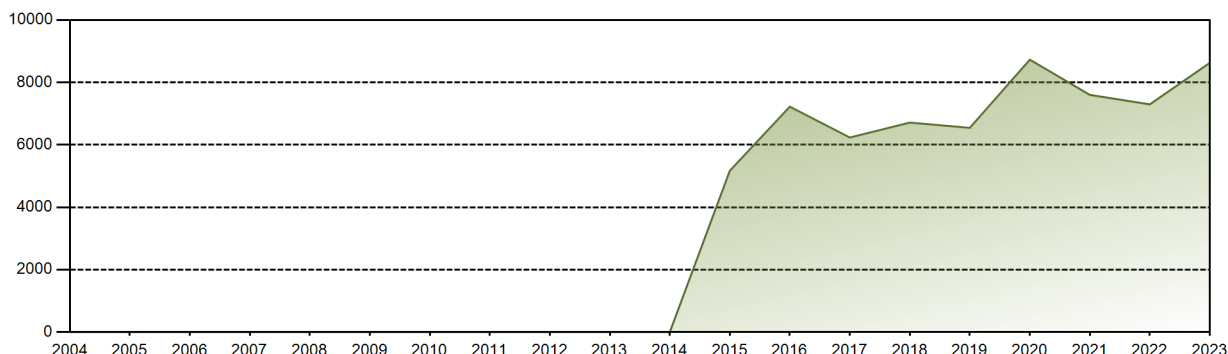


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 735.13 | 662.91 | 739.39 | 715.33 | 738.00 | 713.57 | 737.59 | 727.27 | 701.22 | 731.53 | 711.92 | 713.48 | 8627.32 |
| EAF [%] | 99.50 | 99.34 | 99.99 | 99.96 | 99.89 | 99.80 | 99.83 | 98.44 | 98.08 | 99.02 | 99.57 | 96.57 | 99.16 |
| UCF [%] | 99.97 | 99.99 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 99.97 | 100.00 | 100.00 | 99.99 | 98.88 | 99.90 |
| LF [%] | 99.50 | 99.34 | 100.08 | 100.05 | 99.89 | 99.81 | 99.84 | 98.44 | 98.08 | 99.02 | 99.57 | 96.57 | 99.18 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.01 | 1.12 | 0.10 |
| XUF [%] | 0.47 | 0.64 | 0.01 | 0.04 | 0.10 | 0.19 | 0.17 | 1.54 | 1.92 | 0.98 | 0.41 | 2.31 | 0.73 |

Historical Summary

| | | | |
|---|-------------------|---|-----------|
| Lifetime energy generation | : 64138.7 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.79 % |
| Cumulative Energy Availability Factor (EAF) | : 85.26 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.56 % |
| Cumulative Unit Capability Factor (UCF) | : 85.47 % | Cumulative Planned Unavailability Factor (PUF) | : 12.97 % |
| Cumulative Load Factor (LF) | : 85.44 % | Cumulative Externally cause unavailability (XUF) | : 0.2 % |
| Cumulative Operating Factor (OF) | : 85.93 % | | |

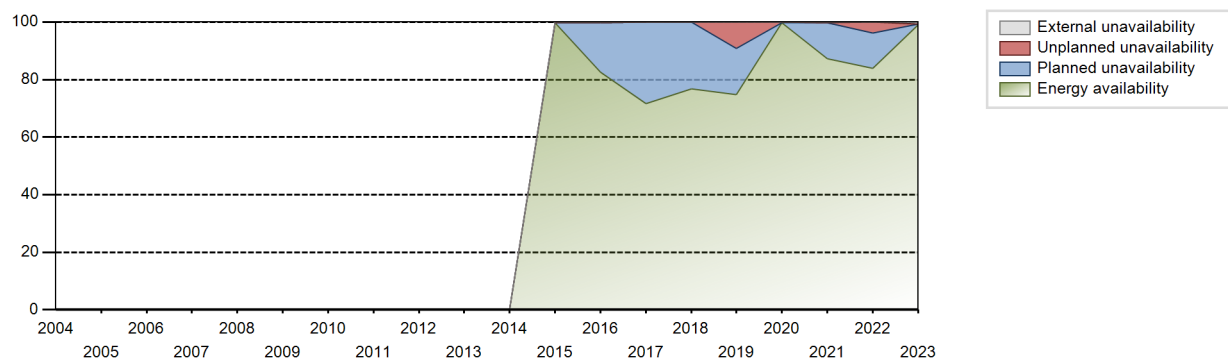
Electricity Production (net) [GWh]



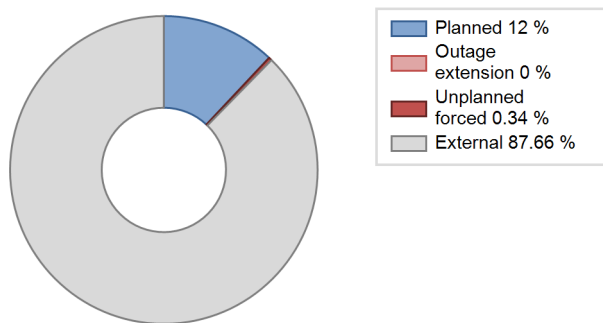
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|--------|--------|-------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2015 | 5169.24 | 5821 | 993 | 99.83 | 99.98 | 100.03 | 100.00 | 0.01 | 0.01 | 0.00 | 0.15 |
| 2016 | 7223.89 | 7328 | 993 | 82.55 | 82.78 | 82.82 | 83.42 | 0.03 | 0.02 | 17.20 | 0.22 |
| 2017 | 6234.20 | 6298 | 993 | 71.59 | 71.71 | 71.67 | 71.89 | 0.01 | 0.01 | 28.29 | 0.12 |
| 2018 | 6712.82 | 6783 | 993 | 76.83 | 76.88 | 77.17 | 77.43 | 0.00 | 0.00 | 23.12 | 0.05 |
| 2019 | 6544.76 | 6622 | 993 | 74.85 | 74.89 | 75.24 | 75.59 | 10.97 | 9.22 | 15.89 | 0.03 |
| 2020 | 8729.35 | 8784 | 993 | 99.82 | 99.91 | 100.08 | 100.00 | 0.08 | 0.08 | 0.00 | 0.09 |
| 2021 | 7600.23 | 7733 | 993 | 87.31 | 87.65 | 87.37 | 88.28 | 0.04 | 0.03 | 12.32 | 0.34 |
| 2022 | 7296.90 | 7433 | 993 | 83.85 | 83.90 | 83.89 | 84.85 | 4.31 | 3.78 | 12.32 | 0.06 |
| 2023 | 8627.32 | 8760 | 993 | 99.16 | 99.90 | 99.18 | 100.00 | 0.00 | 0.00 | 0.10 | 0.73 |

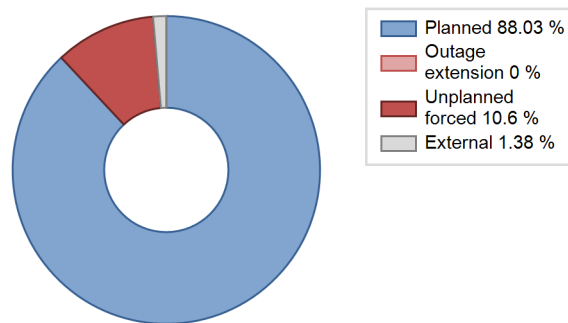
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2015 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 128 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1108 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 192 | | |
| Subtotal | | | | 1300 | 128 | |
| Total | 0 | | | 1428 | | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2015 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 34 |
| 32. Feedwater and Main Steam System | | | | 87 |
| Total | | | | 121 |

Highlights (2023)

Coast-down operation for Refueling and Maintenance(2023.12.21.-2024.1.1)

2023 Operating Experience

KR-4

WOLSONG-2

KOREA, REPUBLIC OF

Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : AECL/DHI (ATOMIC ENERGY OF CANADA LTD./DOOSAN HEAVY INDUSTRIES & CONSTRUCTION)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



Reactor Unit Details

Reactor type and model : PHWR / CANDU 6
 Thermal power : 2061 MWth
 Gross electrical power : 599 MWe
 Reference unit power (net) : 576 MWe

Key Dates

Construction Date : 1992-09-25
 Grid Date : 1997-04-01
 Commercial Date : 1997-07-01
 Age at end of year : 26 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Horizontal
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : D2O
 Average fuel enrichment [% of U235] : 0.72
 Refuelling frequency [month] : NA
 Part of the core refuelled [%] : NA
 Average discharge burnup [MWd/t] : 7500
 Active core diameter [m] : 7.69
 Active core height/length [m] : 5.94
 Number of fissile fuel assemblies/bundles : 4560
 Fuel linear heat generation rate [kW/m] : 0.1615
 Number of control rod assemblies : 21
 Number of external reactor coolant loops : 2
 Coolant type : D2O

Operating coolant pressure [MPa] : 10.5
 Reactor outlet temperature [°C] : 310
 Number of SG : 4
 Containment type : Confinement
 Containment design pressure [MPa] : 0.12

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 4.59
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 2
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

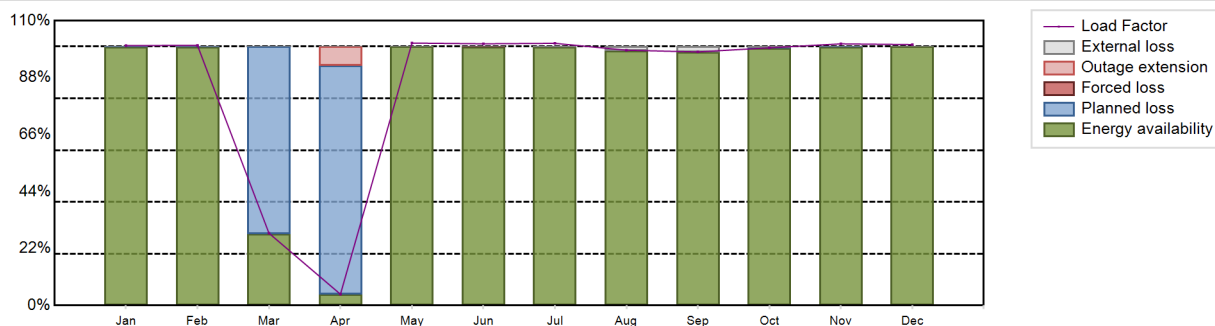
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 4350.62 GW(e).h
 Energy Availability Factor (EAF) : 85.62 %
 Unit Capability Factor (UCF) : 85.97 %
 Load Factor (LF) : 86.22 %
 Operating Factor (OF) : 86.06 %
 Forced Loss Rate (FLR) : 0.01 %
 Unplanned Capability Loss Factor (UCL) : 0.6 %
 Planned Unavailability Factor (PUF) : 13.44 %
 Externally cause unavailability (XUF) : 0.34 %
 Total off-line time : 1221 hours

Annual Summary

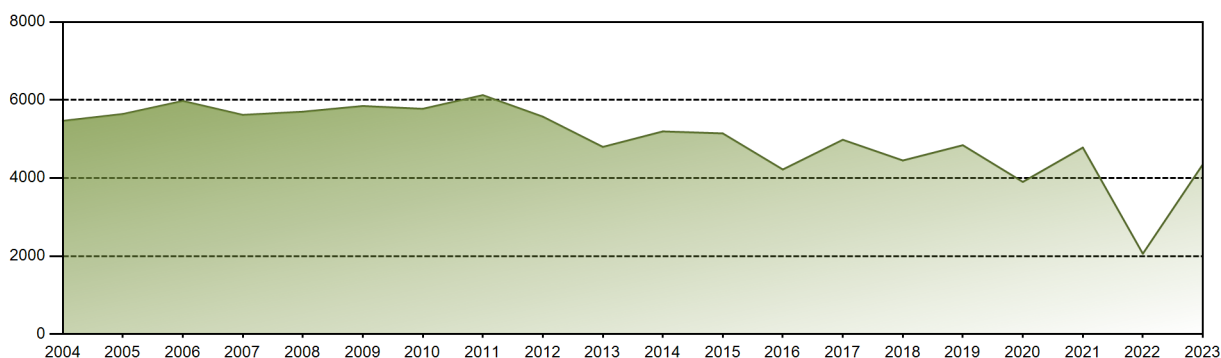


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 430.26 | 388.85 | 119.67 | 18.11 | 434.33 | 419.19 | 433.94 | 422.56 | 406.17 | 426.52 | 419.11 | 431.91 | 4350.62 |
| EAF [%] | 99.93 | 99.98 | 27.68 | 4.33 | 100.00 | 99.95 | 99.98 | 98.45 | 97.94 | 99.35 | 99.98 | 100.00 | 85.62 |
| UCF [%] | 99.93 | 99.98 | 27.68 | 4.33 | 100.00 | 99.95 | 100.00 | 100.00 | 100.00 | 99.84 | 99.98 | 100.00 | 85.97 |
| LF [%] | 100.40 | 100.46 | 27.92 | 4.37 | 101.35 | 101.08 | 101.26 | 98.60 | 97.94 | 99.53 | 101.06 | 100.78 | 86.22 |
| OF [%] | 100.00 | 100.00 | 27.96 | 4.86 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.06 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 7.21 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 |
| PUF [%] | 0.07 | 0.02 | 72.32 | 88.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.02 | 0.00 | 13.44 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 1.55 | 2.06 | 0.49 | 0.00 | 0.00 | 0.34 |

Historical Summary

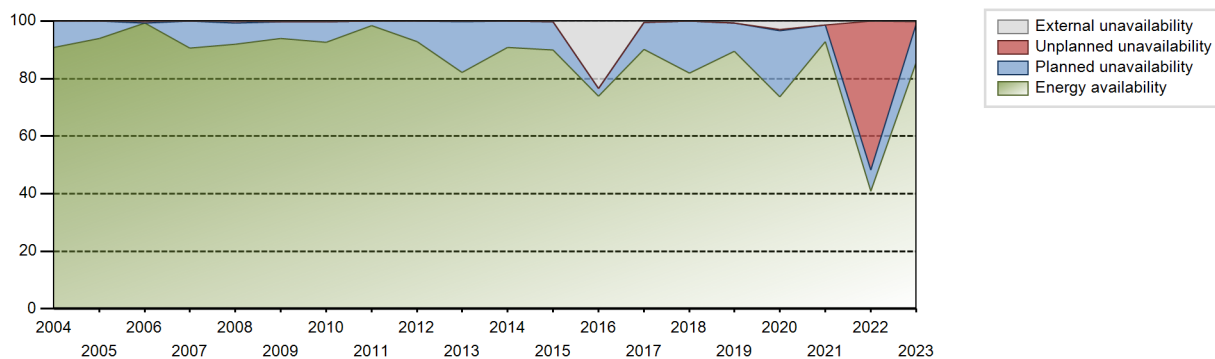
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 136492.63 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.25 % |
| Cumulative Energy Availability Factor (EAF) | : 87.77 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.95 % |
| Cumulative Unit Capability Factor (UCF) | : 88.9 % | Cumulative Planned Unavailability Factor (PUF) | : 9.15 % |
| Cumulative Load Factor (LF) | : 89.53 % | Cumulative Externally cause unavailability (XUF) | : 1.13 % |
| Cumulative Operating Factor (OF) | : 87.73 % | | |

Electricity Production (net) [GWh]

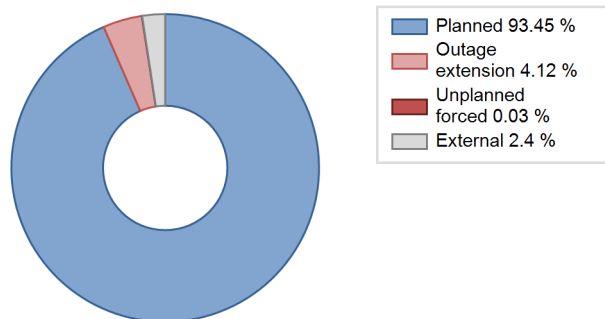


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1997 | 3294.95 | 5296 | 650 | 94.68 | 94.68 | 97.70 | 95.09 | 5.20 | 5.19 | 0.13 | 0.00 |
| 1998 | 4788.68 | 7144 | 650 | 81.01 | 81.02 | 84.10 | 81.55 | 0.00 | 0.00 | 18.98 | 0.00 |
| 1999 | 5211.77 | 7754 | 650 | 88.12 | 88.13 | 91.53 | 88.52 | 0.26 | 0.23 | 11.65 | 0.00 |
| 2000 | 5346.81 | 7843 | 650 | 91.49 | 91.49 | 93.65 | 89.29 | 0.07 | 0.06 | 8.45 | 0.00 |
| 2001 | 5585.43 | 8188 | 650 | 92.79 | 93.01 | 98.09 | 93.47 | 0.34 | 0.32 | 6.67 | 0.22 |
| 2002 | 5265.98 | 7717 | 650 | 87.66 | 87.66 | 92.48 | 88.09 | 0.00 | 0.00 | 12.34 | 0.00 |
| 2003 | 5480.58 | 8015 | 650 | 91.22 | 91.22 | 96.25 | 91.50 | 0.86 | 0.79 | 7.99 | 0.00 |
| 2004 | 5465.46 | 8015 | 650 | 90.88 | 90.91 | 95.72 | 91.25 | 0.00 | 0.00 | 9.09 | 0.03 |
| 2005 | 5641.29 | 8243 | 650 | 93.90 | 93.90 | 99.07 | 94.10 | 0.00 | 0.00 | 6.10 | 0.00 |
| 2006 | 5975.85 | 8711 | 684 | 99.34 | 99.34 | 99.73 | 99.44 | 0.65 | 0.65 | 0.01 | 0.00 |
| 2007 | 5618.82 | 7948 | 683 | 90.58 | 90.58 | 93.91 | 90.73 | 0.03 | 0.02 | 9.40 | 0.00 |
| 2008 | 5700.28 | 8081 | 710 | 91.96 | 92.10 | 91.40 | 92.00 | 0.56 | 0.52 | 7.38 | 0.14 |
| 2009 | 5845.94 | 8265 | 710 | 93.92 | 94.20 | 93.99 | 94.35 | 0.03 | 0.03 | 5.77 | 0.29 |
| 2010 | 5774.27 | 8152 | 710 | 92.67 | 92.96 | 92.84 | 93.06 | 0.00 | 0.00 | 7.04 | 0.29 |
| 2011 | 6124.72 | 8760 | 710 | 98.37 | 98.37 | 98.47 | 100.00 | 0.00 | 0.00 | 1.63 | 0.00 |
| 2012 | 5572.93 | 8187 | 673 | 92.76 | 92.76 | 94.27 | 93.20 | 0.00 | 0.00 | 7.24 | 0.00 |
| 2013 | 4797.42 | 7207 | 655 | 82.18 | 82.18 | 82.86 | 82.27 | 0.19 | 0.16 | 17.66 | 0.01 |
| 2014 | 5194.82 | 7954 | 650 | 90.78 | 90.78 | 90.83 | 90.80 | 0.00 | 0.00 | 9.22 | 0.00 |
| 2015 | 5143.35 | 7921 | 652 | 90.03 | 90.23 | 90.14 | 90.42 | 0.00 | 0.00 | 9.77 | 0.20 |
| 2016 | 4219.27 | 6525 | 647 | 73.90 | 97.43 | 74.24 | 74.28 | 0.00 | 0.00 | 2.57 | 23.53 |
| 2017 | 4981.05 | 7947 | 632 | 90.25 | 90.65 | 89.97 | 90.72 | 0.00 | 0.00 | 9.35 | 0.40 |
| 2018 | 4449.94 | 7190 | 611 | 81.97 | 82.00 | 83.14 | 82.08 | 0.00 | 0.00 | 18.00 | 0.02 |
| 2019 | 4840.92 | 7920 | 606 | 89.59 | 90.33 | 91.19 | 90.41 | 0.00 | 0.00 | 9.67 | 0.74 |
| 2020 | 3900.78 | 6558 | 596 | 73.73 | 76.64 | 74.51 | 74.66 | 0.52 | 0.40 | 22.95 | 2.91 |
| 2021 | 4781.06 | 8248 | 582 | 92.79 | 94.12 | 93.78 | 94.16 | 0.02 | 0.02 | 5.87 | 1.33 |
| 2022 | 2059.85 | 3578 | 569 | 40.78 | 40.79 | 41.33 | 40.84 | 0.00 | 51.67 | 7.55 | 0.01 |
| 2023 | 4350.62 | 7539 | 576 | 85.62 | 85.97 | 86.22 | 86.06 | 0.01 | 0.60 | 13.44 | 0.34 |

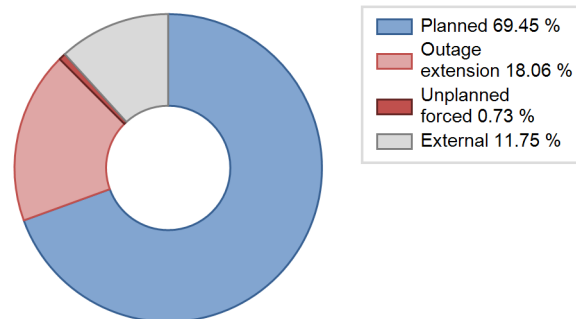
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1997 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 53 | | | 185 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 161 | | |
| D. Inspection, maintenance or repair without refuelling | 1168 | | | 642 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 2 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 84 |
| Subtotal | 1168 | 53 | | 803 | 187 | 86 |
| Total | | 1221 | | | 1076 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1997 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 2 |
| 13. Reactor Auxiliary Systems | | 2 |
| 16. Steam generation systems | | 171 |
| 31. Turbine and auxiliaries | | 3 |
| 32. Feedwater and Main Steam System | | 3 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | 53 | 5 |
| Total | 53 | 188 |

Highlights (2023)

21th Overhaul(Inspection and maintenance, 2023-03-09~2023-04-29)

2023 Operating Experience

KR-15

WOLSONG-3

KOREA, REPUBLIC OF

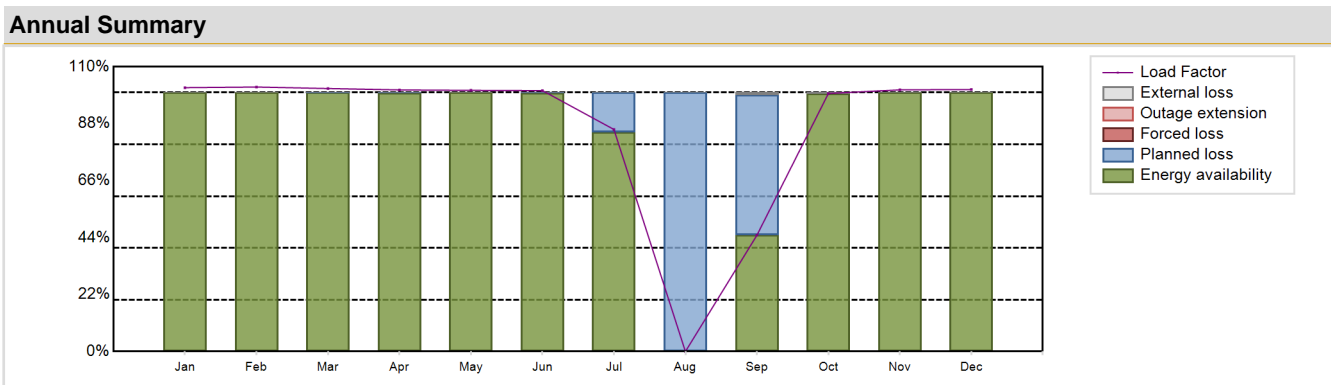
Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : AECL/DHI (ATOMIC ENERGY OF CANADA LTD./DOOSAN HEAVY INDUSTRIES & CONSTRUCTION)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 6 | Construction Date | : 1994-03-17 |
| Thermal power | : 2061 MWth | Grid Date | : 1998-03-25 |
| Gross electrical power | : 624 MWe | Commercial Date | : 1998-07-01 |
| Reference unit power (net) | : 601 MWe | Age at end of year | : 25 years |

| Design Characteristics | | | |
|---|--------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 10.5 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 310 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 0.12 |
| Average fuel enrichment [% of U235] | : 0.71 | Secondary systems | |
| Refuelling frequency [month] | : 15 | Number of turbine-generators per unit/reactor | : 4 |
| Part of the core refuelled [%] | : 96 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 7296 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 7.69 | HP cylinder inlet steam pressure [MPa] | : 4.59 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 4560 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 0.1615 | Number of main condensate pumps | : 2 |
| Number of control rod assemblies | : 21 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : D2O | Non-electrical applications | |
| | | | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4559.74 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 85.65 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 85.76 % | Planned Unavailability Factor (PUF) | : 14.24 % |
| Load Factor (LF) | : 86.61 % | Externally cause unavailability (XUF) | : 0.11 % |
| Operating Factor (OF) | : 85.87 % | Total off-line time | : 1238 hours |

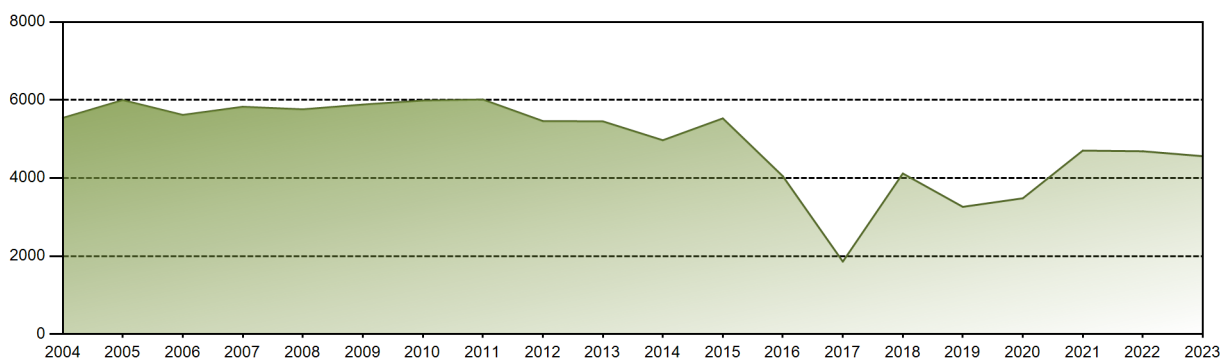


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 455.64 | 412.54 | 454.21 | 437.17 | 451.04 | 436.06 | 383.52 | 0.00 | 194.27 | 445.63 | 437.30 | 452.36 | 4559.74 |
| EAF [%] | 100.00 | 100.00 | 99.99 | 99.93 | 100.00 | 99.98 | 84.85 | 0.00 | 44.89 | 99.60 | 100.00 | 100.00 | 85.65 |
| UCF [%] | 100.00 | 100.00 | 99.99 | 99.93 | 100.00 | 99.98 | 84.85 | 0.00 | 45.85 | 100.00 | 100.00 | 100.00 | 85.76 |
| LF [%] | 101.90 | 102.15 | 101.58 | 101.03 | 100.87 | 100.77 | 85.77 | 0.00 | 44.89 | 99.66 | 101.06 | 101.17 | 86.61 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.08 | 0.00 | 46.81 | 100.00 | 100.00 | 100.00 | 85.87 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.01 | 0.07 | 0.00 | 0.02 | 15.15 | 100.00 | 54.15 | 0.00 | 0.00 | 0.00 | 14.24 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.96 | 0.40 | 0.00 | 0.00 | 0.11 |

Historical Summary

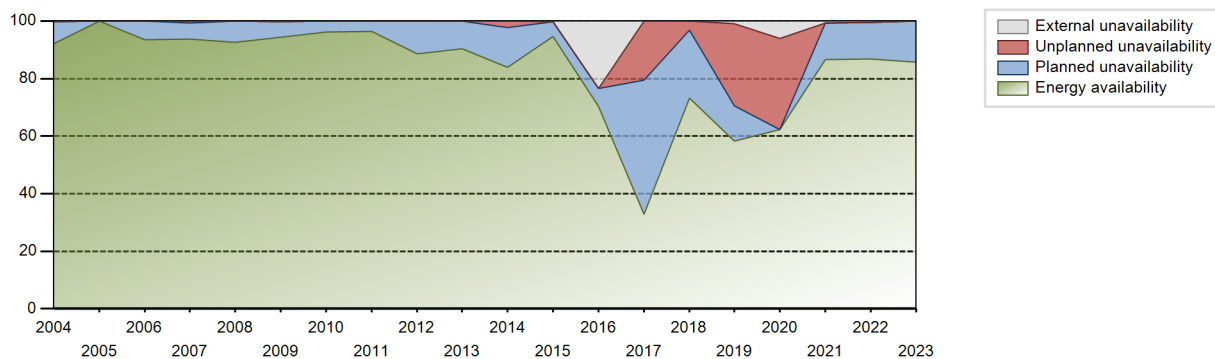
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 129815.79 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.8 % |
| Cumulative Energy Availability Factor (EAF) | : 85.41 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.47 % |
| Cumulative Unit Capability Factor (UCF) | : 86.66 % | Cumulative Planned Unavailability Factor (PUF) | : 9.87 % |
| Cumulative Load Factor (LF) | : 86.86 % | Cumulative Externally cause unavailability (XUF) | : 1.26 % |
| Cumulative Operating Factor (OF) | : 85.42 % | | |

Electricity Production (net) [GWh]

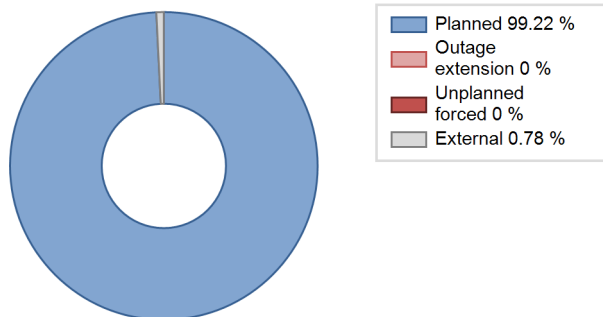


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1998 | 3460.26 | 5326 | 650 | 96.11 | 96.11 | 98.89 | 96.38 | 3.88 | 3.88 | 0.01 | 0.00 |
| 1999 | 4696.65 | 7008 | 650 | 80.23 | 80.24 | 82.48 | 80.00 | 0.00 | 0.00 | 19.76 | 0.00 |
| 2000 | 5925.22 | 8784 | 650 | 99.93 | 99.93 | 103.78 | 100.00 | 0.00 | 0.00 | 0.07 | 0.00 |
| 2001 | 4923.93 | 7409 | 650 | 85.32 | 85.32 | 86.48 | 84.58 | 3.17 | 2.79 | 11.89 | 0.00 |
| 2002 | 5043.33 | 8083 | 650 | 91.79 | 91.79 | 88.57 | 92.27 | 0.00 | 0.00 | 8.21 | 0.00 |
| 2003 | 5579.53 | 8176 | 650 | 93.06 | 93.06 | 97.99 | 93.33 | 0.07 | 0.06 | 6.88 | 0.00 |
| 2004 | 5540.29 | 8152 | 650 | 92.24 | 92.47 | 97.03 | 92.81 | 0.00 | 0.00 | 7.53 | 0.23 |
| 2005 | 5997.86 | 8760 | 650 | 100.00 | 100.00 | 105.34 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2006 | 5617.76 | 8205 | 682 | 93.45 | 93.45 | 94.03 | 93.66 | 0.00 | 0.00 | 6.55 | 0.00 |
| 2007 | 5826.59 | 8239 | 681 | 93.78 | 93.78 | 97.67 | 94.05 | 0.65 | 0.61 | 5.61 | 0.00 |
| 2008 | 5761.08 | 8129 | 707 | 92.63 | 92.71 | 92.77 | 92.54 | 0.00 | 0.00 | 7.29 | 0.08 |
| 2009 | 5882.54 | 8287 | 707 | 94.34 | 94.50 | 94.98 | 94.60 | 0.00 | 0.00 | 5.50 | 0.15 |
| 2010 | 5986.43 | 8433 | 707 | 96.19 | 96.25 | 96.66 | 96.27 | 0.00 | 0.00 | 3.75 | 0.06 |
| 2011 | 6014.37 | 8477 | 707 | 96.45 | 96.50 | 97.11 | 96.77 | 0.00 | 0.00 | 3.50 | 0.05 |
| 2012 | 5460.60 | 7827 | 686 | 88.70 | 88.70 | 90.62 | 89.11 | 0.00 | 0.00 | 11.30 | 0.00 |
| 2013 | 5453.06 | 7937 | 684 | 90.39 | 90.50 | 91.01 | 90.61 | 0.00 | 0.00 | 9.50 | 0.11 |
| 2014 | 4968.56 | 7371 | 665 | 83.99 | 83.99 | 85.29 | 84.14 | 2.67 | 2.30 | 13.71 | 0.00 |
| 2015 | 5528.96 | 8313 | 665 | 94.72 | 94.88 | 94.91 | 94.90 | 0.00 | 0.00 | 5.12 | 0.16 |
| 2016 | 4046.37 | 6216 | 651 | 70.41 | 93.83 | 70.76 | 70.77 | 0.00 | 0.00 | 6.17 | 23.42 |
| 2017 | 1857.46 | 2890 | 648 | 32.82 | 32.87 | 32.72 | 32.99 | 38.40 | 20.49 | 46.64 | 0.06 |
| 2018 | 4116.18 | 6432 | 641 | 73.18 | 73.19 | 73.30 | 73.42 | 4.07 | 3.11 | 23.70 | 0.01 |
| 2019 | 3261.26 | 5184 | 630 | 58.19 | 59.08 | 59.09 | 59.18 | 14.56 | 28.61 | 12.31 | 0.89 |
| 2020 | 3480.85 | 5542 | 627 | 62.27 | 68.35 | 63.20 | 63.09 | 0.00 | 31.58 | 0.07 | 6.08 |
| 2021 | 4704.12 | 7665 | 607 | 86.65 | 87.42 | 88.47 | 87.50 | 0.00 | 0.00 | 12.58 | 0.78 |
| 2022 | 4686.17 | 7665 | 605 | 86.88 | 87.39 | 88.42 | 87.50 | 0.00 | 0.00 | 12.61 | 0.52 |
| 2023 | 4559.74 | 7522 | 601 | 85.65 | 85.76 | 86.61 | 85.87 | 0.00 | 0.00 | 14.24 | 0.11 |

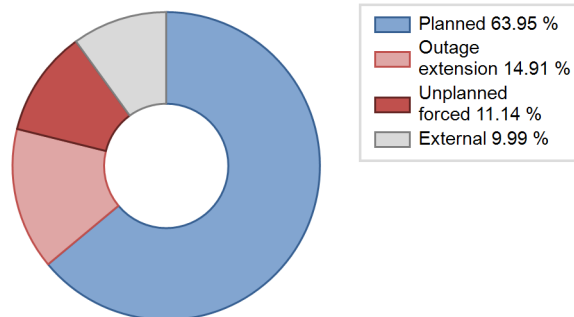
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1998 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 312 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 197 | | |
| D. Inspection, maintenance or repair without refuelling | 1231 | | | 684 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 101 |
| Subtotal | 1231 | | | 881 | 312 | 102 |
| Total | | 1231 | | | 1295 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1998 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 8 |
| 14. Safety Systems | | 83 |
| 15. Reactor Cooling Systems | | 35 |
| 16. Steam generation systems | | 176 |
| 21. Fuel Handling and Storage Facilities | | 2 |
| 35. All other I&C Systems | | 10 |
| Total | | 314 |

Highlights (2023)

Inspection and Maintenance(2023.7.27 ~ 9.16)

2023 Operating Experience

KR-16

WOLSONG-4

KOREA, REPUBLIC OF

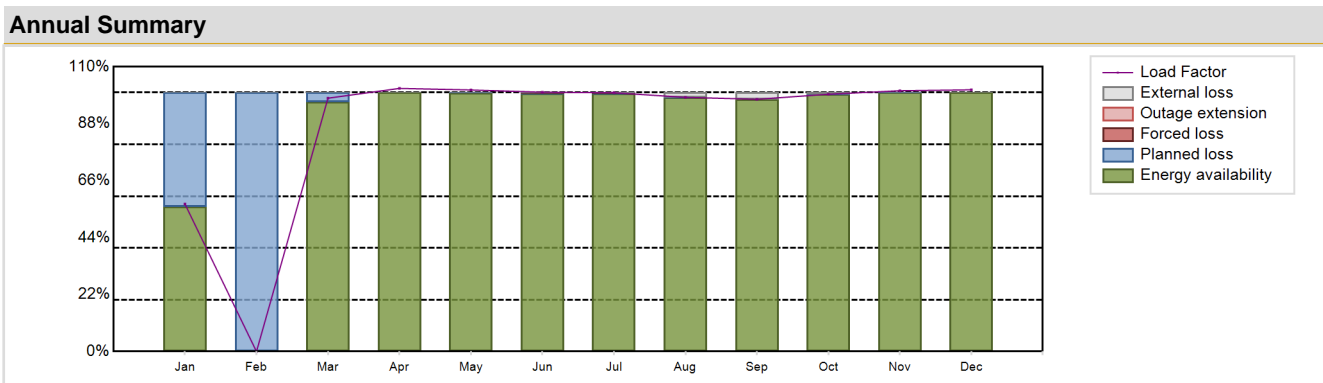
Status at end of year : **Operational**
 Operator : KHNP (Korea Hydro and Nuclear Power Co.)
 Owner : KHNP (Korea Hydro and Nuclear Power Co.)
 Reactor Supplier : AECL/DHI (ATOMIC ENERGY OF CANADA LTD./DOOSAN HEAVY INDUSTRIES & CONSTRUCTION)
 Turbine Supplier : DHICGE (Doosan Heavy Industries & Construction and General Electric)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 6 | Construction Date | : 1994-07-22 |
| Thermal power | : 2061 MWth | Grid Date | : 1999-05-21 |
| Gross electrical power | : 589 MWe | Commercial Date | : 1999-10-01 |
| Reference unit power (net) | : 567 MWe | Age at end of year | : 24 years |

| Design Characteristics | | | |
|---|--------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 10.5 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 310 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 0.12 |
| Average fuel enrichment [% of U235] | : 0.71 | Secondary systems | |
| Refuelling frequency [month] | : 15 | Number of turbine-generators per unit/reactor | : 4 |
| Part of the core refuelled [%] | : 96 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 7296 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 7.69 | HP cylinder inlet steam pressure [MPa] | : 4.59 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 4560 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 0.1615 | Number of main condensate pumps | : 2 |
| Number of control rod assemblies | : 21 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : D2O | Non-electrical applications | |
| | | | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4392.97 GW(e).h | Forced Loss Rate (FLR) | : 0.06 % |
| Energy Availability Factor (EAF) | : 87.76 % | Unplanned Capability Loss Factor (UCL) | : 0.05 % |
| Unit Capability Factor (UCF) | : 88.2 % | Planned Unavailability Factor (PUF) | : 11.75 % |
| Load Factor (LF) | : 88.44 % | Externally cause unavailability (XUF) | : 0.44 % |
| Operating Factor (OF) | : 88.34 % | Total off-line time | : 1021 hours |

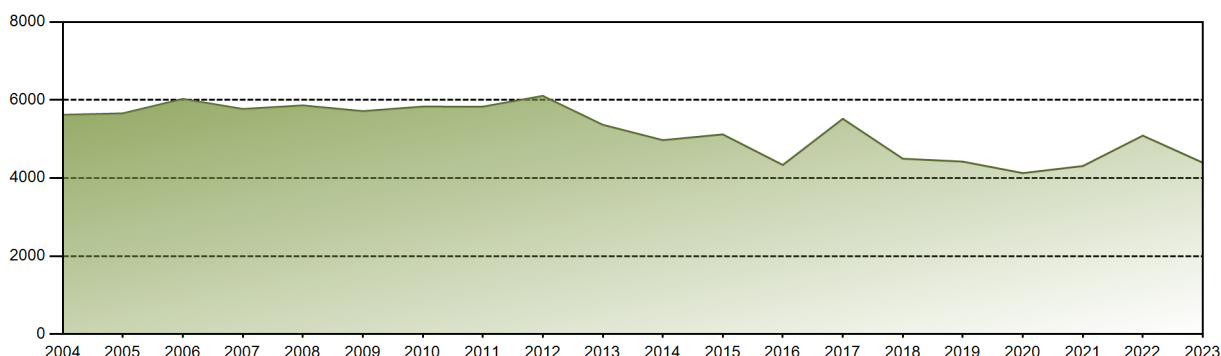


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 240.20 | 0.00 | 412.73 | 414.88 | 426.15 | 408.86 | 421.55 | 414.10 | 397.73 | 419.17 | 411.20 | 426.39 | 4392.97 |
| EAF [%] | 55.82 | 0.00 | 96.31 | 100.00 | 99.97 | 99.63 | 99.57 | 98.12 | 97.43 | 99.26 | 100.00 | 100.00 | 87.76 |
| UCF [%] | 55.82 | 0.00 | 96.31 | 100.00 | 99.97 | 99.65 | 99.61 | 100.00 | 100.00 | 99.99 | 100.00 | 100.00 | 88.20 |
| LF [%] | 56.94 | 0.00 | 97.84 | 101.63 | 101.02 | 100.15 | 99.93 | 98.16 | 97.43 | 99.36 | 100.73 | 101.08 | 88.44 |
| OF [%] | 56.05 | 0.00 | 97.04 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.34 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.37 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.37 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| PUF [%] | 44.18 | 100.00 | 3.69 | 0.00 | 0.03 | 0.07 | 0.03 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 11.75 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 1.88 | 2.57 | 0.73 | 0.00 | 0.00 | 0.44 |

Historical Summary

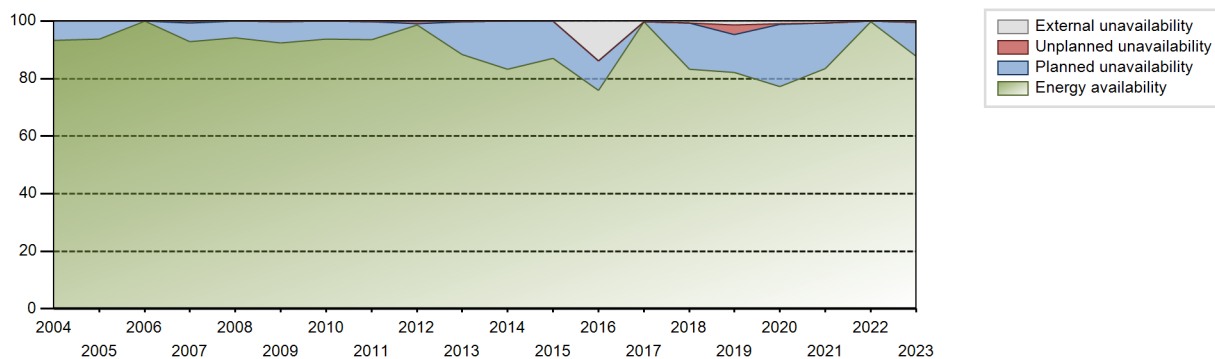
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 130496.49 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.12 % |
| Cumulative Energy Availability Factor (EAF) | : 90.58 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.23 % |
| Cumulative Unit Capability Factor (UCF) | : 91.35 % | Cumulative Planned Unavailability Factor (PUF) | : 8.42 % |
| Cumulative Load Factor (LF) | : 92.3 % | Cumulative Externally cause unavailability (XUF) | : 0.77 % |
| Cumulative Operating Factor (OF) | : 90.79 % | | |

Electricity Production (net) [GWh]

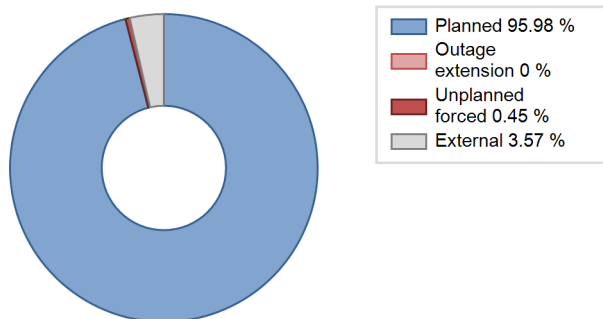


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1999 | 1489.23 | 2208 | 650 | 99.89 | 99.89 | 103.76 | 100.00 | 0.00 | 0.00 | 0.11 | 0.00 |
| 2000 | 5423.32 | 8033 | 650 | 91.36 | 91.36 | 94.99 | 91.45 | 0.10 | 0.09 | 8.55 | 0.00 |
| 2001 | 5493.17 | 8110 | 650 | 92.58 | 92.58 | 96.47 | 92.58 | 0.09 | 0.09 | 7.33 | 0.00 |
| 2002 | 5448.11 | 7971 | 650 | 90.80 | 90.80 | 95.68 | 90.99 | 0.00 | 0.00 | 9.20 | 0.00 |
| 2003 | 5601.86 | 8225 | 650 | 93.49 | 93.49 | 98.38 | 93.89 | 0.12 | 0.11 | 6.40 | 0.00 |
| 2004 | 5620.95 | 8209 | 650 | 93.17 | 93.17 | 98.45 | 93.45 | 0.00 | 0.00 | 6.83 | 0.00 |
| 2005 | 5657.87 | 8254 | 650 | 93.79 | 93.79 | 99.37 | 94.22 | 0.00 | 0.00 | 6.21 | 0.00 |
| 2006 | 6028.31 | 8760 | 685 | 100.00 | 100.00 | 100.46 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 5770.36 | 8157 | 685 | 92.80 | 92.80 | 96.16 | 93.12 | 0.66 | 0.61 | 6.59 | 0.00 |
| 2008 | 5861.40 | 8271 | 708 | 94.15 | 94.23 | 94.25 | 94.16 | 0.00 | 0.00 | 5.77 | 0.08 |
| 2009 | 5714.06 | 8079 | 708 | 92.41 | 92.67 | 92.13 | 92.23 | 0.00 | 0.00 | 7.33 | 0.26 |
| 2010 | 5831.20 | 8218 | 708 | 93.70 | 93.76 | 94.02 | 93.81 | 0.00 | 0.00 | 6.24 | 0.06 |
| 2011 | 5828.85 | 8215 | 708 | 93.51 | 93.71 | 93.98 | 93.78 | 0.00 | 0.00 | 6.29 | 0.20 |
| 2012 | 6105.67 | 8702 | 694 | 98.60 | 98.60 | 100.16 | 99.07 | 1.00 | 1.00 | 0.40 | 0.00 |
| 2013 | 5364.39 | 7761 | 688 | 88.30 | 88.47 | 89.01 | 88.60 | 0.00 | 0.00 | 11.53 | 0.17 |
| 2014 | 4970.75 | 7307 | 669 | 83.30 | 83.30 | 84.82 | 83.41 | 0.02 | 0.02 | 16.68 | 0.00 |
| 2015 | 5117.75 | 7636 | 669 | 87.07 | 87.07 | 87.33 | 87.17 | 0.00 | 0.00 | 12.93 | 0.00 |
| 2016 | 4334.90 | 6720 | 653 | 75.91 | 89.83 | 75.57 | 76.50 | 0.00 | 0.00 | 10.17 | 13.92 |
| 2017 | 5517.85 | 8760 | 635 | 99.63 | 100.00 | 99.20 | 100.00 | 0.00 | 0.00 | 0.00 | 0.37 |
| 2018 | 4494.93 | 7354 | 622 | 83.24 | 83.87 | 82.50 | 83.95 | 0.00 | 0.00 | 16.13 | 0.62 |
| 2019 | 4420.51 | 7310 | 609 | 82.07 | 83.34 | 82.86 | 83.45 | 0.15 | 3.41 | 13.25 | 1.27 |
| 2020 | 4126.51 | 6872 | 600 | 77.26 | 78.12 | 78.30 | 78.23 | 0.45 | 0.35 | 21.53 | 0.85 |
| 2021 | 4307.32 | 7376 | 575 | 83.44 | 84.05 | 85.51 | 84.20 | 0.10 | 0.08 | 15.87 | 0.62 |
| 2022 | 5086.51 | 8760 | 574 | 99.78 | 99.87 | 101.16 | 100.00 | 0.00 | 0.00 | 0.13 | 0.08 |
| 2023 | 4392.97 | 7739 | 567 | 87.76 | 88.20 | 88.44 | 88.34 | 0.06 | 0.05 | 11.75 | 0.44 |

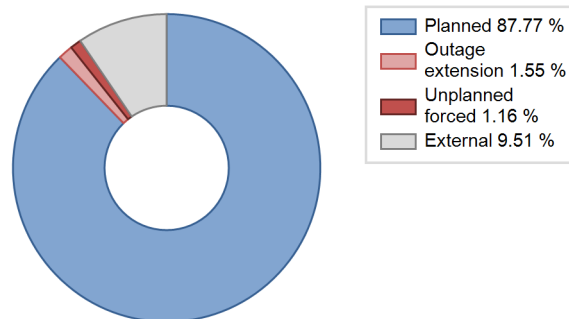
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1999 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 19 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 81 | | |
| D. Inspection, maintenance or repair without refuelling | 1015 | | | 662 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 49 |
| Subtotal | 1015 | | | 743 | 19 | 51 |
| Total | | 1015 | | | 813 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1999 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 13. Reactor Auxiliary Systems | | 2 |
| 15. Reactor Cooling Systems | | 12 |
| 16. Steam generation systems | | 0 |
| 21. Fuel Handling and Storage Facilities | | 3 |
| 31. Turbine and auxiliaries | | 0 |
| 41. Main Generator Systems | | 1 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 20 |

Highlights (2023)

Inspection and Maintenance(2023.1.18 ~ 3.1)

2023 Operating Experience

MX-1

LAGUNA VERDE-1

MEXICO

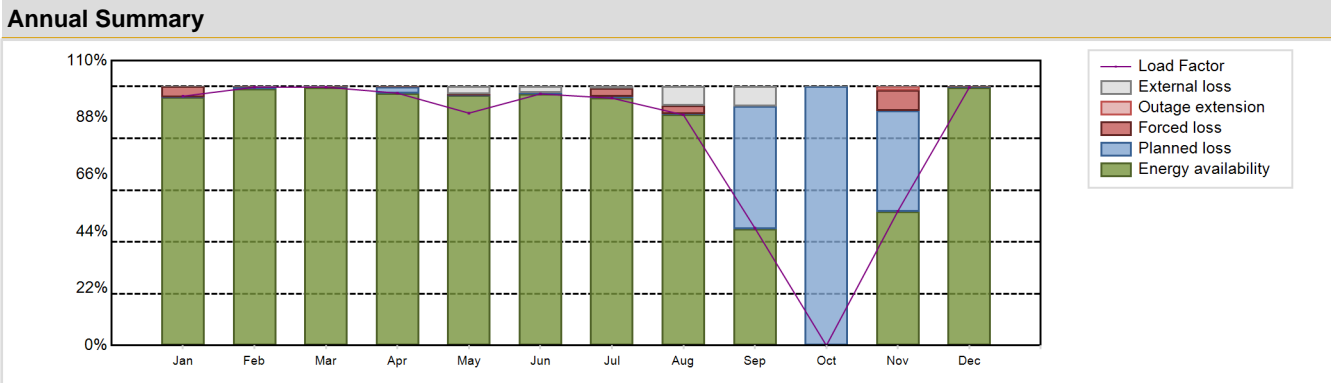
Status at end of year : **Operational**
 Operator : CFE (COMISION FEDERAL DE ELECTRICIDAD)
 Owner : CFE (COMISION FEDERAL DE ELECTRICIDAD)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-5 | Construction Date | : 1976-09-27 |
| Thermal power | : 2317 MWth | Grid Date | : 1989-04-09 |
| Gross electrical power | : 805 MWe | Commercial Date | : 1990-07-25 |
| Reference unit power (net) | : 777 MWe | Age at end of year | : 34 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.2 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 278 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Double |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.31 |
| Average fuel enrichment [% of U235] | : 3.81 | Secondary systems | |
| Refuelling frequency [month] | : 17.5 | Number of turbine-generators per unit/reactor | : 3 |
| Part of the core refuelled [%] | : 28.83 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 42635.75 | Number of LP cylinders per turbine | : 2 |
| Active core diameter [m] | : 3.62 | HP cylinder inlet steam pressure [MPa] | : 6.51 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : 22 |
| Number of fissile fuel assemblies/bundles | : 444 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 16.06 | Number of main condensate pumps | : 4 |
| Number of control rod assemblies | : 109 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 5449.45 GW(e).h | Forced Loss Rate (FLR) | : 1.94 % |
| Energy Availability Factor (EAF) | : 80.5 % | Unplanned Capability Loss Factor (UCL) | : 1.74 % |
| Unit Capability Factor (UCF) | : 82.23 % | Planned Unavailability Factor (PUF) | : 16.03 % |
| Load Factor (LF) | : 80.06 % | Externally cause unavailability (XUF) | : 1.72 % |
| Operating Factor (OF) | : 83.89 % | Total off-line time | : 1411 hours |

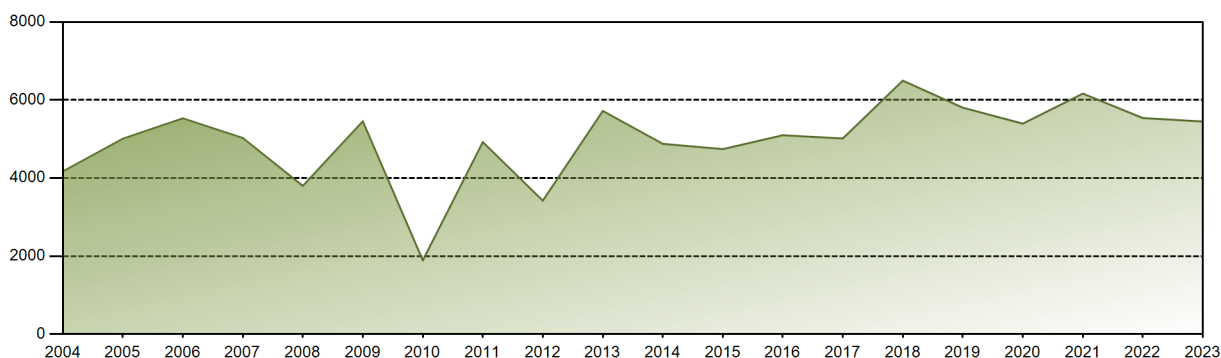


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 556.66 | 520.79 | 576.72 | 545.22 | 518.81 | 543.60 | 552.24 | 514.97 | 253.70 | 0.00 | 290.33 | 576.40 | 5449.45 |
| EAF [%] | 95.77 | 99.18 | 99.62 | 97.39 | 96.69 | 97.17 | 95.53 | 89.08 | 44.96 | 0.00 | 51.83 | 99.64 | 80.50 |
| UCF [%] | 95.77 | 99.18 | 99.62 | 97.39 | 99.44 | 99.45 | 96.23 | 96.44 | 52.47 | 0.00 | 51.83 | 99.64 | 82.23 |
| LF [%] | 96.29 | 99.74 | 99.76 | 97.46 | 89.75 | 97.17 | 95.53 | 89.08 | 45.35 | 0.00 | 51.90 | 99.71 | 80.06 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 93.55 | 100.00 | 100.00 | 100.00 | 53.75 | 0.00 | 60.28 | 100.00 | 83.89 |
| FLR [%] | 4.04 | 0.25 | 0.10 | 0.23 | 0.49 | 0.00 | 3.19 | 3.27 | 0.00 | 0.00 | 13.28 | 0.00 | 1.94 |
| UCL [%] | 4.03 | 0.25 | 0.10 | 0.23 | 0.49 | 0.00 | 3.17 | 3.26 | 0.00 | 0.00 | 9.32 | 0.00 | 1.74 |
| PUF [%] | 0.20 | 0.57 | 0.29 | 2.38 | 0.06 | 0.55 | 0.60 | 0.30 | 47.53 | 100.00 | 38.84 | 0.36 | 16.03 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 2.75 | 2.28 | 0.70 | 7.36 | 7.51 | 0.00 | 0.00 | 0.00 | 1.72 |

Historical Summary

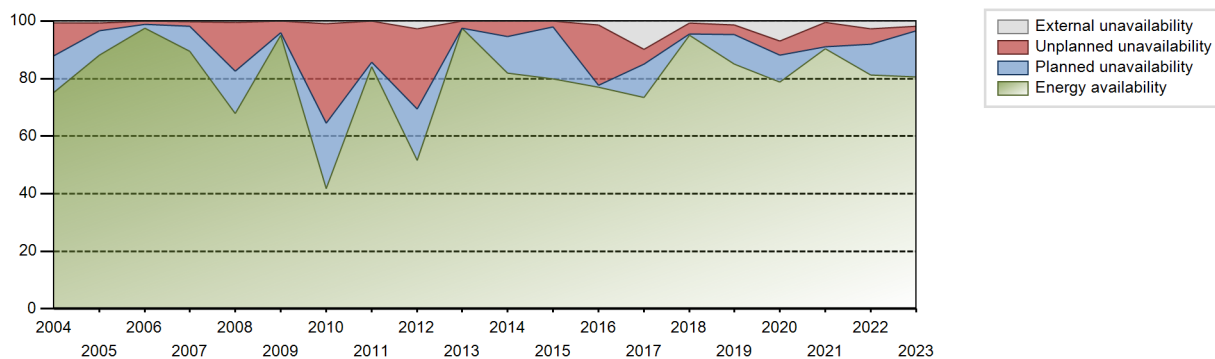
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 158272.06 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.48 % |
| Cumulative Energy Availability Factor (EAF) | : 80.44 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.14 % |
| Cumulative Unit Capability Factor (UCF) | : 81.79 % | Cumulative Planned Unavailability Factor (PUF) | : 10.07 % |
| Cumulative Load Factor (LF) | : 78.52 % | Cumulative Externally cause unavailability (XUF) | : 1.35 % |
| Cumulative Operating Factor (OF) | : 83.84 % | | |

Electricity Production (net) [GWh]

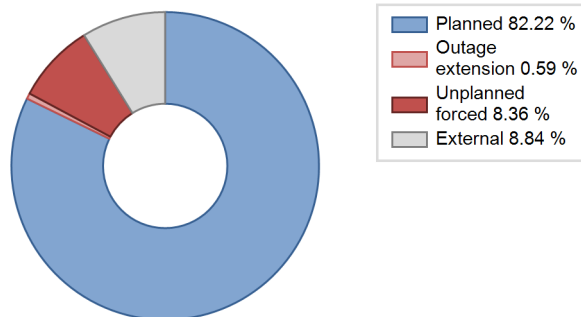


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1990 | 2775.82 | 5370 | 640 | 87.58 | 87.58 | 86.55 | 96.68 | 11.65 | 11.55 | 0.87 | 0.00 |
| 1991 | 4062.09 | 7022 | 640 | 74.45 | 74.45 | 72.45 | 80.16 | 2.12 | 1.61 | 23.94 | 0.00 |
| 1992 | 3746.44 | 7024 | 654 | 70.41 | 70.41 | 65.22 | 79.96 | 16.16 | 13.57 | 16.02 | 0.00 |
| 1993 | 4724.42 | 7851 | 654 | 90.57 | 90.57 | 82.46 | 89.62 | 8.80 | 8.74 | 0.68 | 0.00 |
| 1994 | 4061.96 | 7095 | 628 | 73.84 | 77.82 | 73.84 | 80.99 | 10.85 | 9.47 | 12.71 | 3.99 |
| 1995 | 4154.06 | 7128 | 628 | 75.51 | 78.07 | 75.51 | 81.37 | 10.00 | 8.67 | 13.26 | 2.56 |
| 1996 | 3442.34 | 6628 | 655 | 68.80 | 68.81 | 59.83 | 75.46 | 8.93 | 6.75 | 24.44 | 0.01 |
| 1997 | 5218.80 | 8577 | 615 | 95.87 | 95.97 | 96.87 | 97.91 | 3.71 | 3.70 | 0.33 | 0.10 |
| 1998 | 4412.45 | 7359 | 655 | 81.67 | 82.19 | 76.90 | 84.01 | 8.24 | 7.38 | 10.43 | 0.52 |
| 1999 | 4450.97 | 7466 | 670 | 81.47 | 82.84 | 75.79 | 85.23 | 6.08 | 5.36 | 11.80 | 1.36 |
| 2000 | 4577.65 | 7409 | 645 | 80.27 | 80.56 | 80.80 | 84.35 | 5.08 | 4.31 | 15.13 | 0.29 |
| 2001 | 4144.30 | 6808 | 645 | 73.16 | 74.88 | 73.35 | 77.72 | 9.31 | 7.68 | 17.43 | 1.72 |
| 2002 | 4196.25 | 6876 | 680 | 75.83 | 76.41 | 70.44 | 78.49 | 5.49 | 10.73 | 12.87 | 0.58 |
| 2003 | 5415.44 | 8642 | 680 | 97.60 | 97.94 | 90.91 | 98.65 | 1.69 | 1.69 | 0.37 | 0.34 |
| 2004 | 4168.90 | 6818 | 680 | 75.16 | 75.94 | 69.79 | 77.62 | 4.48 | 11.20 | 12.86 | 0.78 |
| 2005 | 5007.75 | 7884 | 680 | 88.20 | 88.82 | 84.07 | 90.00 | 2.94 | 2.69 | 8.49 | 0.61 |
| 2006 | 5529.73 | 8624 | 680 | 97.55 | 97.55 | 92.83 | 98.45 | 1.20 | 1.19 | 1.26 | 0.00 |
| 2007 | 5027.19 | 7963 | 680 | 89.41 | 89.62 | 84.39 | 90.90 | 1.82 | 1.66 | 8.71 | 0.22 |
| 2008 | 3797.81 | 6169 | 650 | 67.88 | 68.38 | 66.52 | 70.23 | 3.83 | 16.89 | 14.73 | 0.50 |
| 2009 | 5454.49 | 8534 | 650 | 95.01 | 95.01 | 95.79 | 97.42 | 4.20 | 4.17 | 0.83 | 0.00 |
| 2010 | 1886.55 | 3391 | 650 | 41.69 | 42.59 | 33.13 | 38.71 | 15.71 | 34.61 | 22.80 | 0.90 |
| 2011 | 4921.75 | 7598 | 650 | 84.20 | 84.30 | 86.44 | 86.74 | 14.51 | 14.31 | 1.39 | 0.10 |
| 2012 | 3418.65 | 5209 | 765 | 51.49 | 54.22 | 51.53 | 59.30 | 11.86 | 27.76 | 18.02 | 2.72 |
| 2013 | 5719.46 | 8585 | 665 | 97.44 | 97.46 | 98.18 | 98.00 | 2.41 | 2.40 | 0.13 | 0.03 |
| 2014 | 4875.98 | 7461 | 665 | 81.84 | 81.84 | 83.71 | 85.18 | 5.41 | 5.42 | 12.74 | 0.00 |
| 2015 | 4741.77 | 7033 | 665 | 79.88 | 79.91 | 81.41 | 80.29 | 0.87 | 2.07 | 18.02 | 0.03 |
| 2016 | 5096.56 | 6716 | 777 | 77.02 | 78.38 | 77.45 | 76.46 | 0.49 | 21.00 | 0.61 | 1.36 |
| 2017 | 5014.49 | 7454 | 777 | 73.49 | 83.38 | 73.67 | 85.09 | 3.15 | 5.03 | 11.59 | 9.90 |
| 2018 | 6496.56 | 8523 | 777 | 95.17 | 95.89 | 95.45 | 97.29 | 3.84 | 3.83 | 0.28 | 0.72 |
| 2019 | 5803.84 | 7754 | 777 | 85.13 | 86.42 | 85.27 | 88.52 | 1.66 | 3.35 | 10.23 | 1.29 |
| 2020 | 5394.16 | 7629 | 777 | 78.80 | 85.69 | 79.03 | 86.85 | 0.57 | 4.99 | 9.32 | 6.88 |
| 2021 | 6164.50 | 8035 | 777 | 90.45 | 90.99 | 90.58 | 91.73 | 8.48 | 8.44 | 0.57 | 0.55 |
| 2022 | 5537.79 | 7432 | 777 | 81.17 | 83.89 | 81.36 | 84.84 | 1.90 | 5.25 | 10.86 | 2.71 |
| 2023 | 5449.45 | 7349 | 777 | 80.50 | 82.23 | 80.06 | 83.89 | 1.94 | 1.74 | 16.03 | 1.72 |

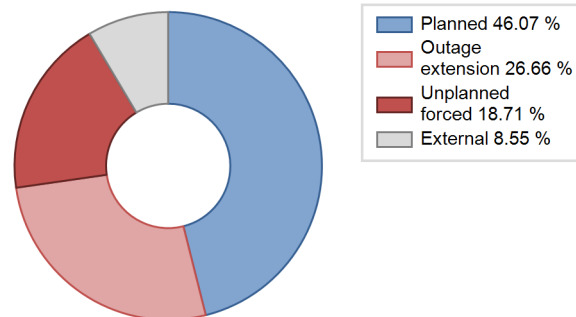
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1990 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 43 | | | 509 | |
| B. Refuelling without maintenance | | | | 21 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1320 | | | 725 | 17 | |
| D. Inspection, maintenance or repair without refuelling | | | | 147 | | |
| E. Testing of plant systems or components | | | | 63 | 4 | |
| J. Grid limitation, failure or grid unavailability | | | 48 | | | 30 |
| L. Human factor related | | | | | 80 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| Z. Other | | | | | 32 | |
| Subtotal | 1320 | 43 | 48 | 956 | 642 | 32 |
| Total | | 1411 | | | 1630 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1990 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 9 |
| 12. Reactor I&C Systems | | 84 |
| 13. Reactor Auxiliary Systems | | 43 |
| 14. Safety Systems | | 5 |
| 15. Reactor Cooling Systems | | 22 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 21. Fuel Handling and Storage Facilities | | 67 |
| 31. Turbine and auxiliaries | | 95 |
| 32. Feedwater and Main Steam System | | 67 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | 10 | 0 |
| 35. All other I&C Systems | | 19 |
| 41. Main Generator Systems | | 16 |
| 42. Electrical Power Supply Systems | 81 | 158 |
| Total | 91 | 589 |

2023 Operating Experience

MX-2

LAGUNA VERDE-2

MEXICO

Status at end of year : **Operational**
 Operator : CFE (COMISION FEDERAL DE ELECTRICIDAD)
 Owner : CFE (COMISION FEDERAL DE ELECTRICIDAD)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : MHI (MITSUBISHI HEAVY INDUSTRIES, LTD.)



Reactor Unit Details

Reactor type and model : BWR / BWR-5
 Thermal power : 2317 MWth
 Gross electrical power : 803 MWe
 Reference unit power (net) : 775 MWe

Key Dates

Construction Date : 1977-06-01
 Grid Date : 1994-11-11
 Commercial Date : 1995-04-10
 Age at end of year : 29 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.88
 Refuelling frequency [month] : 17.5
 Part of the core refuelled [%] : 32.43
 Average discharge burnup [MWd/t] : 45314.13
 Active core diameter [m] : 3.62
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 444
 Fuel linear heat generation rate [kW/m] : 16.06
 Number of control rod assemblies : 109
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.2
 Reactor outlet temperature [°C] : 278
 Number of SG : NA
 Containment type : Double
 Containment design pressure [MPa] : 0.31

Secondary systems

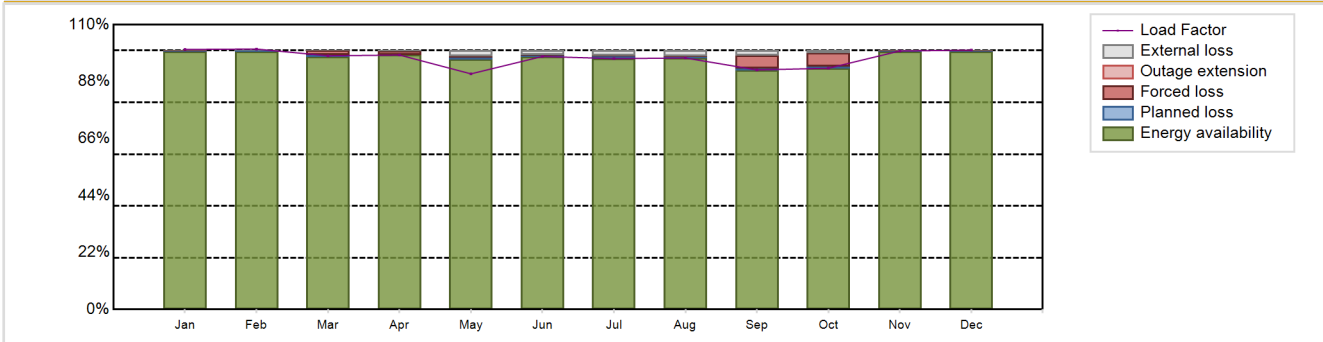
Number of turbine-generators per unit/reactor : 3
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.15
 Output voltage [kV] : 22
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6594.14 GW(e).h
 Energy Availability Factor (EAF) : 97.38 %
 Unit Capability Factor (UCF) : 98.27 %
 Load Factor (LF) : 97.13 %
 Operating Factor (OF) : 99.55 %
 Forced Loss Rate (FLR) : 1.21 %
 Unplanned Capability Loss Factor (UCL) : 1.2 %
 Planned Unavailability Factor (PUF) : 0.53 %
 Externally cause unavailability (XUF) : 0.89 %
 Total off-line time : 39 hours

Annual Summary

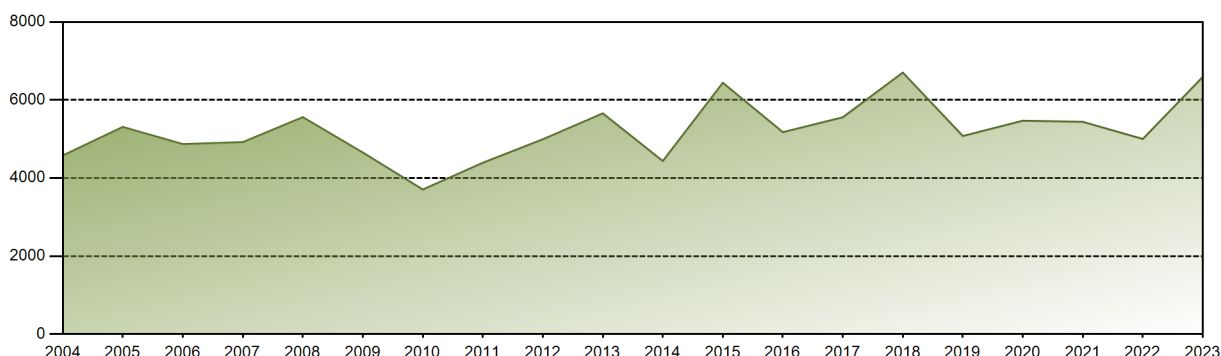


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 579.15 | 523.94 | 565.04 | 548.45 | 524.81 | 545.38 | 558.63 | 560.20 | 516.35 | 537.32 | 557.19 | 577.68 | 6594.14 |
| EAF [%] | 99.66 | 99.61 | 97.53 | 98.29 | 96.74 | 97.74 | 96.88 | 97.16 | 92.54 | 93.19 | 99.68 | 99.68 | 97.38 |
| UCF [%] | 99.66 | 99.61 | 97.53 | 98.35 | 98.84 | 99.47 | 98.69 | 99.40 | 94.29 | 94.08 | 99.68 | 99.68 | 98.27 |
| LF [%] | 100.44 | 100.60 | 97.99 | 98.29 | 91.02 | 97.74 | 96.88 | 97.16 | 92.54 | 93.19 | 99.85 | 100.19 | 97.13 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 94.76 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.55 |
| FLR [%] | 0.04 | 0.00 | 1.54 | 1.65 | 0.49 | 0.02 | 0.34 | 0.00 | 5.10 | 5.20 | 0.01 | 0.06 | 1.21 |
| UCL [%] | 0.04 | 0.00 | 1.52 | 1.65 | 0.48 | 0.02 | 0.34 | 0.00 | 5.07 | 5.16 | 0.01 | 0.06 | 1.20 |
| PUF [%] | 0.30 | 0.39 | 0.95 | 0.00 | 0.68 | 0.51 | 0.97 | 0.60 | 0.64 | 0.76 | 0.31 | 0.26 | 0.53 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.07 | 2.10 | 1.73 | 1.81 | 2.24 | 1.75 | 0.89 | 0.00 | 0.00 | 0.89 |

Historical Summary

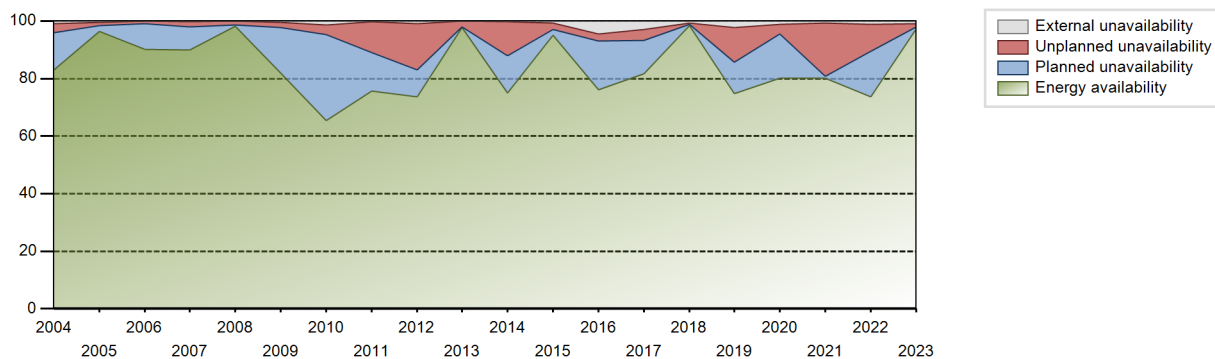
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 143666.47 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.63 % |
| Cumulative Energy Availability Factor (EAF) | : 83.15 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.74 % |
| Cumulative Unit Capability Factor (UCF) | : 84.13 % | Cumulative Planned Unavailability Factor (PUF) | : 10.13 % |
| Cumulative Load Factor (LF) | : 81.44 % | Cumulative Externally cause unavailability (XUF) | : 0.98 % |
| Cumulative Operating Factor (OF) | : 86.65 % | | |

Electricity Production (net) [GWh]

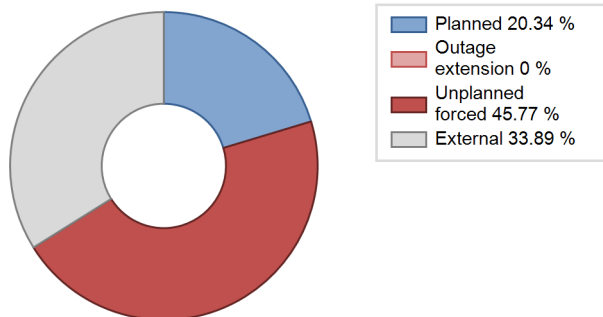


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1995 | 3379.40 | 5687 | 628 | 84.48 | 85.92 | 84.48 | 89.28 | 7.13 | 6.59 | 7.49 | 1.44 |
| 1996 | 3668.41 | 6657 | 619 | 70.97 | 71.67 | 67.47 | 75.79 | 3.52 | 2.61 | 25.71 | 0.71 |
| 1997 | 4805.53 | 7897 | 627 | 88.94 | 89.04 | 87.49 | 90.15 | 0.58 | 0.52 | 10.44 | 0.10 |
| 1998 | 4411.90 | 7609 | 655 | 83.02 | 85.58 | 76.89 | 86.86 | 1.14 | 0.98 | 13.44 | 2.56 |
| 1999 | 5110.57 | 8459 | 668 | 92.29 | 93.25 | 87.32 | 96.56 | 4.61 | 4.51 | 2.24 | 0.96 |
| 2000 | 3339.07 | 5865 | 645 | 56.63 | 58.56 | 58.93 | 66.77 | 29.16 | 24.10 | 17.34 | 1.93 |
| 2001 | 4228.06 | 6952 | 645 | 74.74 | 74.80 | 74.83 | 79.36 | 7.10 | 5.72 | 19.48 | 0.06 |
| 2002 | 5161.00 | 8273 | 680 | 91.49 | 91.54 | 86.63 | 94.43 | 6.98 | 7.69 | 0.77 | 0.05 |
| 2003 | 4604.83 | 7359 | 680 | 82.15 | 82.49 | 77.30 | 84.01 | 3.94 | 4.40 | 13.11 | 0.34 |
| 2004 | 4578.18 | 7449 | 680 | 82.97 | 83.80 | 76.65 | 84.80 | 0.49 | 3.32 | 12.88 | 0.82 |
| 2005 | 5310.30 | 8611 | 680 | 96.48 | 96.90 | 89.15 | 98.30 | 1.10 | 1.08 | 2.02 | 0.42 |
| 2006 | 4870.21 | 8003 | 680 | 90.25 | 90.34 | 81.76 | 91.36 | 0.97 | 0.88 | 8.78 | 0.09 |
| 2007 | 4920.19 | 8013 | 680 | 89.94 | 90.13 | 82.60 | 91.47 | 1.94 | 1.79 | 8.09 | 0.19 |
| 2008 | 5560.95 | 8730 | 650 | 98.29 | 98.29 | 97.40 | 99.39 | 1.27 | 1.27 | 0.44 | 0.00 |
| 2009 | 4653.65 | 7386 | 650 | 81.93 | 82.40 | 81.73 | 84.32 | 2.15 | 1.81 | 15.79 | 0.48 |
| 2010 | 3705.88 | 6289 | 650 | 65.40 | 66.85 | 65.08 | 71.79 | 2.96 | 3.30 | 29.85 | 1.44 |
| 2011 | 4391.62 | 7111 | 650 | 75.73 | 75.95 | 77.13 | 81.18 | 7.95 | 10.68 | 13.37 | 0.22 |
| 2012 | 4993.39 | 6854 | 765 | 73.60 | 74.46 | 74.31 | 78.03 | 3.76 | 16.14 | 9.41 | 0.86 |
| 2013 | 5657.68 | 8522 | 665 | 97.76 | 97.79 | 97.12 | 97.28 | 2.06 | 2.05 | 0.16 | 0.03 |
| 2014 | 4435.62 | 6705 | 665 | 74.95 | 75.25 | 76.15 | 76.55 | 6.61 | 11.68 | 13.07 | 0.30 |
| 2015 | 6442.96 | 8600 | 775 | 94.98 | 95.59 | 94.91 | 98.18 | 2.46 | 2.42 | 2.00 | 0.61 |
| 2016 | 5175.73 | 7194 | 775 | 76.05 | 80.56 | 76.03 | 81.90 | 2.96 | 2.46 | 16.98 | 4.51 |
| 2017 | 5557.43 | 7526 | 775 | 81.66 | 84.57 | 81.86 | 85.91 | 3.33 | 3.89 | 11.54 | 2.91 |
| 2018 | 6703.77 | 8726 | 775 | 98.48 | 99.16 | 98.74 | 99.61 | 0.45 | 0.45 | 0.38 | 0.68 |
| 2019 | 5076.89 | 7096 | 775 | 74.68 | 76.97 | 74.78 | 81.00 | 9.78 | 12.08 | 10.95 | 2.29 |
| 2020 | 5470.11 | 7435 | 775 | 80.23 | 81.31 | 80.36 | 84.65 | 3.99 | 3.38 | 15.31 | 1.08 |
| 2021 | 5441.04 | 7372 | 775 | 80.04 | 80.66 | 80.15 | 84.16 | 10.84 | 18.50 | 0.84 | 0.62 |
| 2022 | 5001.67 | 7089 | 775 | 73.62 | 74.74 | 73.67 | 80.92 | 8.72 | 9.46 | 15.80 | 1.12 |
| 2023 | 6594.14 | 8721 | 775 | 97.38 | 98.27 | 97.13 | 99.55 | 1.21 | 1.20 | 0.53 | 0.89 |

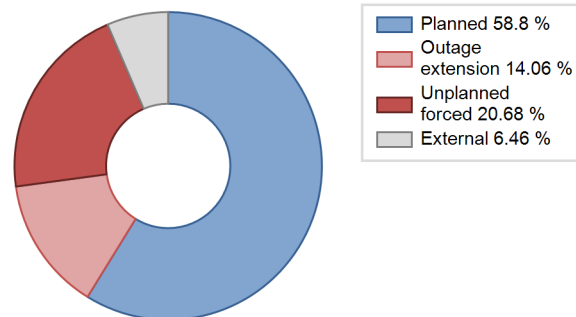
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1995 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 322 | |
| B. Refuelling without maintenance | | | | 22 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 708 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 20 | | |
| E. Testing of plant systems or components | | | | 31 | | |
| J. Grid limitation, failure or grid unavailability | | | 38 | | | 5 |
| L. Human factor related | | | | | 2 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 5 |
| Z. Other | | | | | 42 | |
| Subtotal | | | 38 | 781 | 366 | 10 |
| Total | | 38 | | | 1157 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1995 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 7 |
| 12. Reactor I&C Systems | | 27 |
| 13. Reactor Auxiliary Systems | | 18 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 4 |
| 16. Steam generation systems | | 2 |
| 21. Fuel Handling and Storage Facilities | | 16 |
| 31. Turbine and auxiliaries | | 80 |
| 32. Feedwater and Main Steam System | | 38 |
| 33. Circulating Water System | | 11 |
| 34. Miscellaneous Systems | | 3 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 25 |
| 42. Electrical Power Supply Systems | 38 | 90 |
| Total | 38 | 324 |

2023 Operating Experience

NL-2

BORSSELE

NETHERLANDS, KINGDOM OF THE

Status at end of year : **Operational**
 Operator : EPZ (N.V. ELEKTRICITEITS-PRODUKTIEMAATSCHAPPIJ ZUID-NEDERLAND)
 Owner : EPZ (N.V. ELEKTRICITEITS-PRODUKTIEMAATSCHAPPIJ ZUID-NEDERLAND)
 Reactor Supplier : S/KWU (SIEMENS/KRAFTWERK UNION, AG.)
 Turbine Supplier : S/KWU (SIEMENS/KRAFTWERK UNION, AG.)



Reactor Unit Details

Reactor type and model : PWR / KWU 2LP
 Thermal power : 1366 MWth
 Gross electrical power : 515 MWe
 Reference unit power (net) : 482 MWe

Key Dates

Construction Date : 1969-07-01
 Grid Date : 1973-07-04
 Commercial Date : 1973-10-26
 Age at end of year : 50 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2/MOX
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.4
 Refuelling frequency [month] : 11
 Part of the core refuelled [%] : 23
 Average discharge burnup [MWd/t] : 39000
 Active core diameter [m] : 2.676
 Active core height/length [m] : 2.65
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 20.26
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 313
 Number of SG : 2
 Containment type : -
 Containment design pressure [MPa] : 0.49

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.75
 Output voltage [kV] : 21
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 5

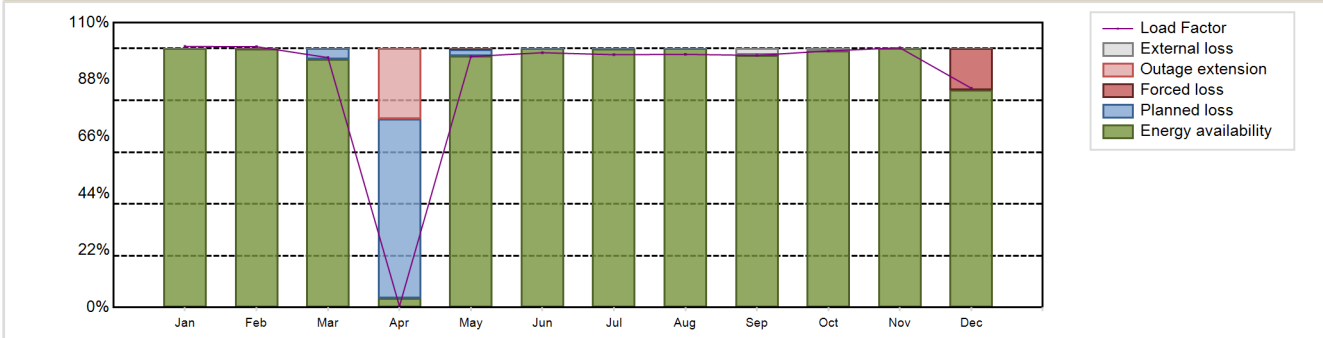
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3771.24 GW(e).h
 Energy Availability Factor (EAF) : 89.83 %
 Unit Capability Factor (UCF) : 90.11 %
 Load Factor (LF) : 89.31 %
 Operating Factor (OF) : 90.8 %

Forced Loss Rate (FLR) : 1.52 %
 Unplanned Capability Loss Factor (UCL) : 3.62 %
 Planned Unavailability Factor (PUF) : 6.27 %
 Externally cause unavailability (XUF) : 0.28 %
 Total off-line time : 806 hours

Annual Summary

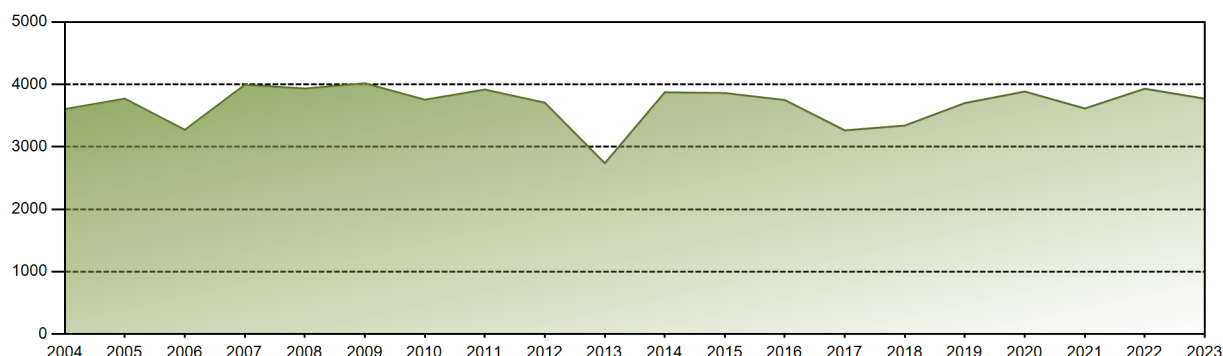


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 361.61 | 326.33 | 346.13 | 1.74 | 347.62 | 341.53 | 350.14 | 350.58 | 337.99 | 355.81 | 348.10 | 303.67 | 3771.24 |
| EAF [%] | 100.00 | 99.96 | 95.95 | 3.62 | 97.18 | 100.00 | 99.86 | 100.00 | 97.39 | 99.09 | 100.00 | 84.01 | 89.83 |
| UCF [%] | 100.00 | 99.96 | 95.95 | 3.62 | 97.18 | 100.00 | 99.86 | 100.00 | 99.83 | 100.00 | 100.00 | 84.01 | 90.11 |
| LF [%] | 100.84 | 100.75 | 96.52 | 0.50 | 96.94 | 98.41 | 97.64 | 97.76 | 97.39 | 99.09 | 100.30 | 84.68 | 89.31 |
| OF [%] | 100.00 | 100.00 | 100.00 | 0.83 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.63 | 90.80 |
| FLR [%] | 0.00 | 0.03 | 0.00 | 0.00 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.99 | 1.52 |
| UCL [%] | 0.00 | 0.03 | 0.00 | 27.11 | 0.41 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.99 | 3.62 |
| PUF [%] | 0.00 | 0.01 | 4.05 | 69.27 | 2.41 | 0.00 | 0.14 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 6.27 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.43 | 0.91 | 0.00 | 0.00 | 0.28 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 171228.64 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.02 % |
| Cumulative Energy Availability Factor (EAF) | : 85.13 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.01 % |
| Cumulative Unit Capability Factor (UCF) | : 85.6 % | Cumulative Planned Unavailability Factor (PUF) | : 10.39 % |
| Cumulative Load Factor (LF) | : 84.76 % | Cumulative Externally cause unavailability (XUF) | : 0.47 % |
| Cumulative Operating Factor (OF) | : 86.42 % | | |

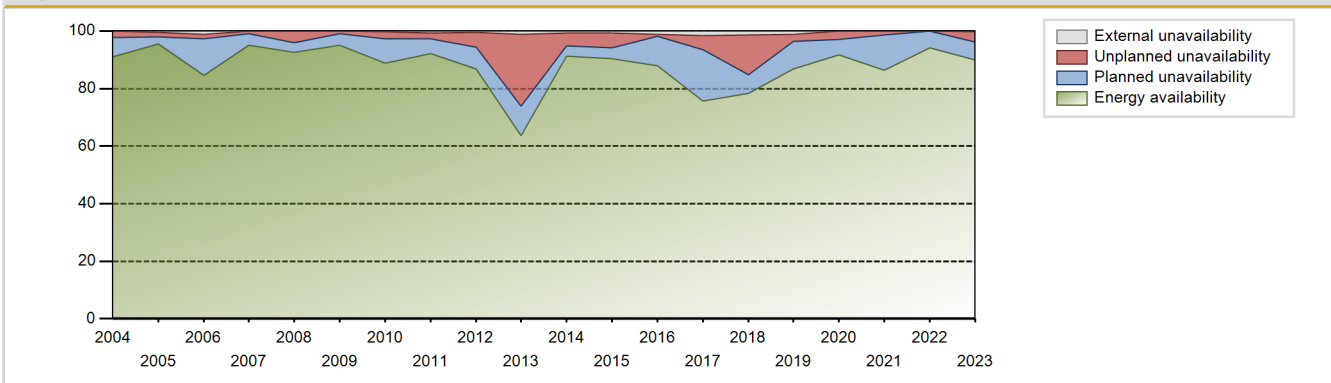
Electricity Production (net) [GWh]



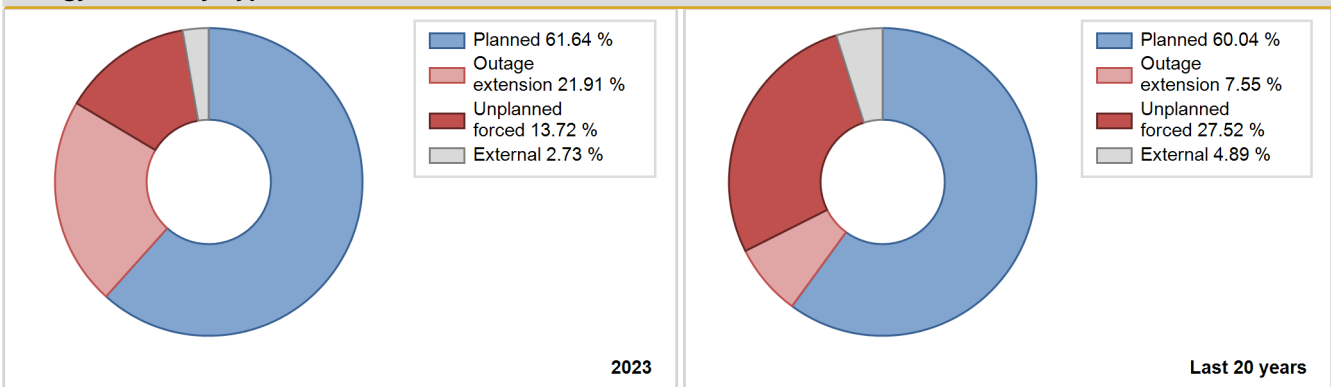
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|-------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1973 | 665.30 | 2682 | 448 | 47.75 | 47.75 | 47.72 | 71.31 | 52.25 | 52.25 | 0.00 | 0.00 |
| 1974 | 2993.70 | 6840 | 477 | 71.63 | 71.63 | 71.64 | 78.08 | 12.52 | 10.25 | 18.12 | 0.00 |
| 1975 | 2776.90 | 6494 | 447 | 70.83 | 70.83 | 70.92 | 74.13 | 4.64 | 3.45 | 25.72 | 0.00 |
| 1976 | 3274.40 | 7521 | 450 | 82.76 | 82.76 | 82.84 | 85.62 | 6.12 | 5.40 | 11.84 | 0.00 |
| 1977 | 3142.40 | 7318 | 450 | 80.38 | 80.38 | 79.72 | 83.54 | 0.00 | 0.00 | 19.62 | 0.00 |
| 1978 | 3424.10 | 7997 | 445 | 88.37 | 88.37 | 87.84 | 91.29 | 0.19 | 0.16 | 11.47 | 0.00 |
| 1979 | 2900.00 | 6785 | 445 | 83.48 | 83.48 | 74.39 | 77.45 | 4.96 | 4.36 | 12.16 | 0.00 |
| 1980 | 3593.00 | 8496 | 447 | 92.85 | 92.85 | 91.51 | 96.72 | 0.00 | 0.00 | 7.15 | 0.00 |
| 1981 | 3048.30 | 7094 | 447 | 78.79 | 78.79 | 77.85 | 80.98 | 0.35 | 0.28 | 20.93 | 0.00 |
| 1982 | 3315.90 | 7489 | 452 | 83.86 | 83.86 | 83.74 | 85.49 | 0.38 | 0.32 | 15.83 | 0.00 |
| 1983 | 3050.00 | 6959 | 452 | 76.92 | 76.92 | 77.03 | 79.44 | 15.15 | 13.73 | 9.35 | 0.00 |
| 1984 | 3062.00 | 6895 | 452 | 76.65 | 76.65 | 77.12 | 78.49 | 11.71 | 10.16 | 13.19 | 0.00 |
| 1985 | 3261.15 | 7299 | 452 | 81.94 | 83.28 | 82.36 | 83.32 | 0.01 | 0.01 | 16.71 | 1.35 |
| 1986 | 3574.00 | 8053 | 452 | 89.93 | 91.58 | 90.26 | 91.93 | 0.69 | 0.64 | 7.78 | 1.65 |
| 1987 | 2950.93 | 6756 | 452 | 74.24 | 76.64 | 74.53 | 77.12 | 5.35 | 4.33 | 19.03 | 2.40 |
| 1988 | 3032.55 | 6763 | 452 | 76.17 | 76.17 | 76.38 | 76.99 | 0.69 | 0.53 | 23.30 | 0.00 |
| 1989 | 3421.85 | 7711 | 452 | 87.05 | 87.05 | 86.42 | 88.03 | 0.83 | 0.73 | 12.22 | 0.00 |
| 1990 | 2885.86 | 6636 | 452 | 74.09 | 74.09 | 72.88 | 75.75 | 0.01 | 0.01 | 25.91 | 0.00 |
| 1991 | 2728.53 | 6221 | 452 | 69.24 | 69.29 | 68.91 | 71.02 | 23.33 | 21.09 | 9.62 | 0.05 |
| 1992 | 2830.34 | 6412 | 452 | 80.59 | 82.86 | 71.29 | 73.00 | 0.66 | 0.55 | 16.59 | 2.27 |
| 1993 | 3328.15 | 7376 | 452 | 83.59 | 84.27 | 84.05 | 84.20 | 6.31 | 5.68 | 10.05 | 0.68 |
| 1994 | 3321.97 | 7489 | 452 | 84.10 | 84.75 | 83.90 | 85.49 | 3.51 | 3.09 | 12.16 | 0.65 |
| 1995 | 3386.75 | 7654 | 452 | 86.84 | 87.08 | 85.53 | 87.37 | 5.56 | 5.13 | 7.79 | 0.25 |
| 1996 | 3520.28 | 7978 | 452 | 88.15 | 88.27 | 88.66 | 90.82 | 2.91 | 2.64 | 9.09 | 0.12 |
| 1997 | Data not provided | | | | | | | | | | |
| 1998 | " | | | | | | | | | | |
| 1999 | 3604.20 | 8363 | 449 | 94.19 | 94.19 | 91.63 | 95.47 | 0.94 | 0.89 | 4.91 | 0.00 |
| 2000 | 3698.96 | 8262 | 449 | 93.09 | 93.89 | 93.79 | 94.06 | 2.38 | 2.29 | 3.82 | 0.80 |
| 2001 | 3746.67 | 8404 | 449 | 94.61 | 94.61 | 95.26 | 95.94 | 0.21 | 0.20 | 5.19 | 0.00 |
| 2002 | 3686.89 | 8284 | 450 | 93.36 | 93.80 | 93.53 | 94.57 | 0.10 | 1.23 | 4.97 | 0.44 |
| 2003 | 3788.31 | 8431 | 450 | 95.31 | 95.31 | 96.10 | 96.24 | 1.09 | 1.44 | 3.25 | 0.00 |
| 2004 | 3604.69 | 8073 | 450 | 91.09 | 91.09 | 91.19 | 91.91 | 1.19 | 2.26 | 6.65 | 0.00 |
| 2005 | 3771.93 | 8430 | 450 | 95.49 | 95.92 | 95.69 | 96.23 | 1.65 | 1.61 | 2.47 | 0.43 |
| 2006 | 3272.61 | 7542 | 482 | 84.57 | 85.70 | 82.52 | 86.10 | 1.72 | 1.50 | 12.80 | 1.14 |
| 2007 | 3993.87 | 8346 | 482 | 95.12 | 95.23 | 94.59 | 95.27 | 0.34 | 0.78 | 3.99 | 0.11 |
| 2008 | 3933.64 | 8161 | 482 | 92.55 | 92.55 | 92.91 | 92.91 | 0.04 | 4.14 | 3.31 | 0.00 |
| 2009 | 4017.67 | 8352 | 482 | 95.08 | 95.13 | 95.15 | 95.34 | 0.92 | 0.90 | 3.96 | 0.05 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2010 | 3754.88 | 7807 | 482 | 88.86 | 89.09 | 88.93 | 89.12 | 1.78 | 2.55 | 8.36 | 0.23 |
| 2011 | 3917.24 | 8092 | 482 | 92.08 | 92.86 | 92.77 | 92.37 | 1.53 | 1.89 | 5.25 | 0.78 |
| 2012 | 3706.68 | 7722 | 482 | 86.89 | 87.43 | 87.55 | 87.91 | 5.52 | 5.10 | 7.47 | 0.54 |
| 2013 | 2736.93 | 5737 | 482 | 63.71 | 64.84 | 64.81 | 65.48 | 26.51 | 25.02 | 10.15 | 1.12 |
| 2014 | 3873.51 | 8054 | 482 | 91.18 | 91.95 | 91.75 | 91.95 | 1.23 | 4.35 | 3.70 | 0.77 |
| 2015 | 3861.63 | 8020 | 482 | 90.48 | 91.27 | 91.47 | 91.56 | 3.86 | 5.03 | 3.70 | 0.78 |
| 2016 | 3749.81 | 7836 | 482 | 87.85 | 89.11 | 88.58 | 89.22 | 0.63 | 0.67 | 10.22 | 1.26 |
| 2017 | 3263.18 | 6672 | 482 | 75.60 | 77.23 | 77.28 | 76.16 | 5.93 | 4.87 | 17.90 | 1.63 |
| 2018 | 3340.53 | 6997 | 482 | 78.30 | 79.70 | 79.13 | 79.88 | 12.43 | 13.88 | 6.41 | 1.41 |
| 2019 | 3700.71 | 7769 | 482 | 86.84 | 88.05 | 87.66 | 88.70 | 2.64 | 2.39 | 9.56 | 1.22 |
| 2020 | 3885.68 | 8100 | 482 | 91.69 | 91.79 | 91.78 | 92.21 | 2.93 | 2.77 | 5.44 | 0.10 |
| 2021 | 3614.16 | 7956 | 482 | 86.45 | 86.45 | 85.60 | 90.82 | 1.48 | 1.30 | 12.24 | 0.00 |
| 2022 | 3930.57 | 8265 | 482 | 94.13 | 94.13 | 93.10 | 94.36 | 0.03 | 0.02 | 5.85 | 0.00 |
| 2023 | 3771.24 | 7955 | 482 | 89.83 | 90.11 | 89.31 | 90.80 | 1.52 | 3.62 | 6.27 | 0.28 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1973 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 290 | | | 225 | |
| B. Refuelling without maintenance | | | | 21 | | |
| C. Inspection, maintenance or repair combined with refuelling | 517 | | | 715 | 19 | |
| D. Inspection, maintenance or repair without refuelling | | | | 38 | | |
| E. Testing of plant systems or components | | | | | 18 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 21 | | |
| H. Nuclear regulatory requirements | | | | | 2 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 4 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| Z. Other | | | | 13 | 3 | |
| Subtotal | 517 | 290 | | 808 | 271 | 6 |
| Total | | 807 | | | 1085 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1973 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 30 |
| 13. Reactor Auxiliary Systems | 197 | 10 |
| 14. Safety Systems | | 26 |
| 15. Reactor Cooling Systems | | 19 |
| 16. Steam generation systems | | 29 |
| 31. Turbine and auxiliaries | | 18 |
| 32. Feedwater and Main Steam System | | 27 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | | 22 |
| 41. Main Generator Systems | 93 | 42 |
| 42. Electrical Power Supply Systems | | 17 |
| Total | 290 | 249 |

2023 Operating Experience

PK-2

CHASNUPP-1

PAKISTAN

Status at end of year : **Operational**
 Operator : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Owner : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Reactor Supplier : CNNC (CHINA NATIONAL NUCLEAR CORPORATION)
 Turbine Supplier : STW (Shanghai Turbine Works)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-----------------|--------------------|--------------|
| Reactor type and model | : PWR / CNP-300 | Construction Date | : 1993-08-01 |
| Thermal power | : 999 MWth | Grid Date | : 2000-06-13 |
| Gross electrical power | : 325 MWe | Commercial Date | : 2000-09-15 |
| Reference unit power (net) | : 300 MWe | Age at end of year | : 23 years |

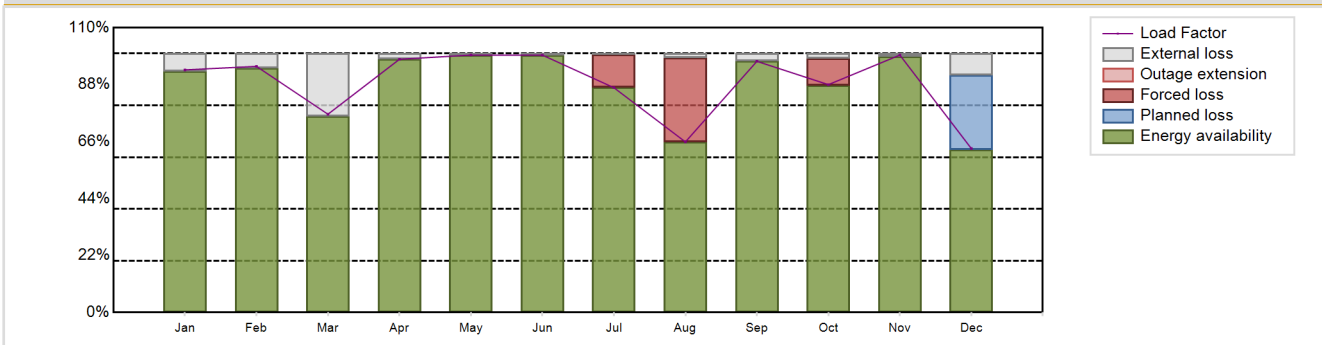
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|------------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.2 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 315.5 |
| Refuelling type | : OFF-line | Number of SG | : 2 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 3.4 | Containment design pressure [MPa] | : 0.26 |
| Refuelling frequency [month] | : 14 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 30000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 2.486 | Number of LP cylinders per turbine | : 2 |
| Active core height/length [m] | : 2.9 | HP cylinder inlet steam pressure [MPa] | : 5.34 |
| Number of fissile fuel assemblies/bundles | : 121 | Output voltage [kV] | : 20 |
| Fuel linear heat generation rate [kW/m] | : 13.59 | Primary means of condenser cooling | : River (once-through) |
| Number of control rod assemblies | : 37 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 2322.68 GW(e).h | Forced Loss Rate (FLR) | : 4.86 % |
| Energy Availability Factor (EAF) | : 88.11 % | Unplanned Capability Loss Factor (UCL) | : 4.74 % |
| Unit Capability Factor (UCF) | : 92.8 % | Planned Unavailability Factor (PUF) | : 2.45 % |
| Load Factor (LF) | : 88.38 % | Externally cause unavailability (XUF) | : 4.7 % |
| Operating Factor (OF) | : 92.82 % | Total off-line time | : 629 hours |

Annual Summary

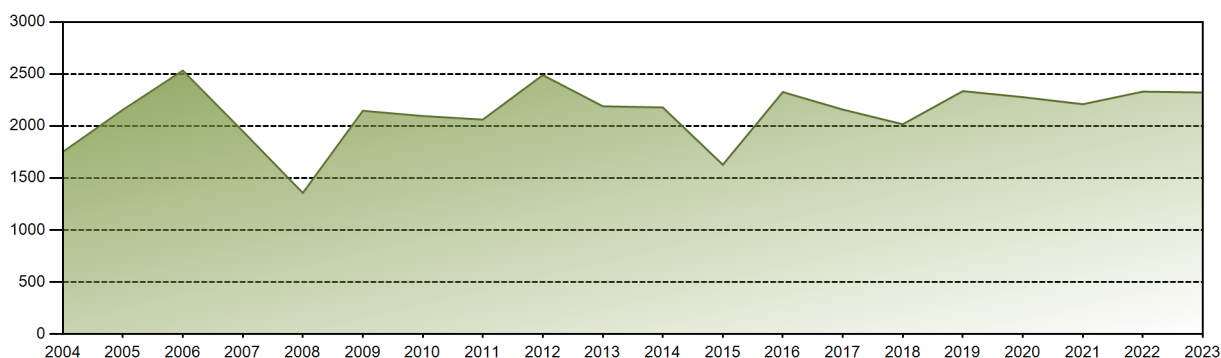


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 209.17 | 191.63 | 170.94 | 211.26 | 221.93 | 214.74 | 193.82 | 147.08 | 209.55 | 196.44 | 214.77 | 141.35 | 2322.68 |
| EAF [%] | 93.12 | 94.45 | 75.75 | 97.81 | 99.43 | 99.41 | 86.84 | 65.90 | 97.01 | 87.66 | 98.93 | 62.89 | 88.11 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.15 | 67.53 | 100.00 | 89.48 | 100.00 | 71.11 | 92.80 |
| LF [%] | 93.71 | 95.06 | 76.59 | 97.81 | 99.43 | 99.41 | 86.84 | 65.90 | 97.01 | 88.01 | 99.43 | 63.33 | 88.38 |
| OF [%] | 95.30 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.04 | 68.82 | 100.00 | 91.80 | 99.72 | 71.77 | 92.82 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.85 | 32.47 | 0.00 | 10.52 | 0.00 | 0.00 | 4.86 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.85 | 32.47 | 0.00 | 10.52 | 0.00 | 0.00 | 4.74 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 28.89 | 2.45 |
| XUF [%] | 6.88 | 5.55 | 24.25 | 2.19 | 0.57 | 0.59 | 0.32 | 1.63 | 2.99 | 1.82 | 1.07 | 8.22 | 4.70 |

Historical Summary

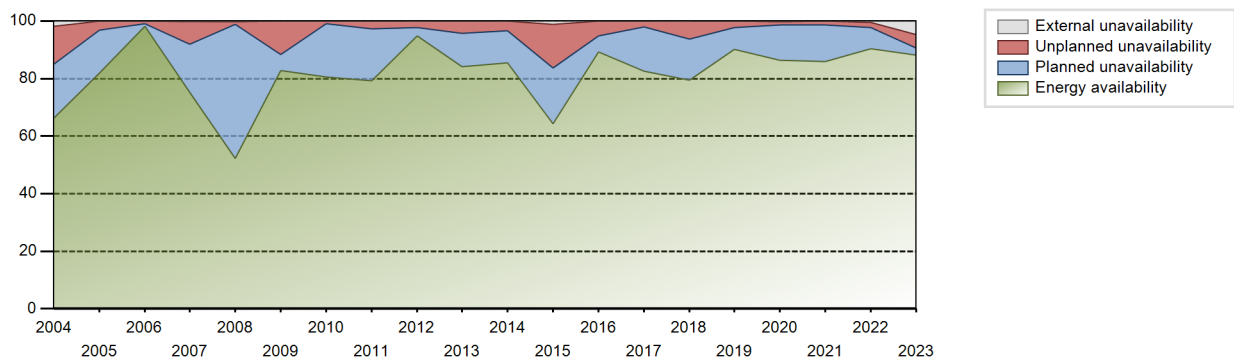
| | | | | | |
|---|---|------------------|---|---|---------|
| Lifetime energy generation | : | 47998.31 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 6.62 % |
| Cumulative Energy Availability Factor (EAF) | : | 78.99 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 7.48 % |
| Cumulative Unit Capability Factor (UCF) | : | 79.55 % | Cumulative Planned Unavailability Factor (PUF) | : | 12.97 % |
| Cumulative Load Factor (LF) | : | 78.02 % | Cumulative Externally cause unavailability (XUF) | : | 0.56 % |
| Cumulative Operating Factor (OF) | : | 81.05 % | | | |

Electricity Production (net) [GWh]

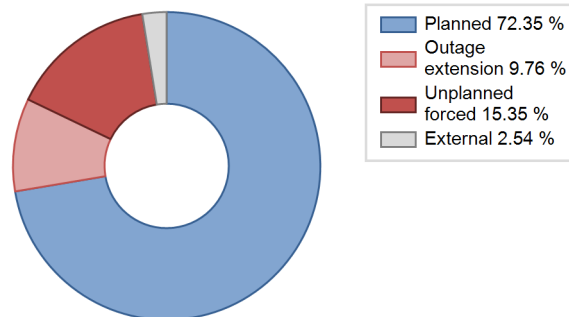
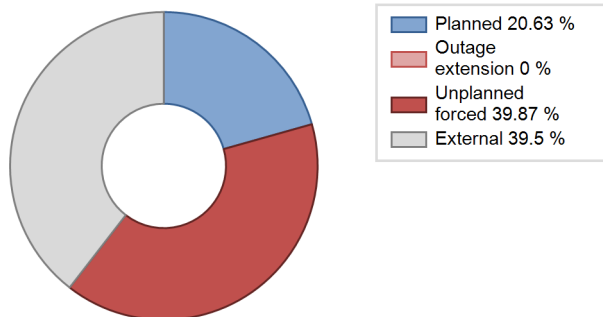


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2000 | 529.15 | 1860 | 300 | 72.19 | 72.19 | 68.69 | 72.43 | 19.54 | 17.53 | 10.28 | 0.00 |
| 2001 | 1581.75 | 5918 | 300 | 60.06 | 62.44 | 60.19 | 67.56 | 37.40 | 37.31 | 0.25 | 2.38 |
| 2002 | 1356.00 | 4790 | 300 | 52.25 | 53.69 | 51.60 | 54.68 | 20.87 | 16.73 | 29.58 | 1.44 |
| 2003 | 1809.80 | 6879 | 300 | 68.85 | 68.85 | 68.87 | 78.53 | 21.84 | 24.04 | 7.11 | 0.00 |
| 2004 | 1750.71 | 5949 | 300 | 66.35 | 68.12 | 66.44 | 67.73 | 4.20 | 13.12 | 18.76 | 1.77 |
| 2005 | 2155.19 | 7458 | 300 | 81.92 | 81.92 | 82.01 | 85.14 | 3.83 | 3.26 | 14.82 | 0.00 |
| 2006 | 2532.91 | 8569 | 300 | 98.19 | 98.19 | 96.38 | 97.82 | 0.91 | 0.90 | 0.91 | 0.00 |
| 2007 | 1949.13 | 6669 | 300 | 75.22 | 75.55 | 74.17 | 76.13 | 2.98 | 7.76 | 16.69 | 0.33 |
| 2008 | 1356.45 | 4795 | 300 | 52.25 | 52.40 | 51.47 | 54.59 | 1.70 | 0.90 | 46.69 | 0.15 |
| 2009 | 2145.87 | 7379 | 300 | 82.80 | 82.82 | 81.65 | 84.24 | 10.86 | 11.69 | 5.49 | 0.02 |
| 2010 | 2095.76 | 7160 | 300 | 80.66 | 80.66 | 79.75 | 81.74 | 0.96 | 0.96 | 18.37 | 0.00 |
| 2011 | 2061.67 | 7008 | 300 | 79.31 | 79.31 | 78.45 | 80.00 | 3.04 | 2.83 | 17.87 | 0.00 |
| 2012 | 2489.25 | 8370 | 300 | 94.74 | 94.79 | 94.46 | 95.29 | 2.34 | 2.27 | 2.94 | 0.05 |
| 2013 | 2189.64 | 7481 | 300 | 84.04 | 84.04 | 83.32 | 85.40 | 4.53 | 4.38 | 11.59 | 0.00 |
| 2014 | 2178.22 | 7434 | 300 | 85.57 | 85.61 | 82.89 | 84.86 | 3.64 | 3.23 | 11.16 | 0.04 |
| 2015 | 1627.53 | 5831 | 300 | 64.28 | 65.44 | 61.93 | 66.56 | 3.33 | 15.04 | 19.52 | 1.17 |
| 2016 | 2326.46 | 8291 | 300 | 89.27 | 89.27 | 88.28 | 94.39 | 0.82 | 5.23 | 5.50 | 0.00 |
| 2017 | 2157.86 | 7391 | 300 | 82.53 | 82.55 | 82.11 | 84.37 | 2.48 | 2.10 | 15.36 | 0.01 |
| 2018 | 2017.02 | 6950 | 300 | 79.42 | 79.52 | 76.75 | 79.34 | 7.15 | 6.12 | 14.36 | 0.10 |
| 2019 | 2335.20 | 7907 | 300 | 90.23 | 90.33 | 88.86 | 90.26 | 2.44 | 2.26 | 7.41 | 0.10 |
| 2020 | 2277.56 | 7682 | 300 | 86.43 | 86.65 | 86.43 | 87.45 | 1.31 | 1.15 | 12.20 | 0.22 |
| 2021 | 2209.57 | 7546 | 300 | 85.84 | 85.89 | 84.08 | 86.14 | 1.46 | 1.27 | 12.84 | 0.05 |
| 2022 | 2330.60 | 8020 | 300 | 90.46 | 90.99 | 88.68 | 91.55 | 1.92 | 1.78 | 7.23 | 0.53 |
| 2023 | 2322.68 | 8131 | 300 | 88.11 | 92.80 | 88.38 | 92.82 | 4.86 | 4.74 | 2.45 | 4.70 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2000 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 382 | | | 486 | |
| C. Inspection, maintenance or repair combined with refuelling | 210 | | | 990 | 6 | |
| D. Inspection, maintenance or repair without refuelling | | | | 58 | | |
| E. Testing of plant systems or components | | | | 3 | 1 | |
| J. Grid limitation, failure or grid unavailability | | | 37 | | | 86 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 13 |
| L. Human factor related | | | | | 5 | |
| P. Fire | | | | | 5 | |
| Z. Other | | | | | 20 | |
| Subtotal | 210 | 382 | 37 | 1051 | 523 | 99 |
| Total | | 629 | | | 1673 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2000 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 38 |
| 12. Reactor I&C Systems | 61 | 26 |
| 13. Reactor Auxiliary Systems | | 7 |
| 14. Safety Systems | | 36 |
| 15. Reactor Cooling Systems | | 109 |
| 16. Steam generation systems | | 6 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 124 |
| 32. Feedwater and Main Steam System | 321 | 40 |
| 33. Circulating Water System | | 7 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 31 |
| 42. Electrical Power Supply Systems | | 89 |
| Total | 382 | 517 |

Highlights (2023)

2023 Q1

--- Plant remained critical for 85.33 days.
 --- Plant was started on 02-01-2022 after Manual shutdown (on 29-12-2022) due to abnormal degradation of Condenser Vacuum.
 --- Plant faced 02 automatic scrams while critical:

- 1) Reactor tripped on SG-A Hi Hi level signal due to malfunctioning of SMF-V03A. (January 18, 2022, 15:46 Hrs.)
- 2) Reactor tripped on RCP-B (SRC-004BRP) tripping. (March 30, 2022, 00:32 Hrs.)

2023 Q2

--- Plant remained critical for 91.0 days.

2023 Q3

--- Plant remained critical for 78.87 days.
 --- Plant faced Spurious Activation of the Containment Spray and Containment Phase-B Isolation during Monthly Functional Test of Reactor Protection and Engineering Safeguard System test of Channel B1 on July 27th, 2023 (1117 Hrs.).
 --- Plant faced 01 automatic scrams while critical: 1) Reactor tripped on Steam Generator (SG-B) Level Hi-Hi due to malfunction of SG-B level control. (July 28th, 2023, 06:42 Hrs.)

2023 Q4

--- Plant remained critical for 81.03 days.
 --- Plant faced power reduction and manual shutdown due to problem in control rod drive mechanism (A1-2 dropped to zero position) on October 6th, 2023 (21:05 Hrs.).
 --- Plant faced House load at over frequency of Grid on November 21st, 2023 (00:58 Hrs.).
 --- Plant entered in Refueling Outage (RFO-16) on December 23rd, 2023 (05:38 Hrs.).

2023 Operating Experience

PK-3

CHASNUPP-2

PAKISTAN

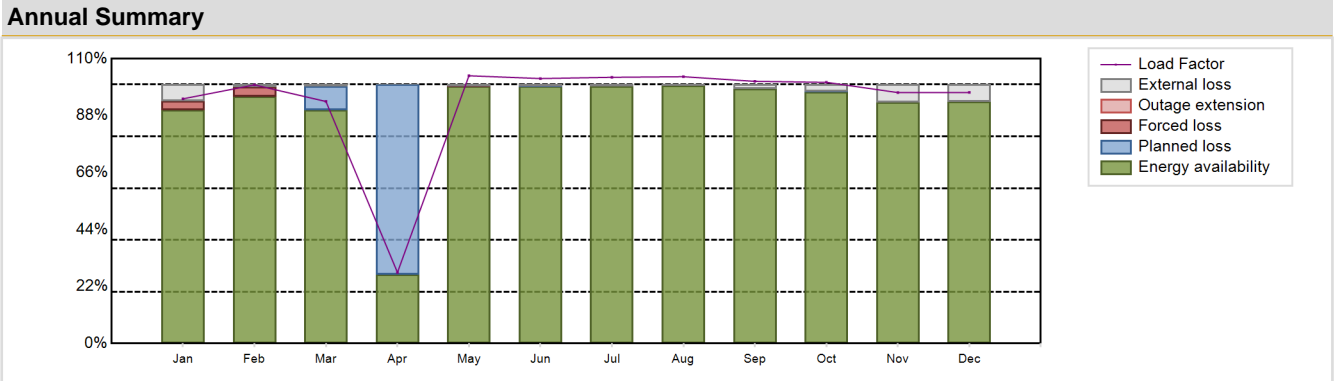
Status at end of year : **Operational**
 Operator : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Owner : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Reactor Supplier : CNNC (CHINA NATIONAL NUCLEAR CORPORATION)
 Turbine Supplier : STC (Shanghai Turbine Co.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-----------------|--------------------|--------------|
| Reactor type and model | : PWR / CNP-300 | Construction Date | : 2005-12-28 |
| Thermal power | : 999 MWth | Grid Date | : 2011-03-14 |
| Gross electrical power | : 325 MWe | Commercial Date | : 2011-05-18 |
| Reference unit power (net) | : 300 MWe | Age at end of year | : 12 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.2 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 315.5 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.26 |
| Average fuel enrichment [% of U235] | : 3.4 | Secondary systems | |
| Refuelling frequency [month] | : 14 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 32000 | Number of LP cylinders per turbine | : 2 |
| Active core diameter [m] | : 2.486 | HP cylinder inlet steam pressure [MPa] | : 5.34 |
| Active core height/length [m] | : 2.9 | Output voltage [kV] | : 20 |
| Number of fissile fuel assemblies/bundles | : 121 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 13.59 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 37 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------|--|----------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0.6 % |
| Energy Availability Factor (EAF) | : 90.3 % | Unplanned Capability Loss Factor (UCL) | : 0.56 % |
| Unit Capability Factor (UCF) | : 92.63 % | Planned Unavailability Factor (PUF) | : 6.81 % |
| Load Factor (LF) | : 93.65 % | Externally cause unavailability (XUF) | : 2.33 % |
| Operating Factor (OF) | : 92.97 % | Total off-line time | : hours |

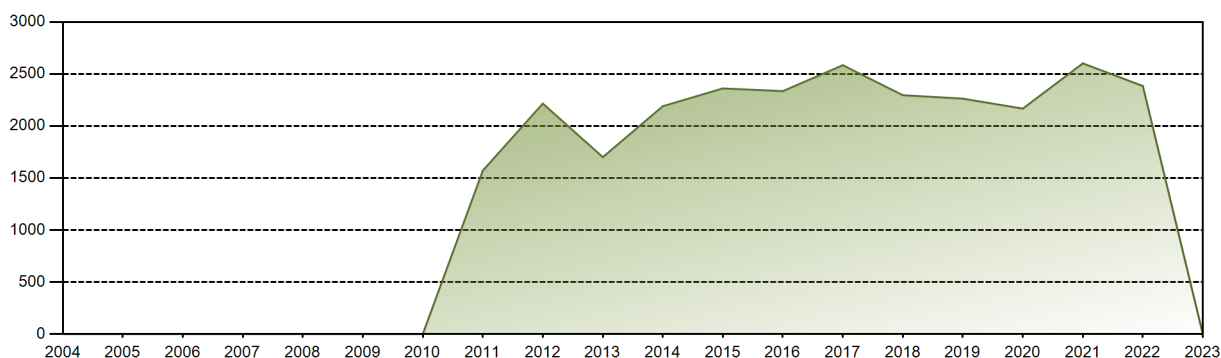


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 210.95 | 201.35 | 208.65 | 59.27 | 230.79 | 221.03 | 229.50 | 230.02 | 218.69 | 225.17 | 209.33 | 216.38 | 2461.13 |
| EAF [%] | 90.26 | 95.50 | 90.18 | 26.77 | 99.47 | 99.45 | 99.33 | 99.53 | 98.45 | 97.22 | 93.06 | 93.52 | 90.30 |
| UCF [%] | 96.61 | 96.50 | 90.87 | 26.77 | 99.99 | 99.98 | 100.00 | 100.00 | 100.00 | 99.85 | 100.00 | 100.00 | 92.63 |
| LF [%] | 94.51 | 99.87 | 93.48 | 27.44 | 103.40 | 102.33 | 102.82 | 103.05 | 101.25 | 100.88 | 96.91 | 96.95 | 93.65 |
| OF [%] | 92.74 | 100.00 | 91.67 | 30.83 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.72 | 100.00 | 92.97 |
| FLR [%] | 3.39 | 3.50 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 |
| UCL [%] | 3.39 | 3.50 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.56 |
| PUF [%] | 0.00 | 0.00 | 9.13 | 73.23 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 | 6.81 |
| XUF [%] | 6.36 | 1.00 | 0.68 | 0.00 | 0.52 | 0.54 | 0.67 | 0.47 | 1.55 | 2.63 | 6.94 | 6.48 | 2.33 |

Historical Summary

| | | | | | |
|---|---|-----------|---|---|--------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 3.08 % |
| Cumulative Energy Availability Factor (EAF) | : | 86.87 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 3.53 % |
| Cumulative Unit Capability Factor (UCF) | : | 87.31 % | Cumulative Planned Unavailability Factor (PUF) | : | 9.16 % |
| Cumulative Load Factor (LF) | : | 87.25 % | Cumulative Externally cause unavailability (XUF) | : | 0.44 % |
| Cumulative Operating Factor (OF) | : | 88.32 % | | | |

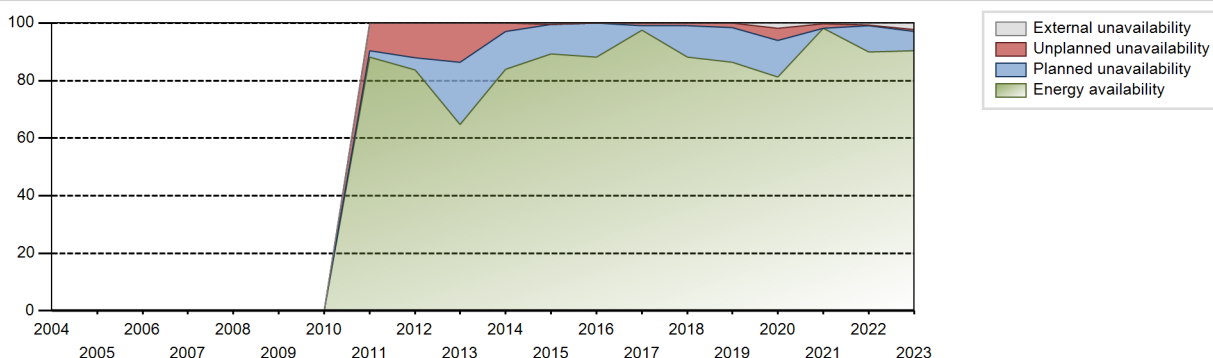
Electricity Production (net) [GWh]



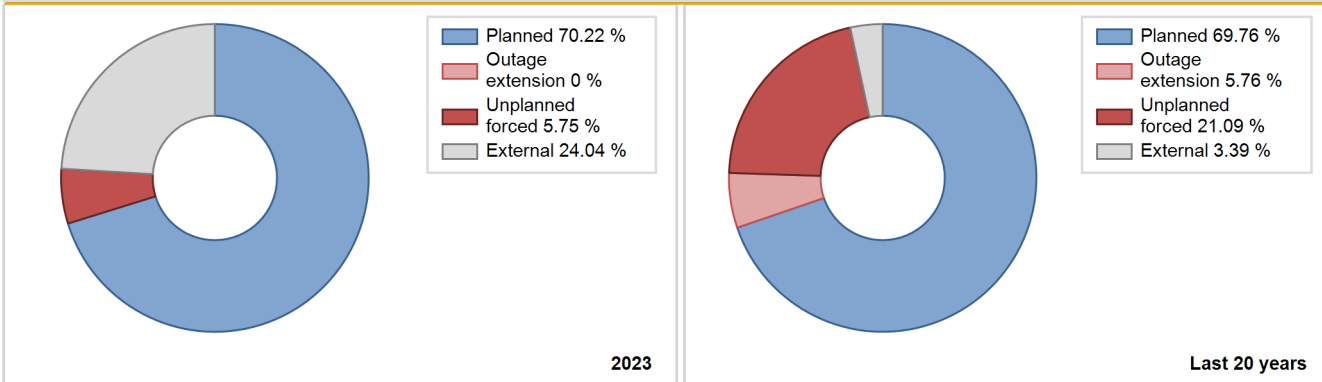
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF | | |
|------|------------------|---------------------------|---------------------------------|-------------------|-------|-------|-------|-------|-------|-------|------|-----|--|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | |
| 2011 | 1570.98 | 5766 | 300 | 88.25 | 88.25 | 85.28 | 86.94 | 7.81 | 9.56 | 2.19 | 0.00 | | |
| 2012 | 2215.76 | 7864 | 300 | 83.74 | 83.77 | 84.08 | 89.53 | 12.44 | 11.96 | 4.27 | 0.03 | | |
| 2013 | 1700.82 | 6308 | 300 | 64.68 | 64.68 | 64.72 | 72.01 | 7.80 | 13.73 | 21.59 | 0.00 | | |
| 2014 | 2190.36 | 7546 | 300 | 83.93 | 83.93 | 83.35 | 86.14 | 3.49 | 3.04 | 13.03 | 0.00 | | |
| 2015 | 2361.48 | 7855 | 300 | 89.21 | 89.74 | 89.86 | 89.67 | 0.02 | 0.02 | 10.24 | 0.54 | | |
| 2016 | 2335.43 | 7718 | 300 | 88.18 | 88.18 | 88.62 | 87.86 | 0.00 | 0.00 | 11.82 | 0.00 | | |
| 2017 | 2584.57 | 8520 | 300 | 97.61 | 97.61 | 98.35 | 97.26 | 0.87 | 0.86 | 1.53 | 0.00 | | |
| 2018 | 2296.39 | 7679 | 300 | 88.15 | 88.16 | 87.38 | 87.66 | 1.05 | 0.94 | 10.91 | 0.00 | | |
| 2019 | 2263.06 | 7573 | 300 | 86.37 | 86.41 | 86.11 | 86.45 | 1.79 | 1.57 | 12.02 | 0.04 | | |
| 2020 | 2167.47 | 7379 | 300 | 81.33 | 83.13 | 82.25 | 84.01 | 4.82 | 4.21 | 12.66 | 1.80 | | |
| 2021 | 2602.18 | 8493 | 300 | 98.19 | 98.41 | 99.02 | 96.95 | 1.54 | 1.54 | 0.05 | 0.22 | | |
| 2022 | 2384.89 | 7902 | 300 | 89.90 | 90.53 | 90.75 | 90.21 | 0.39 | 0.35 | 9.12 | 0.63 | | |
| 2023 | | | | Data not provided | | | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2011 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 19 | | | 269 | |
| C. Inspection, maintenance or repair combined with refuelling | 561 | | | 687 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 9 | | |
| J. Grid limitation, failure or grid unavailability | | | 37 | | | 72 |
| Subtotal | 561 | 19 | 37 | 696 | 269 | 72 |
| Total | | 617 | | | 1037 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2011 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 25 |
| 15. Reactor Cooling Systems | | 66 |
| 16. Steam generation systems | 19 | 16 |
| 31. Turbine and auxiliaries | | 41 |
| 32. Feedwater and Main Steam System | | 10 |
| 33. Circulating Water System | | 3 |
| 41. Main Generator Systems | | 41 |
| 42. Electrical Power Supply Systems | | 62 |
| Total | 19 | 264 |

2023 Operating Experience

PK-4

CHASNUPP-3

PAKISTAN

Status at end of year : **Operational**
 Operator : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Owner : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Reactor Supplier : CNNC (CHINA NATIONAL NUCLEAR CORPORATION)
 Turbine Supplier : STC (Shanghai Turbine Co.)



Reactor Unit Details

Reactor type and model : PWR / CNP-300
 Thermal power : 999 MWth
 Gross electrical power : 340 MWe
 Reference unit power (net) : 315 MWe

Key Dates

Construction Date : 2011-05-28
 Grid Date : 2016-10-15
 Commercial Date : 2016-12-06
 Age at end of year : 7 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.4
 Refuelling frequency [month] : 14
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 32000
 Active core diameter [m] : 2.486
 Active core height/length [m] : 2.9
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 13.59
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.2
 Reactor outlet temperature [°C] : 315.5
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.26

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 5.34
 Output voltage [kV] : 20
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

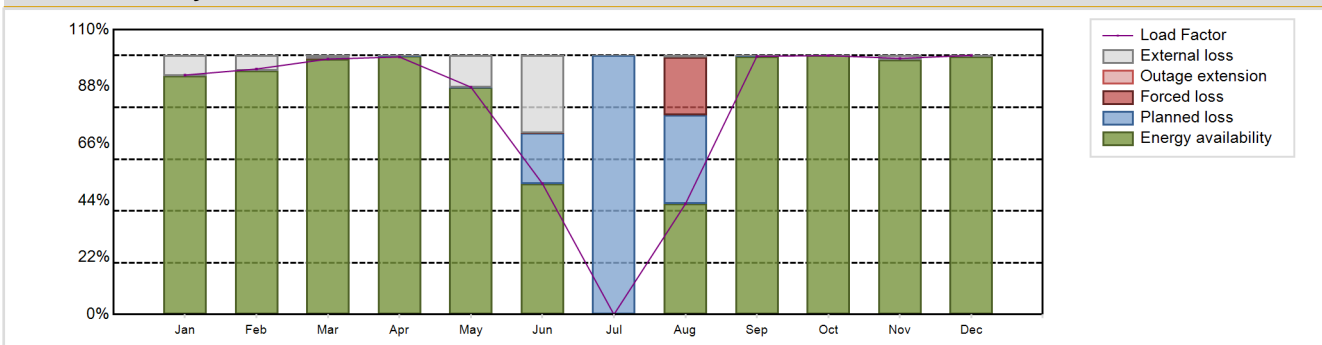
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 0 GW(e).h
 Energy Availability Factor (EAF) : 80.12 %
 Unit Capability Factor (UCF) : 85.07 %
 Load Factor (LF) : 80.24 %
 Operating Factor (OF) : 85.47 %
 Forced Loss Rate (FLR) : 2.19 %
 Unplanned Capability Loss Factor (UCL) : 1.9 %
 Planned Unavailability Factor (PUF) : 13.02 %
 Externally cause unavailability (XUF) : 4.96 %
 Total off-line time : hours

Annual Summary

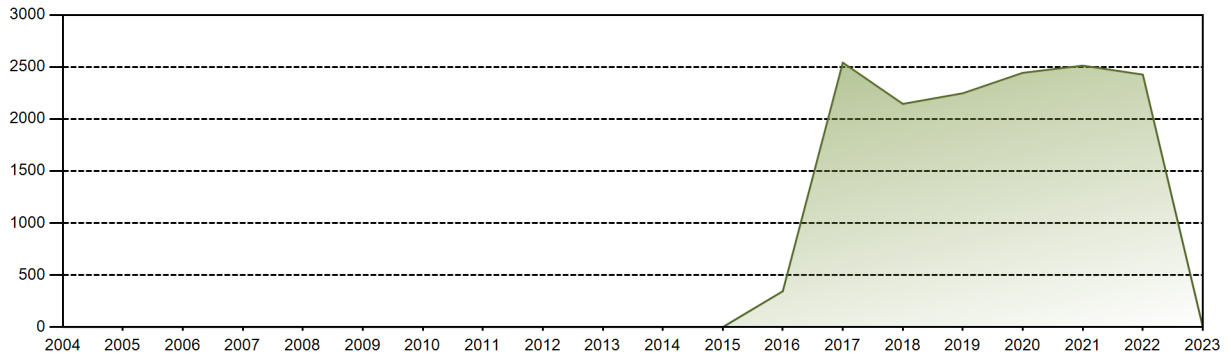


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 216.72 | 200.70 | 231.21 | 225.59 | 205.79 | 114.65 | 0.00 | 100.04 | 226.19 | 234.36 | 224.36 | 234.53 | 2214.14 |
| EAF [%] | 92.09 | 94.19 | 98.66 | 99.82 | 87.81 | 50.55 | 0.00 | 42.68 | 99.73 | 100.00 | 98.43 | 99.70 | 80.12 |
| UCF [%] | 100.00 | 100.00 | 99.89 | 99.99 | 99.99 | 80.41 | 0.00 | 43.38 | 99.96 | 100.00 | 100.00 | 100.00 | 85.07 |
| LF [%] | 92.47 | 94.81 | 98.66 | 99.47 | 87.81 | 50.55 | 0.00 | 42.68 | 99.73 | 100.00 | 98.92 | 100.07 | 80.24 |
| OF [%] | 95.16 | 100.00 | 100.00 | 100.00 | 100.00 | 81.25 | 0.00 | 52.15 | 100.00 | 100.00 | 99.72 | 100.00 | 85.47 |
| FLR [%] | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 33.96 | 0.00 | 0.00 | 0.00 | 0.00 | 2.19 |
| UCL [%] | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 22.31 | 0.00 | 0.00 | 0.00 | 0.00 | 1.90 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 19.59 | 100.00 | 34.31 | 0.04 | 0.00 | 0.00 | 0.00 | 13.02 |
| XUF [%] | 7.91 | 5.81 | 1.23 | 0.17 | 12.18 | 29.86 | 0.00 | 0.70 | 0.22 | 0.00 | 1.57 | 0.30 | 4.96 |

Historical Summary

| | | | |
|---|-------------|---|----------|
| Lifetime energy generation | : 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.39 % |
| Cumulative Energy Availability Factor (EAF) | : 88.21 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.27 % |
| Cumulative Unit Capability Factor (UCF) | : 89.67 % | Cumulative Planned Unavailability Factor (PUF) | : 9.06 % |
| Cumulative Load Factor (LF) | : 85.71 % | Cumulative Externally cause unavailability (XUF) | : 1.46 % |
| Cumulative Operating Factor (OF) | : 89.87 % | | |

Electricity Production (net) [GWh]

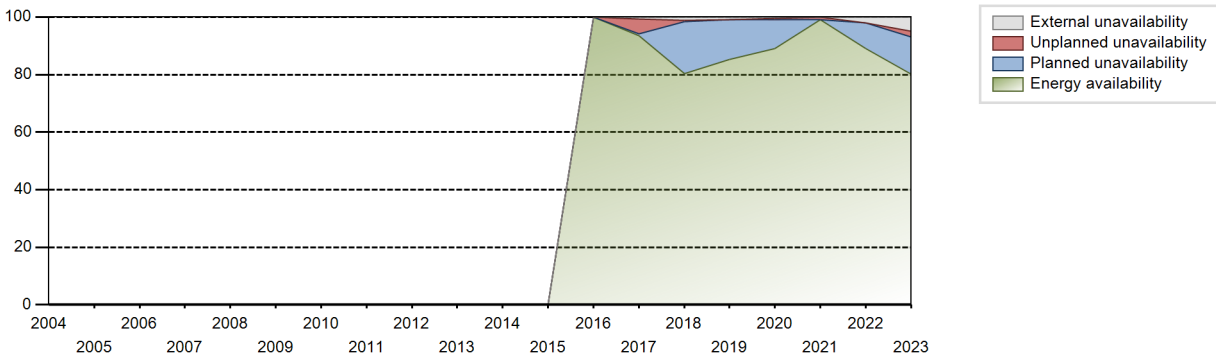


Performance for Years of Commercial Operation

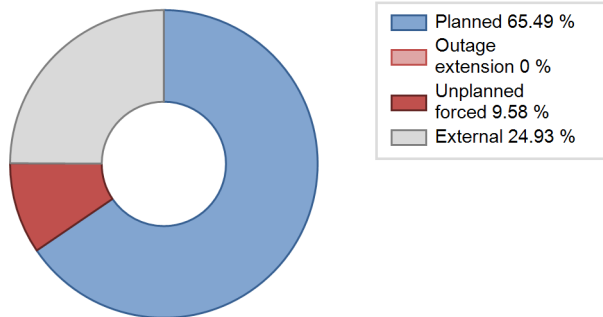
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 344.98 | 1436 | 315 | 100.00 | 100.00 | 97.84 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 2542.08 | 8256 | 315 | 93.53 | 94.13 | 92.12 | 94.25 | 5.36 | 5.33 | 0.54 | 0.60 |
| 2018 | 2145.22 | 7152 | 315 | 80.37 | 81.52 | 77.74 | 81.64 | 0.66 | 0.54 | 17.94 | 1.16 |
| 2019 | 2247.57 | 7508 | 315 | 85.26 | 86.16 | 81.45 | 85.71 | 0.00 | 0.00 | 13.84 | 0.90 |
| 2020 | 2444.19 | 7931 | 315 | 89.15 | 89.70 | 88.33 | 90.29 | 0.49 | 0.44 | 9.86 | 0.55 |
| 2021 | 2513.45 | 8649 | 315 | 99.02 | 99.16 | 91.09 | 98.73 | 0.73 | 0.73 | 0.11 | 0.14 |
| 2022 | 2426.79 | 8071 | 315 | 89.05 | 91.08 | 87.95 | 92.13 | 0.04 | 0.03 | 8.88 | 2.03 |
| 2023 | | | | | | | | | | | |

Data not provided

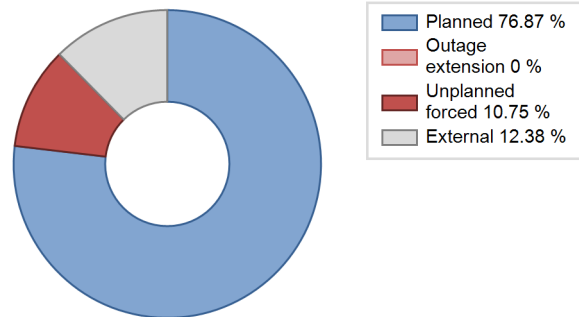
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 137 | | | 97 | |
| C. Inspection, maintenance or repair combined with refuelling | 1099 | | | 748 | | |
| J. Grid limitation, failure or grid unavailability | | | 38 | | | 48 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 7 |
| Subtotal | 1099 | 137 | 38 | 748 | 97 | 55 |
| Total | | 1274 | | | 900 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 24 |
| 15. Reactor Cooling Systems | | | | 5 |
| 16. Steam generation systems | | | | 39 |
| 31. Turbine and auxiliaries | | | 137 | 25 |
| 33. Circulating Water System | | | | 4 |
| Total | | | 137 | 97 |

2023 Operating Experience

PK-5

CHASNUPP-4

PAKISTAN

Status at end of year : **Operational**
 Operator : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Owner : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Reactor Supplier : CNNC (CHINA NATIONAL NUCLEAR CORPORATION)
 Turbine Supplier : STC (Shanghai Turbine Co.)



Reactor Unit Details

Reactor type and model : PWR / CNP-300
 Thermal power : 999 MWth
 Gross electrical power : 340 MWe
 Reference unit power (net) : 313 MWe

Key Dates

Construction Date : 2011-12-18
 Grid Date : 2017-06-25
 Commercial Date : 2017-09-19
 Age at end of year : 6 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.4
 Refuelling frequency [month] : 14
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 32000
 Active core diameter [m] : 2.486
 Active core height/length [m] : 2.9
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 13.59
 Number of control rod assemblies : 34
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.2
 Reactor outlet temperature [°C] : 315.5
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.26

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 5.34
 Output voltage [kV] : 20
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

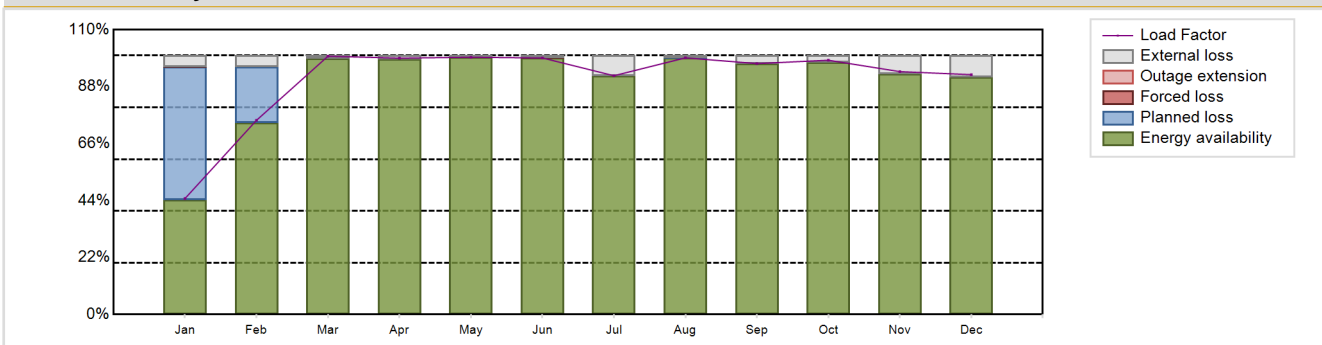
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 0 GW(e).h
 Energy Availability Factor (EAF) : 90.44 %
 Unit Capability Factor (UCF) : 93.97 %
 Load Factor (LF) : 90.89 %
 Operating Factor (OF) : 93.76 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 6.03 %
 Externally cause unavailability (XUF) : 3.53 %
 Total off-line time : hours

Annual Summary

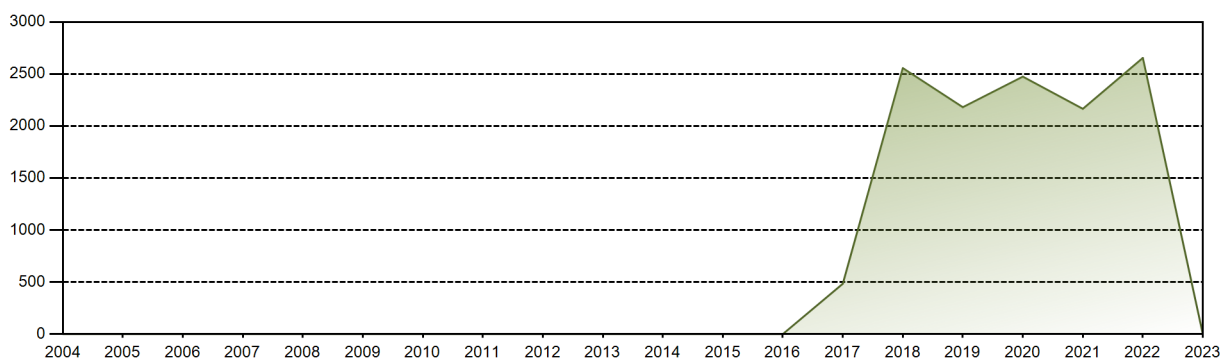


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 104.33 | 157.77 | 232.32 | 223.14 | 231.36 | 223.30 | 214.78 | 230.83 | 218.44 | 228.70 | 211.42 | 215.75 | 2492.14 |
| EAF [%] | 44.20 | 74.13 | 98.80 | 98.72 | 99.32 | 99.09 | 92.23 | 99.12 | 96.93 | 97.42 | 92.82 | 91.69 | 90.44 |
| UCF [%] | 48.55 | 78.43 | 100.00 | 100.00 | 100.00 | 99.99 | 100.00 | 99.90 | 100.00 | 100.00 | 100.00 | 100.00 | 93.97 |
| LF [%] | 44.80 | 75.01 | 99.77 | 99.01 | 99.35 | 99.09 | 92.23 | 99.12 | 96.93 | 98.21 | 93.81 | 92.65 | 90.89 |
| OF [%] | 49.06 | 82.74 | 100.00 | 100.00 | 100.00 | 100.00 | 93.41 | 100.00 | 100.00 | 100.00 | 99.58 | 100.00 | 93.76 |
| FLR [%] | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 51.43 | 21.57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 6.03 |
| XUF [%] | 4.35 | 4.31 | 1.20 | 1.28 | 0.68 | 0.91 | 7.77 | 0.77 | 3.07 | 2.58 | 7.18 | 8.31 | 3.53 |

Historical Summary

| | | | |
|---|-------------|---|----------|
| Lifetime energy generation | : 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.93 % |
| Cumulative Energy Availability Factor (EAF) | : 90.19 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.86 % |
| Cumulative Unit Capability Factor (UCF) | : 91.44 % | Cumulative Planned Unavailability Factor (PUF) | : 7.71 % |
| Cumulative Load Factor (LF) | : 86.11 % | Cumulative Externally cause unavailability (XUF) | : 1.25 % |
| Cumulative Operating Factor (OF) | : 89.23 % | | |

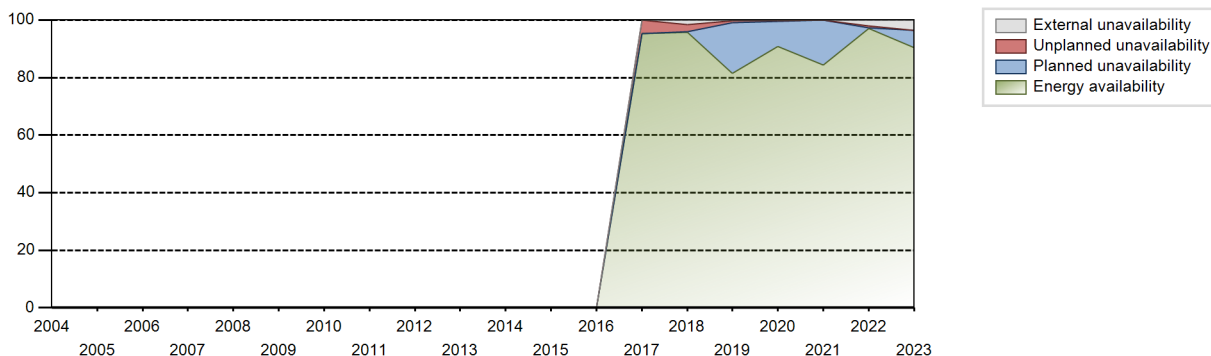
Electricity Production (net) [GWh]



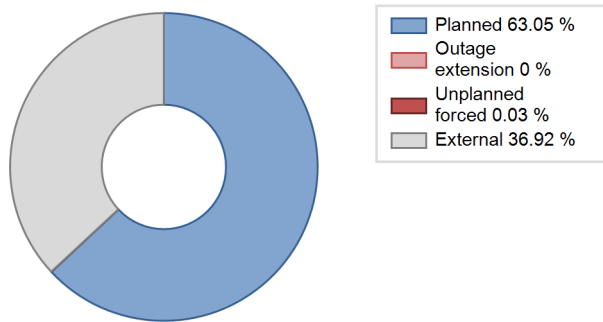
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------------------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2017 | 484.17 | 1946 | 313 | 95.21 | 95.22 | 35.01 | 38.13 | 4.78 | 4.78 | 0.00 | 0.01 |
| 2018 | 2557.08 | 8452 | 313 | 95.74 | 97.25 | 93.26 | 96.48 | 2.63 | 2.63 | 0.12 | 1.51 |
| 2019 | 2181.00 | 7237 | 313 | 81.52 | 81.88 | 79.54 | 82.61 | 0.80 | 0.66 | 17.46 | 0.36 |
| 2020 | 2474.85 | 8068 | 313 | 90.76 | 91.09 | 90.01 | 91.85 | 0.05 | 0.05 | 8.86 | 0.34 |
| 2021 | 2165.43 | 7407 | 313 | 84.32 | 84.42 | 78.98 | 84.55 | 0.00 | 0.00 | 15.58 | 0.11 |
| 2022 | 2654.75 | 8673 | 313 | 97.10 | 99.04 | 96.82 | 99.01 | 0.83 | 0.83 | 0.13 | 1.94 |
| 2023 | | | | Data not provided | | | | | | | |

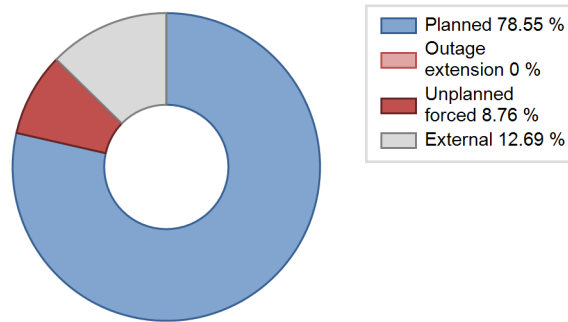
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2017 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 0 | | | 56 | |
| C. Inspection, maintenance or repair combined with refuelling | 494 | | | 641 | | |
| J. Grid limitation, failure or grid unavailability | | | 52 | | | 240 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 7 |
| Subtotal | 494 | 0 | 52 | 641 | 56 | 247 |
| Total | | 546 | | | 944 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2017 to 2023 | |
|------------------------------|------------|----------|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 15. Reactor Cooling Systems | | | | 3 |
| 16. Steam generation systems | | 0 | | 0 |
| 31. Turbine and auxiliaries | | | | 19 |
| 41. Main Generator Systems | | | | 31 |
| Total | | 0 | | 53 |

2023 Operating Experience

PK-6

KANUPP-2

PAKISTAN

Status at end of year : **Operational**
 Operator : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Owner : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Reactor Supplier : CZEC (China Zhongyuan Engineering Corporation)
 Turbine Supplier : STC (Shanghai Turbine Co.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PWR / ACP-1000 | Construction Date | : 2015-08-20 |
| Thermal power | : 3060 MWth | Grid Date | : 2021-03-18 |
| Gross electrical power | : 1100 MWe | Commercial Date | : 2021-05-21 |
| Reference unit power (net) | : 1017 MWe | Age at end of year | : 2 years |

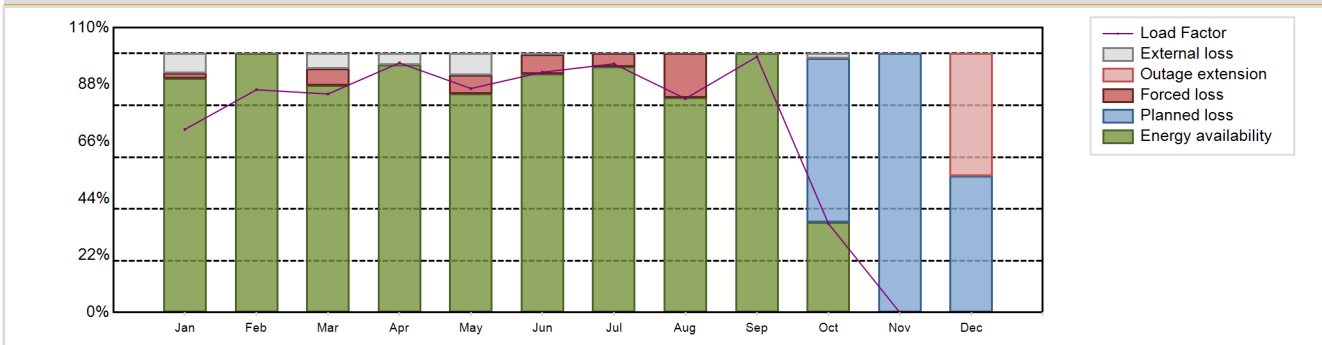
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|---|--|--------|
| Reactor vessel centreline orientation | : | Operating coolant pressure [MPa] | : |
| Fuel material | : | Reactor outlet temperature [°C] | : |
| Refuelling type | : | Number of SG | : |
| Moderator material | : | Containment type | : |
| Average fuel enrichment [% of U235] | : | Containment design pressure [MPa] | : |
| Refuelling frequency [month] | : | Secondary systems | |
| Part of the core refuelled [%] | : | Number of turbine-generators per unit/reactor | : |
| Average discharge burnup [MWd/t] | : | Turbine speed [rpm] | : |
| Active core diameter [m] | : | Number of LP cylinders per turbine | : |
| Active core height/length [m] | : | HP cylinder inlet steam pressure [MPa] | : |
| Number of fissile fuel assemblies/bundles | : | Output voltage [kV] | : |
| Fuel linear heat generation rate [kW/m] | : | Primary means of condenser cooling | : |
| Number of control rod assemblies | : | Number of main condensate pumps | : |
| Number of external reactor coolant loops | : | Number of FW pumps for full power operation | : |
| Coolant type | : | Number of on-site safety related diesel generators | : |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|------------------|--|--------------|
| Net Energy Production | : 6136.8 GW(e).h | Forced Loss Rate (FLR) | : 4.91 % |
| Energy Availability Factor (EAF) | : 71.67 % | Unplanned Capability Loss Factor (UCL) | : 7.84 % |
| Unit Capability Factor (UCF) | : 74.08 % | Planned Unavailability Factor (PUF) | : 18.08 % |
| Load Factor (LF) | : 68.88 % | Externally cause unavailability (XUF) | : 2.41 % |
| Operating Factor (OF) | : 75 % | Total off-line time | : 2190 hours |

Annual Summary

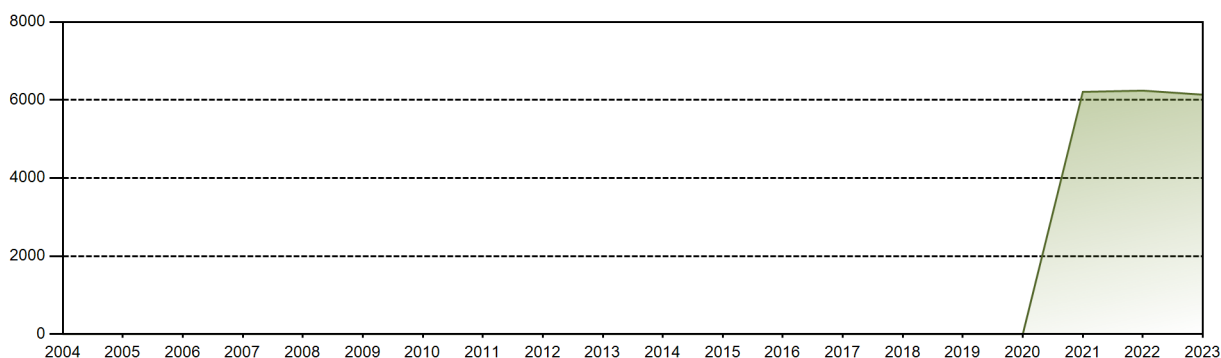


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|---------|
| GW(e)-h | 535.21 | 587.95 | 638.49 | 705.83 | 654.61 | 679.59 | 726.63 | 624.92 | 723.40 | 260.17 | 0.00 | 0.00 | 6136.80 |
| EAF [%] | 90.42 | 100.00 | 87.71 | 95.57 | 84.40 | 92.09 | 94.99 | 82.89 | 100.00 | 34.75 | 0.00 | 0.00 | 71.67 |
| UCF [%] | 98.07 | 100.00 | 93.65 | 100.00 | 92.75 | 92.41 | 94.99 | 82.89 | 100.00 | 36.56 | 0.00 | 0.00 | 74.08 |
| LF [%] | 70.73 | 86.03 | 84.38 | 96.39 | 86.51 | 92.81 | 96.03 | 82.59 | 98.79 | 34.38 | 0.00 | 0.00 | 68.88 |
| OF [%] | 88.84 | 100.00 | 94.89 | 100.00 | 94.22 | 95.28 | 97.85 | 94.62 | 100.00 | 36.56 | 0.00 | 0.00 | 75.00 |
| FLR [%] | 1.93 | 0.00 | 6.35 | 0.00 | 7.25 | 7.59 | 5.01 | 17.11 | 0.00 | 0.00 | 0.00 | 0.00 | 4.91 |
| UCL [%] | 1.93 | 0.00 | 6.35 | 0.00 | 7.25 | 7.59 | 5.01 | 17.11 | 0.00 | 0.00 | 0.00 | 47.31 | 7.84 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 63.44 | 100.00 | 52.69 | 18.08 |
| XUF [%] | 7.65 | 0.00 | 5.94 | 4.43 | 8.35 | 0.32 | 0.00 | 0.00 | 0.00 | 1.81 | 0.00 | 0.00 | 2.41 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 18586.05 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.6 % |
| Cumulative Energy Availability Factor (EAF) | : 77.25 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.29 % |
| Cumulative Unit Capability Factor (UCF) | : 79.18 % | Cumulative Planned Unavailability Factor (PUF) | : 12.53 % |
| Cumulative Load Factor (LF) | : 76.09 % | Cumulative Externally cause unavailability (XUF) | : 1.93 % |
| Cumulative Operating Factor (OF) | : 79.72 % | | |

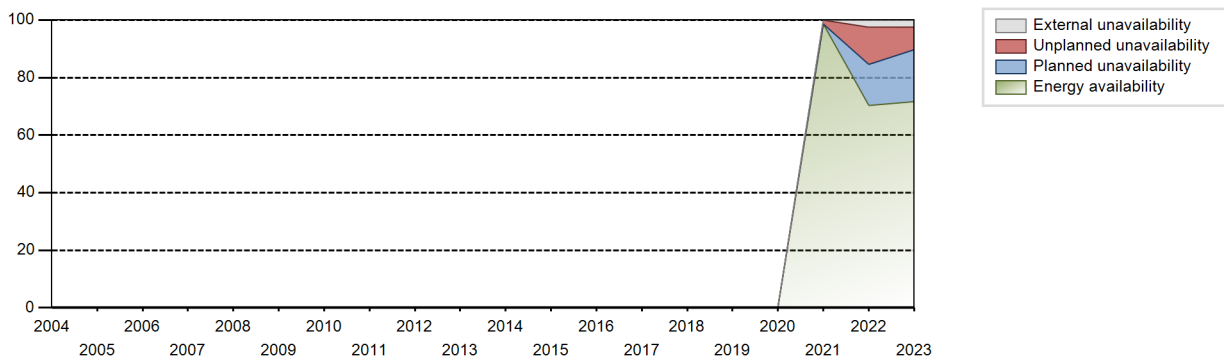
Electricity Production (net) [GWh]



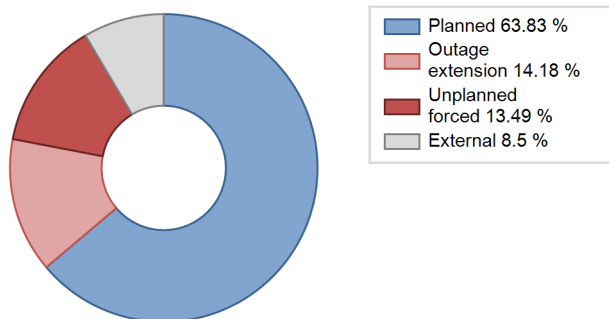
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2021 | 6208.89 | 5910 | 1014 | 98.64 | 98.64 | 98.78 | 96.42 | 1.36 | 1.36 | 0.00 | 0.00 |
| 2022 | 6240.36 | 6540 | 1017 | 70.32 | 72.91 | 70.05 | 74.66 | 11.90 | 12.80 | 14.30 | 2.59 |
| 2023 | 6136.80 | 6570 | 1017 | 71.67 | 74.08 | 68.88 | 75.00 | 4.91 | 7.84 | 18.08 | 2.41 |

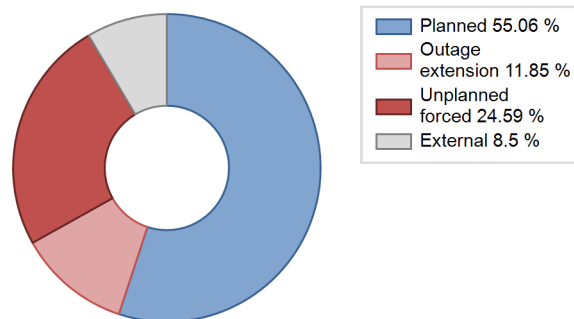
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2021 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 523 | | | 349 | |
| C. Inspection, maintenance or repair combined with refuelling | 1576 | | | 1072 | | |
| H. Nuclear regulatory requirements | | | | | 234 | |
| J. Grid limitation, failure or grid unavailability | | | 73 | | | 117 |
| L. Human factor related | | 10 | | | 4 | |
| Subtotal | 1576 | 533 | 73 | 1072 | 587 | 117 |
| Total | | 2182 | | | 1776 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2021 to 2023 | |
|--|------------|------------|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 15. Reactor Cooling Systems | | 53 | | 19 |
| 16. Steam generation systems | | | | 213 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 8 |
| 31. Turbine and auxiliaries | | 117 | | 76 |
| 32. Feedwater and Main Steam System | | 362 | | 128 |
| 41. Main Generator Systems | | | | 91 |
| 42. Electrical Power Supply Systems | | | | 48 |
| Total | | 532 | | 583 |

Highlights (2023)

RFO-2 planned from 12-10-2023 to 17-12-2023. RFO-2 extended till 04-01-2024 due to MSIV stem detachment issue.

2023 Operating Experience

PK-7

KANUPP-3

PAKISTAN

Status at end of year : **Operational**
 Operator : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Owner : PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
 Reactor Supplier : CZEC (China Zhongyuan Engineering Corporation)
 Turbine Supplier : STC (Shanghai Turbine Co.)



Reactor Unit Details

Reactor type and model : PWR / ACP-1000
 Thermal power : 3060 MWth
 Gross electrical power : 1100 MWe
 Reference unit power (net) : 1017 MWe

Key Dates

Construction Date : 2016-05-31
 Grid Date : 2022-03-04
 Commercial Date : 2022-04-18
 Age at end of year : 1 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : -
 Fuel material : -
 Refuelling type : -
 Moderator material : -
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : -
 Active core diameter [m] : -
 Active core height/length [m] : -
 Number of fissile fuel assemblies/bundles : -
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : -
 Number of external reactor coolant loops : -
 Coolant type : -

Operating coolant pressure [MPa] : -
 Reactor outlet temperature [°C] : -
 Number of SG : -
 Containment type : -
 Containment design pressure [MPa] : -

Secondary systems

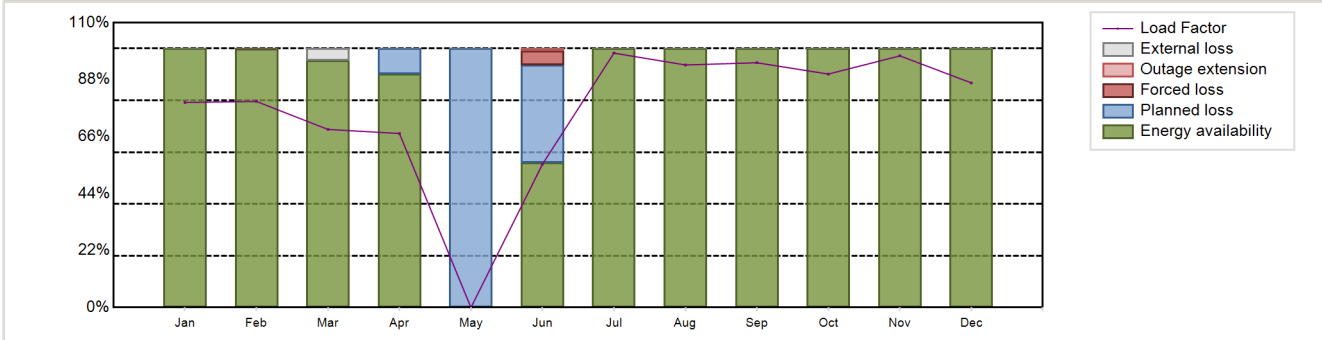
Number of turbine-generators per unit/reactor : -
 Turbine speed [rpm] : -
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : -
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 6755.72 GW(e).h | Forced Loss Rate (FLR) | : 0.52 % |
| Energy Availability Factor (EAF) | : 86.67 % | Unplanned Capability Loss Factor (UCL) | : 0.52 % |
| Unit Capability Factor (UCF) | : 87.07 % | Planned Unavailability Factor (PUF) | : 12.41 % |
| Load Factor (LF) | : 75.83 % | Externally cause unavailability (XUF) | : 0.4 % |
| Operating Factor (OF) | : 85.73 % | Total off-line time | : 1250 hours |

Annual Summary

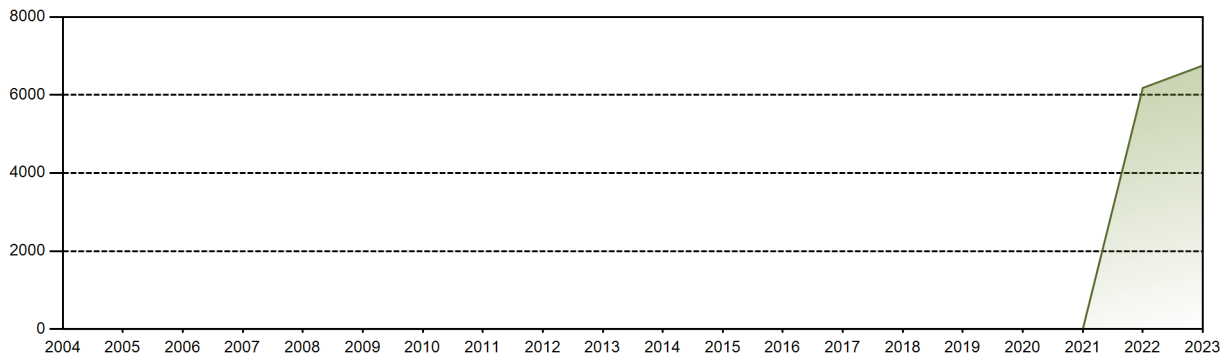


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 599.27 | 543.87 | 520.42 | 492.16 | 0.00 | 405.15 | 743.45 | 708.87 | 692.19 | 682.20 | 711.72 | 656.42 | 6755.72 |
| EAF [%] | 100.00 | 99.96 | 95.33 | 90.09 | 0.00 | 55.93 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.67 |
| UCF [%] | 100.00 | 99.96 | 100.00 | 90.09 | 0.00 | 55.93 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.07 |
| LF [%] | 79.20 | 79.58 | 68.78 | 67.21 | 0.00 | 55.33 | 98.26 | 93.69 | 94.53 | 90.16 | 97.20 | 86.75 | 75.83 |
| OF [%] | 91.67 | 100.00 | 95.83 | 90.83 | 0.00 | 61.81 | 100.00 | 98.39 | 100.00 | 91.94 | 100.00 | 100.00 | 85.73 |
| FLR [%] | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 8.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.52 |
| UCL [%] | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 6.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.52 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 9.91 | 100.00 | 37.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.41 |
| XUF [%] | 0.00 | 0.00 | 4.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 12937.62 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.79 % |
| Cumulative Energy Availability Factor (EAF) | : 90.64 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.7 % |
| Cumulative Unit Capability Factor (UCF) | : 90.87 % | Cumulative Planned Unavailability Factor (PUF) | : 7.43 % |
| Cumulative Load Factor (LF) | : 81.51 % | Cumulative Externally cause unavailability (XUF) | : 0.24 % |
| Cumulative Operating Factor (OF) | : 87.94 % | | |

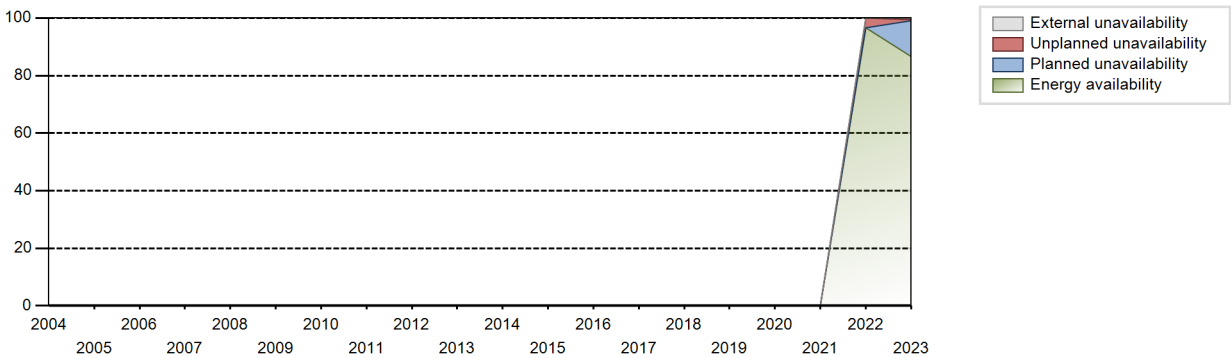
Electricity Production (net) [GWh]



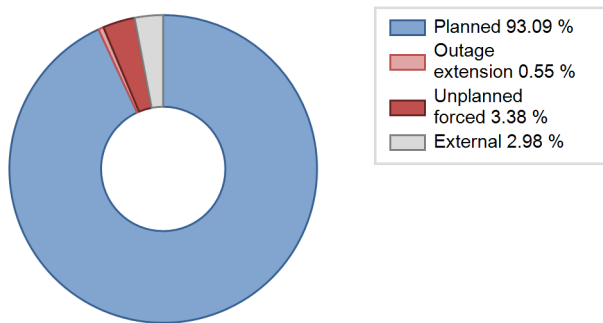
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2022 | 6181.90 | 6287 | 1017 | 96.55 | 96.55 | 89.98 | 91.24 | 3.45 | 3.45 | 0.00 | 0.00 |
| 2023 | 6755.72 | 7510 | 1017 | 86.67 | 87.07 | 75.83 | 85.73 | 0.52 | 0.52 | 12.41 | 0.40 |

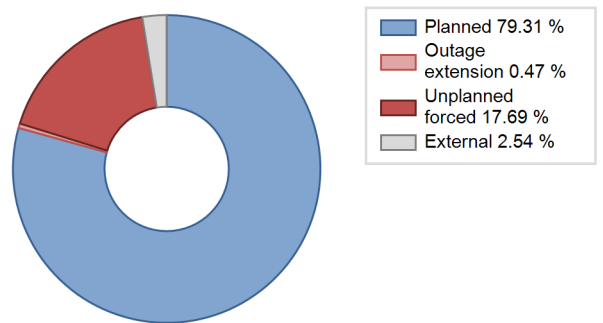
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2022 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 35 | | | 76 | |
| C. Inspection, maintenance or repair combined with refuelling | 1049 | | | 629 | | |
| J. Grid limitation, failure or grid unavailability | | | 132 | | | 302 |
| L. Human factor related | | | | | 31 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 30 | | | 18 |
| Subtotal | 1049 | 35 | 162 | 629 | 107 | 320 |
| Total | | 1246 | | | 1056 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2022 to 2023 | |
|--|------------|-----------|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 17. Safety I&C Systems (excluding reactor I&C) | | 29 | | 16 |
| 32. Feedwater and Main Steam System | | | | 28 |
| 41. Main Generator Systems | | 6 | | 54 |
| Total | | 35 | | 98 |

Highlights (2023)

RFO-1 was planned from 28-4-2023 to 10-6-2023. RFO-1 extended till 11-6-2023 due to delay in identification and resolution of leakage in hydrogen purification system.

2023 Operating Experience

RO-1 CERNAVODA-1 ROMANIA

Status at end of year : **Operational**
 Operator : SNN (SOCIETATEA NATIONALA NUCLEARELECTRICA, S.A.)
 Owner : MECMA (Ministerul Economiei, Comertului si mediului de Afaceri)
 Reactor Supplier : AECL (ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : G.E. (General Electric)

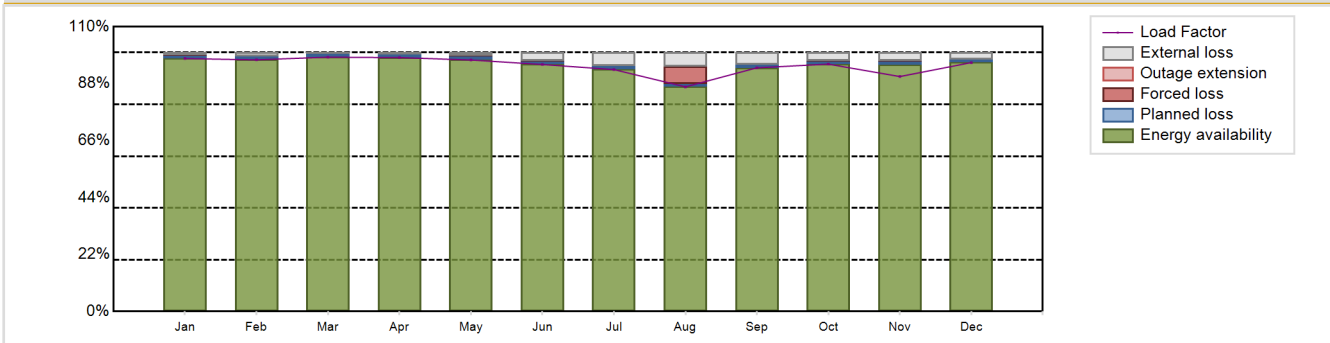


| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 6 | Construction Date | : 1983-03-31 |
| Thermal power | : 2180 MWth | Grid Date | : 1996-07-11 |
| Gross electrical power | : 706 MWe | Commercial Date | : 1996-12-02 |
| Reference unit power (net) | : 650 MWe | Age at end of year | : 27 years |

| Design Characteristics | | | |
|---|--------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 9.99 |
| Reactor vessel centreline orientation | : Horizontal | Reactor outlet temperature [°C] | : 310 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : Single |
| Moderator material | : D2O | Containment design pressure [MPa] | : 0.1241 |
| Average fuel enrichment [% of U235] | : 0.71 | Secondary systems | |
| Refuelling frequency [month] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : NA | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 7100 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 6.123 | HP cylinder inlet steam pressure [MPa] | : 4.551 |
| Active core height/length [m] | : 5.94 | Output voltage [kV] | : 24 |
| Number of fissile fuel assemblies/bundles | : 4560 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 42.9 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 65 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : D2O | Non-electrical applications | : DH |

| Annual Production Results (2023) | | | |
|--|-------------------|--|------------|
| Net Energy Production | : 5410.94 GW(e).h | Forced Loss Rate (FLR) | : 0.66 % |
| Energy Availability Factor (EAF) | : 95.51 % | Unplanned Capability Loss Factor (UCL) | : 0.65 % |
| Unit Capability Factor (UCF) | : 98.1 % | Planned Unavailability Factor (PUF) | : 1.24 % |
| Load Factor (LF) | : 95.03 % | Externally cause unavailability (XUF) | : 2.59 % |
| Operating Factor (OF) | : 99.26 % | Total off-line time | : 65 hours |
| Equivalent non-electrical energy generated (NEG) | : 20.43 GW(e).h | | |

Annual Summary

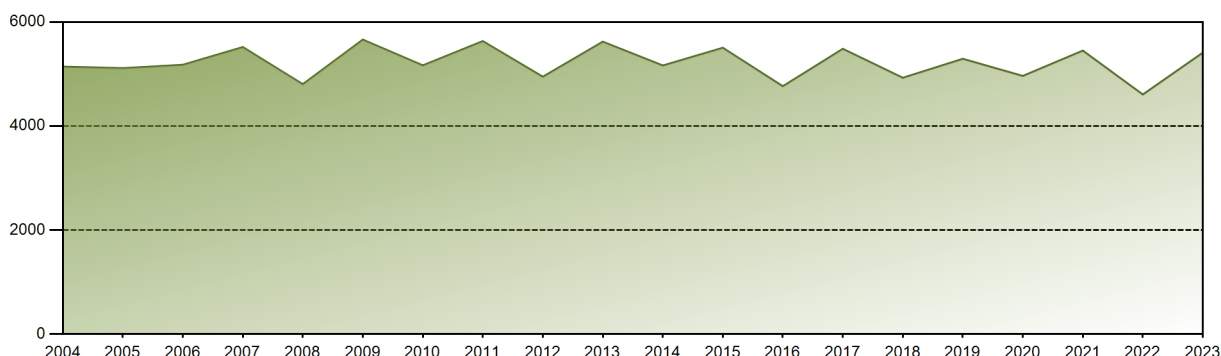


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 472.45 | 424.57 | 474.46 | 458.94 | 469.78 | 446.48 | 451.87 | 419.61 | 440.53 | 462.64 | 424.70 | 464.91 | 5410.94 |
| EAF [%] | 97.83 | 97.34 | 98.32 | 98.17 | 97.27 | 95.53 | 93.56 | 86.88 | 94.25 | 95.66 | 95.28 | 96.28 | 95.51 |
| UCF [%] | 98.60 | 98.63 | 98.77 | 98.72 | 98.42 | 98.73 | 98.71 | 92.11 | 98.74 | 98.66 | 98.32 | 98.92 | 98.10 |
| LF [%] | 97.70 | 97.20 | 98.24 | 98.06 | 97.14 | 95.40 | 93.44 | 86.77 | 94.13 | 95.54 | 90.75 | 96.14 | 95.03 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.95 | 100.00 | 100.00 | 97.22 | 100.00 | 99.26 |
| FLR [%] | 0.24 | 0.00 | 0.00 | 0.00 | 0.12 | 0.05 | 0.00 | 6.92 | 0.00 | 0.18 | 0.29 | 0.00 | 0.66 |
| UCL [%] | 0.24 | 0.00 | 0.00 | 0.00 | 0.12 | 0.05 | 0.00 | 6.85 | 0.00 | 0.18 | 0.29 | 0.00 | 0.65 |
| PUF [%] | 1.16 | 1.37 | 1.23 | 1.28 | 1.46 | 1.21 | 1.29 | 1.04 | 1.26 | 1.16 | 1.39 | 1.08 | 1.24 |
| XUF [%] | 0.78 | 1.30 | 0.45 | 0.55 | 1.15 | 3.20 | 5.15 | 5.23 | 4.49 | 3.00 | 3.04 | 2.64 | 2.59 |

Historical Summary

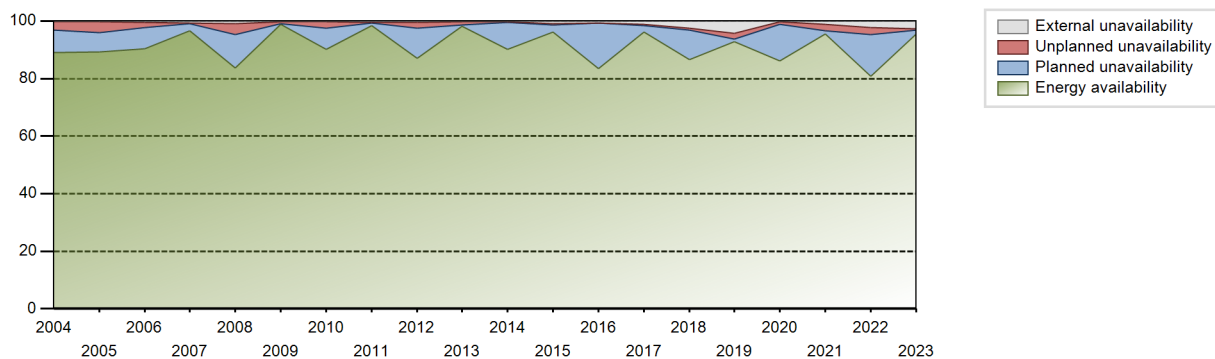
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 140002.15 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.16 % |
| Cumulative Energy Availability Factor (EAF) | : 89.75 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.29 % |
| Cumulative Unit Capability Factor (UCF) | : 90.9 % | Cumulative Planned Unavailability Factor (PUF) | : 6.81 % |
| Cumulative Load Factor (LF) | : 90.02 % | Cumulative Externally cause unavailability (XUF) | : 1.15 % |
| Cumulative Operating Factor (OF) | : 91.36 % | | |

Electricity Production (net) [GWh]

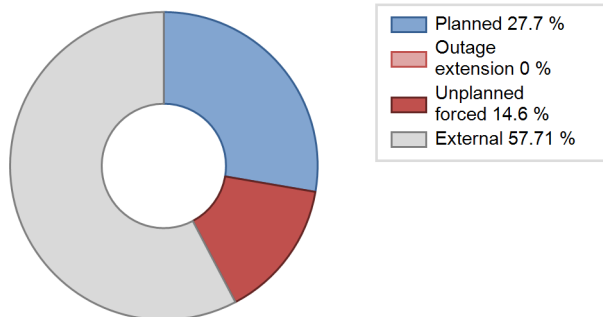


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1996 | 1186.44 | 2686 | 647 | 94.44 | 94.44 | 99.60 | 100.00 | 3.52 | 3.45 | 2.11 | 0.00 |
| 1997 | 4953.29 | 7753 | 646 | 86.74 | 87.32 | 87.53 | 88.50 | 9.94 | 9.64 | 3.05 | 0.58 |
| 1998 | 4908.68 | 7585 | 655 | 85.22 | 85.81 | 85.55 | 86.59 | 4.44 | 3.99 | 10.20 | 0.60 |
| 1999 | 4813.03 | 7389 | 654 | 83.50 | 83.76 | 83.93 | 84.35 | 8.13 | 7.42 | 8.82 | 0.27 |
| 2000 | 5053.35 | 7791 | 655 | 87.57 | 87.89 | 87.83 | 88.70 | 5.23 | 4.85 | 7.26 | 0.31 |
| 2001 | 5049.86 | 7717 | 655 | 87.52 | 88.24 | 88.01 | 88.09 | 0.96 | 0.85 | 10.91 | 0.72 |
| 2002 | 5106.22 | 7854 | 655 | 88.65 | 89.07 | 88.99 | 89.66 | 5.09 | 4.78 | 6.15 | 0.42 |
| 2003 | 4541.42 | 7024 | 655 | 78.68 | 86.69 | 79.15 | 80.18 | 0.57 | 0.96 | 12.35 | 8.01 |
| 2004 | 5142.31 | 7892 | 655 | 89.10 | 89.39 | 89.38 | 89.85 | 1.15 | 2.91 | 7.70 | 0.29 |
| 2005 | 5112.96 | 7878 | 655 | 89.28 | 89.58 | 89.11 | 89.93 | 4.05 | 3.79 | 6.63 | 0.30 |
| 2006 | 5177.96 | 7987 | 655 | 90.29 | 90.76 | 90.24 | 91.18 | 2.05 | 1.90 | 7.34 | 0.48 |
| 2007 | 5518.35 | 8527 | 655 | 96.51 | 97.13 | 96.18 | 97.34 | 0.34 | 0.33 | 2.55 | 0.61 |
| 2008 | 4805.48 | 7411 | 650 | 83.76 | 84.58 | 84.16 | 84.37 | 0.11 | 3.84 | 11.58 | 0.82 |
| 2009 | 5661.65 | 8709 | 650 | 98.94 | 99.17 | 99.43 | 99.42 | 0.73 | 0.72 | 0.11 | 0.23 |
| 2010 | 5167.23 | 7982 | 650 | 90.15 | 90.52 | 90.75 | 91.12 | 2.33 | 2.16 | 7.32 | 0.37 |
| 2011 | 5633.14 | 8694 | 650 | 98.43 | 98.93 | 98.93 | 99.25 | 0.19 | 0.18 | 0.89 | 0.50 |
| 2012 | 4948.20 | 7652 | 650 | 87.11 | 87.50 | 86.66 | 87.11 | 2.24 | 2.01 | 10.49 | 0.39 |
| 2013 | 5622.01 | 8681 | 650 | 98.24 | 98.55 | 98.74 | 99.10 | 1.00 | 1.00 | 0.45 | 0.31 |
| 2014 | 5164.38 | 8032 | 650 | 90.21 | 90.45 | 90.70 | 91.69 | 0.33 | 0.30 | 9.25 | 0.25 |
| 2015 | 5504.93 | 8612 | 650 | 96.10 | 97.02 | 96.68 | 98.31 | 0.54 | 0.53 | 2.45 | 0.93 |
| 2016 | 4765.82 | 7489 | 650 | 83.39 | 84.04 | 83.47 | 85.26 | 0.16 | 0.14 | 15.82 | 0.65 |
| 2017 | 5485.44 | 8637 | 650 | 96.13 | 97.21 | 96.34 | 98.60 | 0.52 | 0.51 | 2.28 | 1.08 |
| 2018 | 4928.50 | 7920 | 650 | 86.60 | 89.05 | 86.56 | 90.41 | 0.82 | 0.73 | 10.22 | 2.45 |
| 2019 | 5292.67 | 8600 | 650 | 92.81 | 97.11 | 92.95 | 98.17 | 1.97 | 1.95 | 0.94 | 4.30 |
| 2020 | 4963.25 | 7666 | 650 | 86.13 | 86.46 | 86.93 | 87.27 | 0.12 | 0.77 | 12.77 | 0.33 |
| 2021 | 5450.51 | 8588 | 650 | 95.51 | 96.61 | 95.72 | 98.04 | 2.42 | 2.39 | 1.00 | 1.09 |
| 2022 | 4606.58 | 7394 | 650 | 80.90 | 83.22 | 80.90 | 84.41 | 1.78 | 2.46 | 14.32 | 2.32 |
| 2023 | 5410.94 | 8695 | 650 | 95.51 | 98.10 | 95.03 | 99.26 | 0.66 | 0.65 | 1.24 | 2.59 |

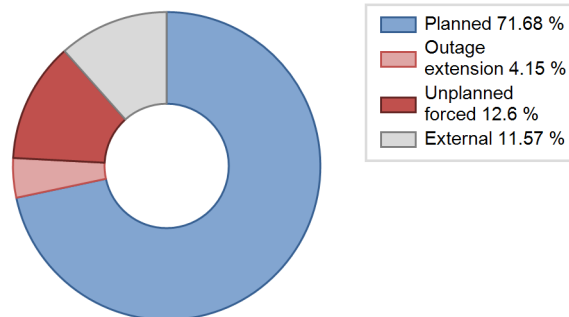
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1996 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1 | | | 152 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 2 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 545 | | |
| E. Testing of plant systems or components | | | | | 2 | |
| J. Grid limitation, failure or grid unavailability | | | 19 | | | 4 |
| L. Human factor related | | 45 | | | 15 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 32 |
| Z. Other | | | | | 4 | |
| Subtotal | | 46 | 19 | 547 | 173 | 36 |
| Total | | 65 | | | 756 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1996 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 30 |
| 13. Reactor Auxiliary Systems | | 7 |
| 14. Safety Systems | | 3 |
| 15. Reactor Cooling Systems | | 6 |
| 16. Steam generation systems | | 6 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | | 32 |
| 32. Feedwater and Main Steam System | 1 | 24 |
| 33. Circulating Water System | | 38 |
| 34. Miscellaneous Systems | | 13 |
| 41. Main Generator Systems | | 20 |
| 42. Electrical Power Supply Systems | 63 | 18 |
| Total | 64 | 207 |

2023 Operating Experience

RO-2

CERNAVODA-2

ROMANIA

Status at end of year : **Operational**
 Operator : SNN (SOCIETATEA NATIONALA NUCLEARELECTRICA, S.A.)
 Owner : MECMA (Ministerul Economiei, Comertului si mediului de Afaceri)
 Reactor Supplier : AECL (ATOMIC ENERGY OF CANADA, LTD.)
 Turbine Supplier : G.E. (General Electric)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|--------------|
| Reactor type and model | : PHWR / CANDU 6 | Construction Date | : 1983-07-01 |
| Thermal power | : 2180 MWth | Grid Date | : 2007-08-07 |
| Gross electrical power | : 705 MWe | Commercial Date | : 2007-11-01 |
| Reference unit power (net) | : 650 MWe | Age at end of year | : 16 years |

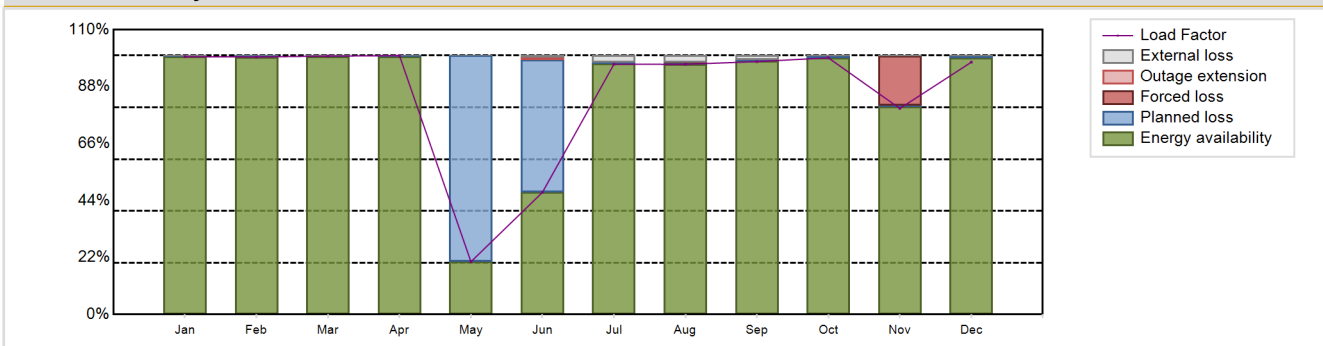
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|--------------|--|------------------------|
| Reactor vessel centreline orientation | : Horizontal | Operating coolant pressure [MPa] | : 9.99 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 310 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : D2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 0.71 | Containment design pressure [MPa] | : 0.1241 |
| Refuelling frequency [month] | : NA | Secondary systems | |
| Part of the core refuelled [%] | : NA | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 7100 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 6.123 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 5.94 | HP cylinder inlet steam pressure [MPa] | : 4.551 |
| Number of fissile fuel assemblies/bundles | : 4560 | Output voltage [kV] | : 24 |
| Fuel linear heat generation rate [kW/m] | : 42.9 | Primary means of condenser cooling | : River (once-through) |
| Number of control rod assemblies | : 65 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : D2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : DH |

Annual Production Results (2023)

| | | | |
|--|------------------|--|--------------|
| Net Energy Production | : 4901.2 GW(e).h | Forced Loss Rate (FLR) | : 1.77 % |
| Energy Availability Factor (EAF) | : 86.26 % | Unplanned Capability Loss Factor (UCL) | : 1.65 % |
| Unit Capability Factor (UCF) | : 86.95 % | Planned Unavailability Factor (PUF) | : 11.4 % |
| Load Factor (LF) | : 86.08 % | Externally cause unavailability (XUF) | : 0.68 % |
| Operating Factor (OF) | : 87.74 % | Total off-line time | : 1074 hours |
| Equivalent non-electrical energy generated (NEG) | : 10.04 GW(e).h | | |

Annual Summary

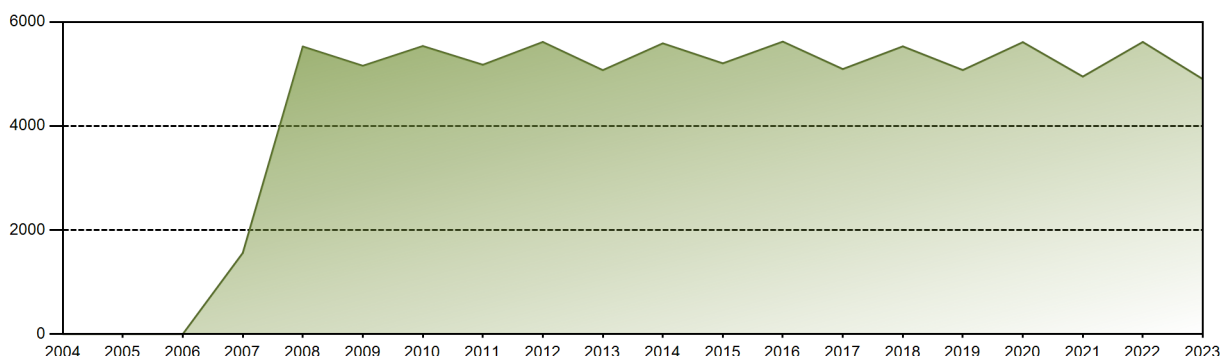


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 481.62 | 434.55 | 481.99 | 467.91 | 98.61 | 220.81 | 467.49 | 467.32 | 457.18 | 479.98 | 372.47 | 471.28 | 4901.20 |
| EAF [%] | 99.54 | 99.48 | 99.51 | 99.68 | 20.39 | 47.25 | 96.79 | 96.75 | 97.81 | 99.16 | 80.26 | 99.18 | 86.26 |
| UCF [%] | 99.58 | 99.48 | 99.51 | 99.68 | 20.39 | 47.95 | 99.41 | 99.39 | 99.37 | 99.34 | 80.49 | 99.34 | 86.95 |
| LF [%] | 99.59 | 99.48 | 99.80 | 99.98 | 20.39 | 47.18 | 96.67 | 96.63 | 97.69 | 99.12 | 79.59 | 97.45 | 86.08 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 20.83 | 51.11 | 100.00 | 100.00 | 100.00 | 100.00 | 82.64 | 98.92 | 87.74 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 19.18 | 0.00 | 1.77 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.93 | 0.00 | 0.02 | 0.00 | 0.00 | 19.10 | 0.00 | 1.65 |
| PUF [%] | 0.42 | 0.52 | 0.49 | 0.32 | 79.61 | 51.12 | 0.59 | 0.59 | 0.63 | 0.66 | 0.42 | 0.66 | 11.40 |
| XUF [%] | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.70 | 2.62 | 2.64 | 1.57 | 0.18 | 0.23 | 0.16 | 0.68 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 86847.61 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.3 % |
| Cumulative Energy Availability Factor (EAF) | : 93.48 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.35 % |
| Cumulative Unit Capability Factor (UCF) | : 94.32 % | Cumulative Planned Unavailability Factor (PUF) | : 4.33 % |
| Cumulative Load Factor (LF) | : 93.55 % | Cumulative Externally cause unavailability (XUF) | : 0.84 % |
| Cumulative Operating Factor (OF) | : 94.84 % | | |

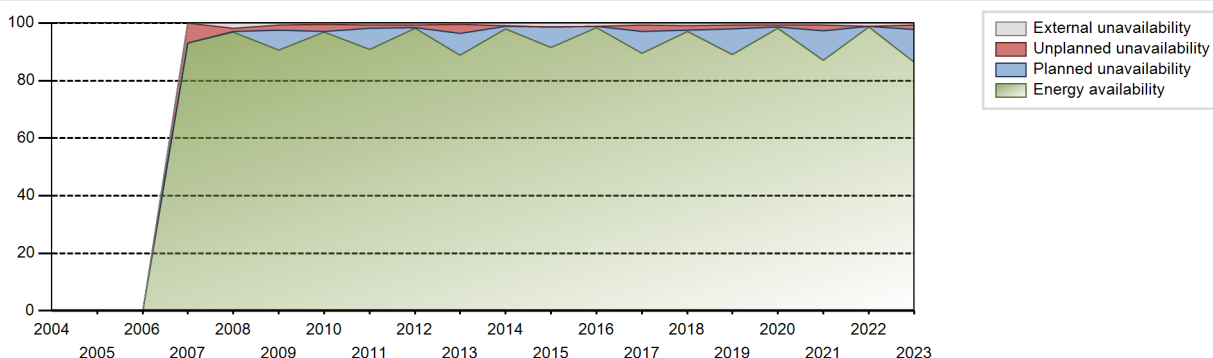
Electricity Production (net) [GWh]



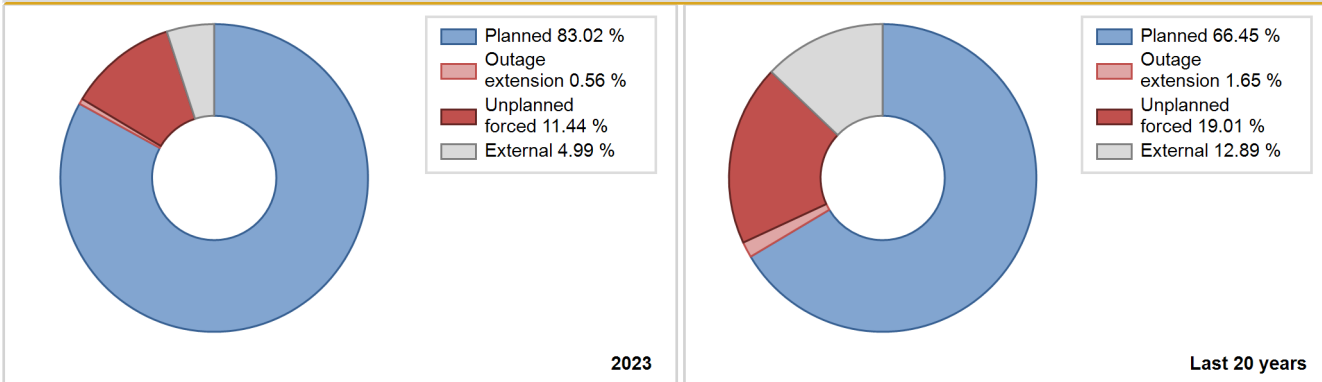
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2007 | 1560.20 | 2729 | 650 | 93.03 | 93.03 | 93.24 | 94.19 | 6.91 | 6.91 | 0.06 | 0.00 |
| 2008 | 5528.11 | 8669 | 650 | 96.85 | 98.63 | 96.82 | 98.69 | 1.24 | 1.24 | 0.13 | 1.78 |
| 2009 | 5158.25 | 8044 | 650 | 90.62 | 91.32 | 90.59 | 91.83 | 2.02 | 1.89 | 6.79 | 0.70 |
| 2010 | 5537.52 | 8551 | 650 | 96.92 | 97.33 | 97.25 | 97.61 | 2.53 | 2.52 | 0.14 | 0.42 |
| 2011 | 5177.84 | 8052 | 650 | 90.75 | 91.50 | 90.93 | 91.92 | 1.19 | 1.10 | 7.40 | 0.75 |
| 2012 | 5615.32 | 8701 | 650 | 98.11 | 98.78 | 98.35 | 99.06 | 1.04 | 1.04 | 0.19 | 0.67 |
| 2013 | 5073.74 | 7905 | 650 | 88.80 | 89.21 | 89.11 | 90.24 | 3.44 | 3.18 | 7.61 | 0.41 |
| 2014 | 5589.30 | 8680 | 650 | 97.95 | 98.80 | 98.16 | 99.09 | 0.31 | 0.31 | 0.90 | 0.85 |
| 2015 | 5204.74 | 8179 | 650 | 91.50 | 92.84 | 91.41 | 93.37 | 0.00 | 0.00 | 7.16 | 1.34 |
| 2016 | 5622.38 | 8784 | 650 | 98.51 | 99.66 | 98.47 | 100.00 | 0.00 | 0.00 | 0.34 | 1.14 |
| 2017 | 5094.71 | 7963 | 650 | 89.38 | 90.07 | 89.48 | 90.90 | 2.37 | 2.19 | 7.74 | 0.69 |
| 2018 | 5530.84 | 8658 | 650 | 97.17 | 98.16 | 97.13 | 98.84 | 1.43 | 1.43 | 0.42 | 0.99 |
| 2019 | 5075.54 | 7910 | 650 | 89.05 | 89.72 | 89.14 | 90.30 | 0.00 | 1.34 | 8.94 | 0.67 |
| 2020 | 5611.82 | 8737 | 650 | 98.21 | 98.96 | 98.29 | 99.46 | 0.65 | 0.65 | 0.39 | 0.75 |
| 2021 | 4950.65 | 7742 | 650 | 87.08 | 87.73 | 86.95 | 88.39 | 2.00 | 2.11 | 10.16 | 0.65 |
| 2022 | 5615.46 | 8760 | 650 | 98.53 | 99.63 | 98.62 | 100.00 | 0.00 | 0.00 | 0.37 | 1.10 |
| 2023 | 4901.20 | 7686 | 650 | 86.26 | 86.95 | 86.08 | 87.74 | 1.77 | 1.65 | 11.40 | 0.68 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2007 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 132 | | | 90 | |
| D. Inspection, maintenance or repair without refuelling | 934 | | | 346 | | |
| E. Testing of plant systems or components | | | | | 2 | |
| J. Grid limitation, failure or grid unavailability | | | 8 | | | 1 |
| L. Human factor related | | | | | 8 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| Subtotal | 934 | 132 | 8 | 346 | 100 | 5 |
| Total | | 1074 | | | 451 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2007 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 7 |
| 12. Reactor I&C Systems | | 14 |
| 13. Reactor Auxiliary Systems | 125 | 8 |
| 15. Reactor Cooling Systems | 7 | 7 |
| 16. Steam generation systems | | 3 |
| 21. Fuel Handling and Storage Facilities | | 11 |
| 31. Turbine and auxiliaries | | 16 |
| 32. Feedwater and Main Steam System | | 5 |
| 41. Main Generator Systems | | 18 |
| 42. Electrical Power Supply Systems | 8 | 15 |
| Total | 140 | 104 |

2023 Operating Experience

RU-151 **AKADEMIK LOMONOSOV-1** **RUSSIA**

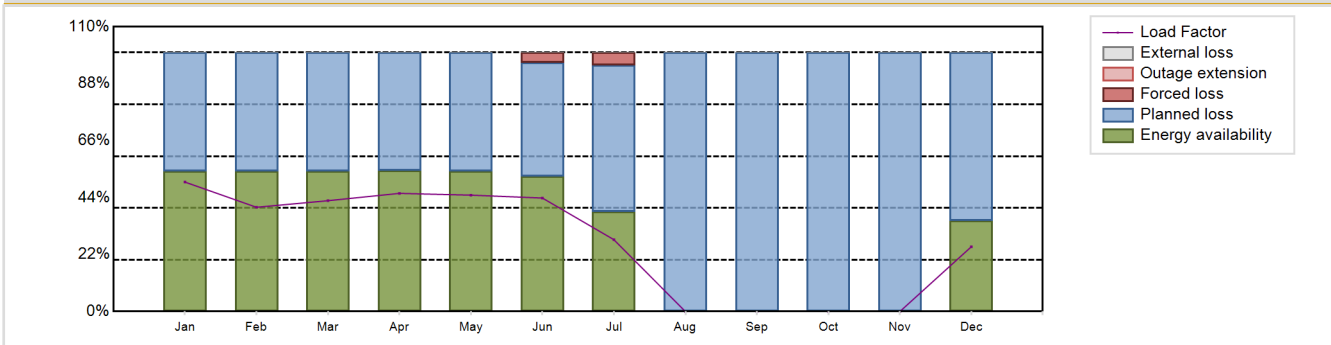
Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KALUGA (JSC "Kaluga turbine plant" 32, Glagoleva Street, Kaluga, 248021, Russia)

| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------------------|--------------------|--------------|
| Reactor type and model | : PWR / KLT-40S 'Floating' | Construction Date | : 2007-04-15 |
| Thermal power | : 150 MWth | Grid Date | : 2019-12-19 |
| Gross electrical power | : 35 MWe | Commercial Date | : 2020-05-22 |
| Reference unit power (net) | : 32 MWe | Age at end of year | : 4 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 12.7 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 316 |
| Fuel material | : Other | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.4 |
| Average fuel enrichment [% of U235] | : 14.1 | Secondary systems | |
| Refuelling frequency [month] | : 29 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 100 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 68700 | Number of LP cylinders per turbine | : NA |
| Active core diameter [m] | : 1.220 | HP cylinder inlet steam pressure [MPa] | : 3.43 |
| Active core height/length [m] | : 1.2 | Output voltage [kV] | : 10.5 |
| Number of fissile fuel assemblies/bundles | : 121 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 14 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 11 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | |
| | | | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-----------------|--|--------------|
| Net Energy Production | : 74.63 GW(e).h | Forced Loss Rate (FLR) | : 2.16 % |
| Energy Availability Factor (EAF) | : 33.02 % | Unplanned Capability Loss Factor (UCL) | : 0.73 % |
| Unit Capability Factor (UCF) | : 33.02 % | Planned Unavailability Factor (PUF) | : 66.25 % |
| Load Factor (LF) | : 26.62 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 58.71 % | Total off-line time | : 3617 hours |

Annual Summary

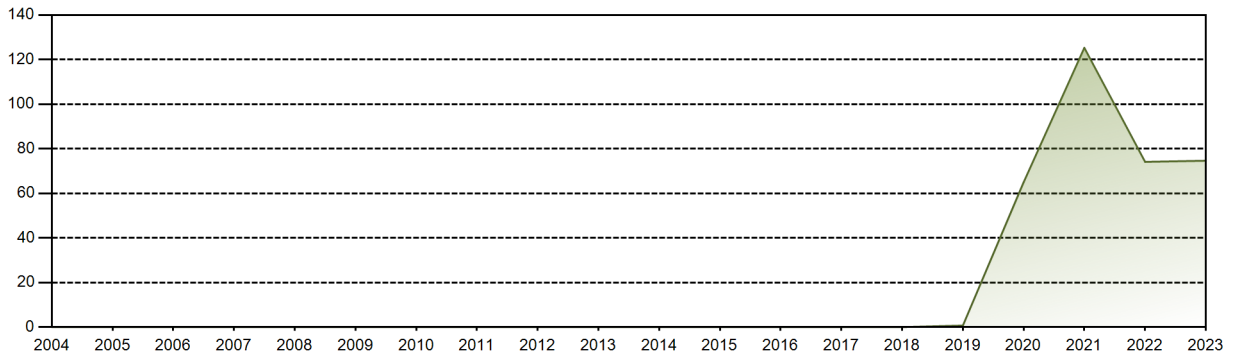


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|-------|--------|--------|--------|--------|-------|--------|
| GW(e)-h | 11.90 | 8.66 | 10.19 | 10.52 | 10.70 | 10.10 | 6.61 | 0.00 | 0.00 | 0.00 | 0.00 | 5.96 | 74.63 |
| EAF [%] | 54.28 | 54.29 | 54.28 | 54.36 | 54.28 | 52.25 | 38.67 | 0.00 | 0.00 | 0.00 | 0.00 | 35.02 | 33.02 |
| UCF [%] | 54.28 | 54.29 | 54.28 | 54.36 | 54.28 | 52.25 | 38.67 | 0.00 | 0.00 | 0.00 | 0.00 | 35.02 | 33.02 |
| LF [%] | 50.00 | 40.26 | 42.80 | 45.64 | 44.94 | 43.83 | 27.74 | 0.00 | 0.00 | 0.00 | 0.00 | 25.03 | 26.62 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.11 | 71.24 | 0.00 | 0.00 | 0.00 | 0.00 | 39.92 | 58.71 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.70 | 11.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.16 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.75 | 4.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.73 |
| PUF [%] | 45.72 | 45.71 | 45.72 | 45.64 | 45.72 | 44.00 | 56.36 | 100.00 | 100.00 | 100.00 | 100.00 | 64.98 | 66.25 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|------------------|---|-----------|
| Lifetime energy generation | : 339.64 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.64 % |
| Cumulative Energy Availability Factor (EAF) | : 61.66 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3 % |
| Cumulative Unit Capability Factor (UCF) | : 61.66 % | Cumulative Planned Unavailability Factor (PUF) | : 35.34 % |
| Cumulative Load Factor (LF) | : 31.96 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 70.96 % | | |

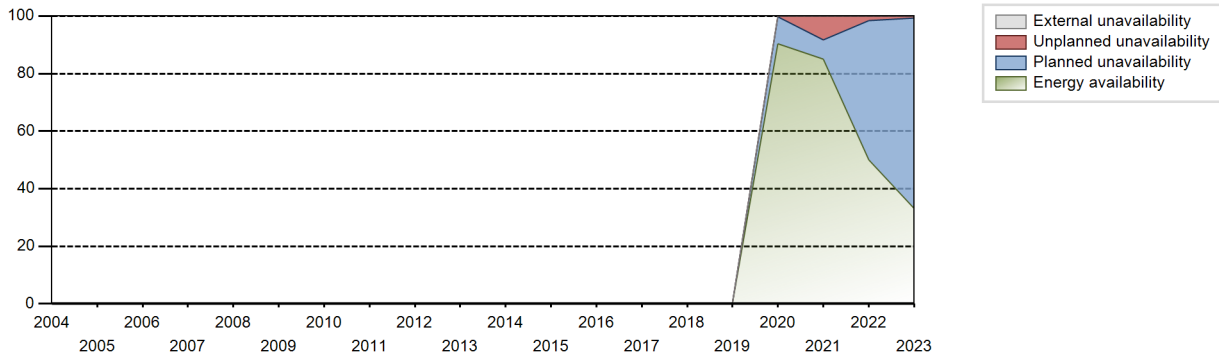
Electricity Production (net) [GWh]



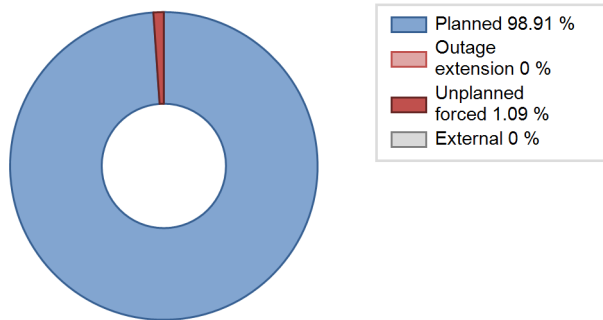
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2020 | 64.94 | 5138 | 32 | 90.38 | 90.38 | 28.76 | 71.63 | 0.30 | 0.27 | 9.34 | 0.00 |
| 2021 | 125.26 | 7104 | 32 | 85.08 | 85.08 | 44.69 | 81.10 | 8.98 | 8.39 | 6.53 | 0.00 |
| 2022 | 74.13 | 6367 | 32 | 50.04 | 50.04 | 26.44 | 72.68 | 2.89 | 1.49 | 48.47 | 0.00 |
| 2023 | 74.63 | 5143 | 32 | 33.02 | 33.02 | 26.62 | 58.71 | 2.16 | 0.73 | 66.25 | 0.00 |

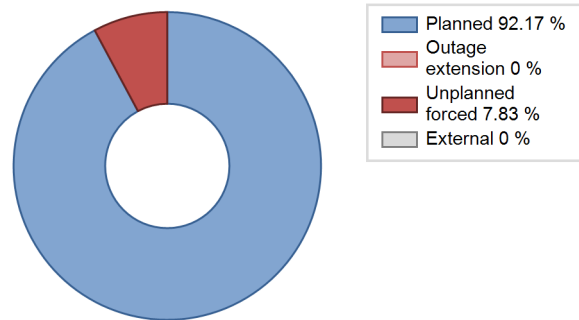
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2020 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 81 | | | 265 | |
| C. Inspection, maintenance or repair combined with refuelling | 3552 | | | 991 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 511 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 56 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 226 |
| L. Human factor related | | | | | 4 | |
| Z. Other | | | | 224 | | |
| Subtotal | 3552 | 81 | | 1726 | 269 | 282 |
| Total | | 3633 | | | 2277 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2020 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 6 |
| 16. Steam generation systems | | | | 185 |
| 31. Turbine and auxiliaries | | | 51 | 16 |
| 32. Feedwater and Main Steam System | | | 30 | 24 |
| 33. Circulating Water System | | | | 9 |
| 42. Electrical Power Supply Systems | | | | 1 |
| Total | | | 81 | 241 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. The unit was in the routine maintenance from 2023.07.24 to 2023.12.19. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-152

AKADEMIK LOMONOSOV-2

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KALUGA (JSC "Kaluga turbine plant" 32, Glagoleva Street, Kaluga, 248021, Russia)

| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------------------|--------------------|--------------|
| Reactor type and model | : PWR / KLT-40S 'Floating' | Construction Date | : 2007-04-15 |
| Thermal power | : 150 MWth | Grid Date | : 2019-12-19 |
| Gross electrical power | : 35 MWe | Commercial Date | : 2020-05-22 |
| Reference unit power (net) | : 32 MWe | Age at end of year | : 4 years |

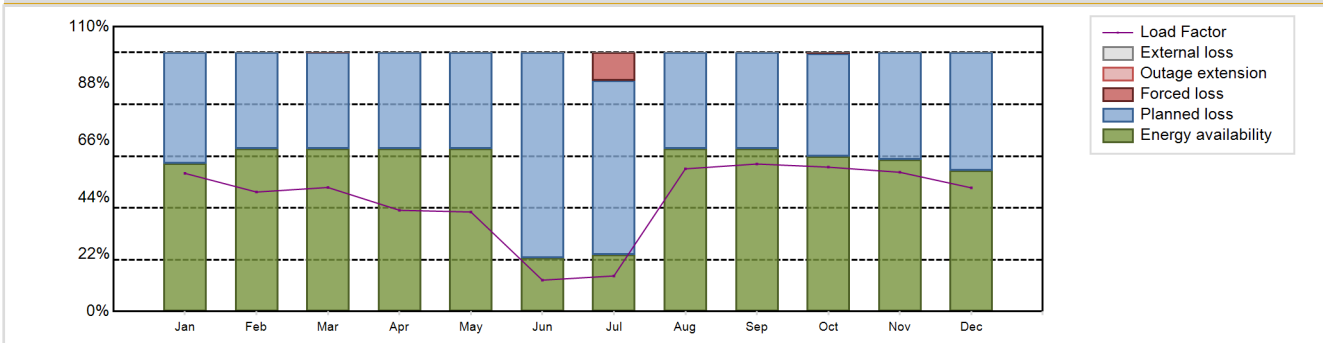
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 12.7 |
| Fuel material | : Other | Reactor outlet temperature [°C] | : 316 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 14.1 | Containment design pressure [MPa] | : 0.4 |
| Refuelling frequency [month] | : 29 | Secondary systems | |
| Part of the core refuelled [%] | : 100 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 68700 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 1.220 | Number of LP cylinders per turbine | : NA |
| Active core height/length [m] | : 1.2 | HP cylinder inlet steam pressure [MPa] | : 3.43 |
| Number of fissile fuel assemblies/bundles | : 121 | Output voltage [kV] | : 10.5 |
| Fuel linear heat generation rate [kW/m] | : 14 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 11 | Number of main condensate pumps | : 3 |
| Number of external reactor coolant loops | : 4 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|------------------|--|-------------|
| Net Energy Production | : 121.54 GW(e).h | Forced Loss Rate (FLR) | : 1.73 % |
| Energy Availability Factor (EAF) | : 54.12 % | Unplanned Capability Loss Factor (UCL) | : 0.95 % |
| Unit Capability Factor (UCF) | : 54.12 % | Planned Unavailability Factor (PUF) | : 44.93 % |
| Load Factor (LF) | : 43.36 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 88.96 % | Total off-line time | : 967 hours |

Annual Summary

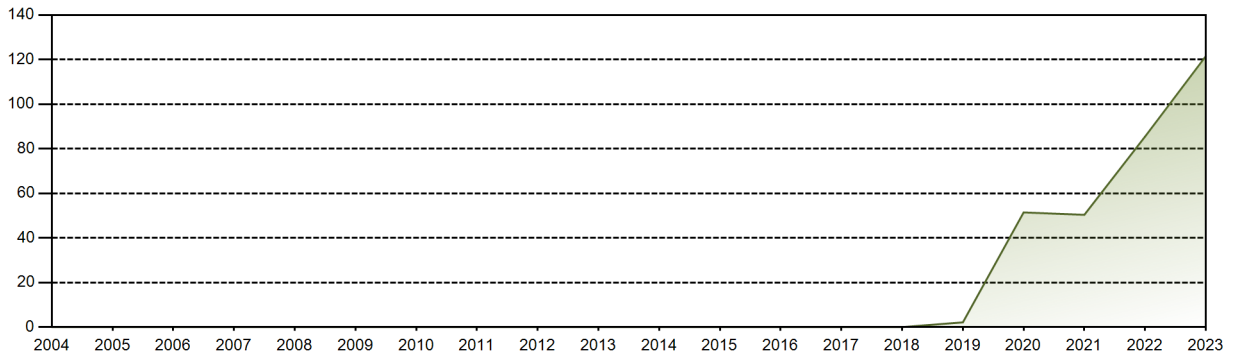


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|-------|--------|--------|--------|--------|--------|--------|
| GW(e)-h | 12.70 | 9.92 | 11.40 | 9.01 | 9.15 | 2.79 | 3.27 | 13.12 | 13.13 | 13.28 | 12.39 | 11.37 | 121.54 |
| EAF [%] | 57.14 | 62.86 | 62.85 | 62.86 | 62.86 | 20.69 | 21.93 | 62.86 | 62.86 | 59.99 | 58.60 | 54.38 | 54.12 |
| UCF [%] | 57.14 | 62.86 | 62.85 | 62.86 | 62.86 | 20.69 | 21.93 | 62.86 | 62.86 | 59.99 | 58.60 | 54.38 | 54.12 |
| LF [%] | 53.36 | 46.14 | 47.90 | 39.11 | 38.44 | 12.11 | 13.75 | 55.11 | 56.97 | 55.76 | 53.77 | 47.76 | 43.36 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 32.92 | 34.95 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.96 |
| FLR [%] | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 32.89 | 0.00 | 0.00 | 0.78 | 0.00 | 0.00 | 1.73 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.75 | 0.00 | 0.00 | 0.47 | 0.00 | 0.00 | 0.95 |
| PUF [%] | 42.86 | 37.14 | 37.14 | 37.14 | 37.14 | 79.31 | 67.32 | 37.14 | 37.14 | 39.54 | 41.40 | 45.62 | 44.93 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|------------------|---|-----------|
| Lifetime energy generation | : 310.94 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.78 % |
| Cumulative Energy Availability Factor (EAF) | : 64.95 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.72 % |
| Cumulative Unit Capability Factor (UCF) | : 64.95 % | Cumulative Planned Unavailability Factor (PUF) | : 30.33 % |
| Cumulative Load Factor (LF) | : 28.22 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 60.42 % | | |

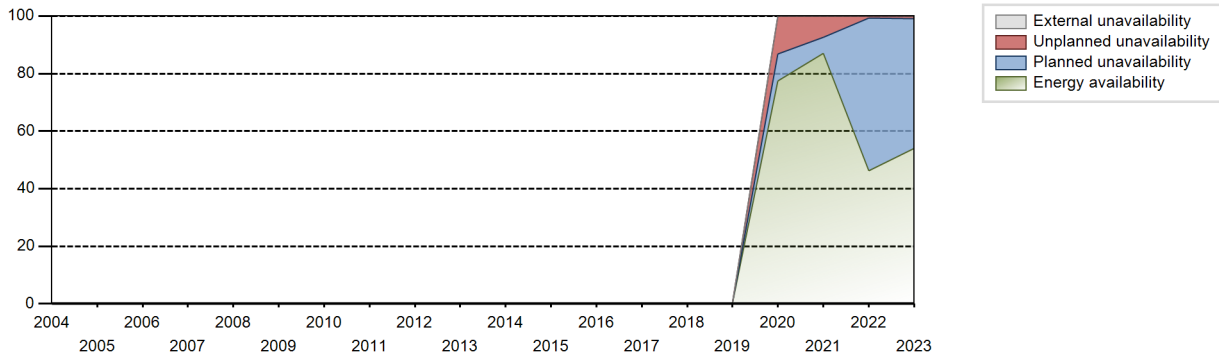
Electricity Production (net) [GWh]



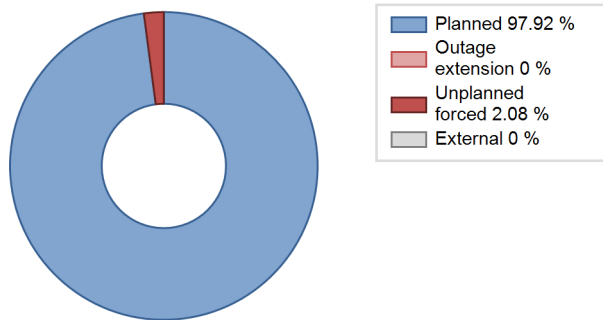
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2020 | 51.44 | 3942 | 32 | 77.36 | 77.36 | 15.99 | 38.32 | 14.66 | 13.29 | 9.35 | 0.00 |
| 2021 | 50.36 | 2265 | 32 | 87.11 | 87.11 | 17.97 | 25.86 | 7.93 | 7.51 | 5.39 | 0.00 |
| 2022 | 85.48 | 6956 | 32 | 46.34 | 46.34 | 30.50 | 79.41 | 1.44 | 0.68 | 52.99 | 0.00 |
| 2023 | 121.54 | 7793 | 32 | 54.12 | 54.12 | 43.36 | 88.96 | 1.73 | 0.95 | 44.93 | 0.00 |

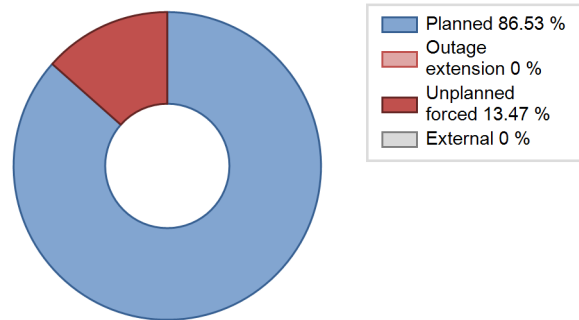
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2020 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 80 | | | 421 | |
| D. Inspection, maintenance or repair without refuelling | 888 | | | 910 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1614 |
| L. Human factor related | | | | | 5 | |
| Subtotal | 888 | 80 | | 910 | 426 | 1614 |
| Total | | 968 | | | 2950 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2020 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 16. Steam generation systems | | | | 320 |
| 31. Turbine and auxiliaries | | | | 7 |
| 32. Feedwater and Main Steam System | | 80 | | 20 |
| 33. Circulating Water System | | | | 21 |
| 41. Main Generator Systems | | | | 2 |
| 42. Electrical Power Supply Systems | | | | 8 |
| Total | | 80 | | 378 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-96

BALAKOVO-1

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

Reactor Unit Details

Reactor type and model : PWR / VVER V-320
 Thermal power : 3000 MWth
 Gross electrical power : 1000 MWe
 Reference unit power (net) : 950 MWe

Key Dates

Construction Date : 1980-12-01
 Grid Date : 1985-12-28
 Commercial Date : 1986-05-23
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 40000
 Active core diameter [m] : 3.16
 Active core height/length [m] : 3.53
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : 17.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 16
 Reactor outlet temperature [°C] : 322
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

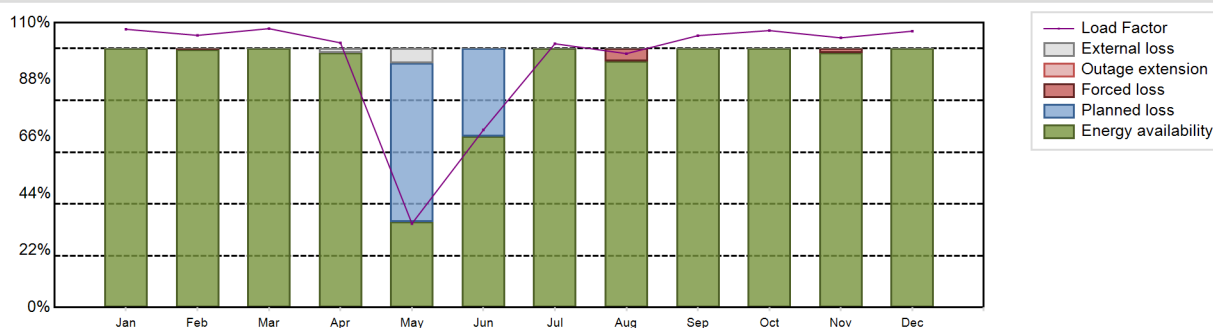
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 7943.1 GW(e).h
 Energy Availability Factor (EAF) : 90.81 %
 Unit Capability Factor (UCF) : 91.43 %
 Load Factor (LF) : 95.45 %
 Operating Factor (OF) : 91.88 %
 Equivalent non-electrical energy generated (NEG) : 5.31 GW(e).h

Forced Loss Rate (FLR) : 0.63 %
 Unplanned Capability Loss Factor (UCL) : 0.58 %
 Planned Unavailability Factor (PUF) : 7.99 %
 Externally cause unavailability (XUF) : 0.62 %
 Total off-line time : 711 hours

Annual Summary

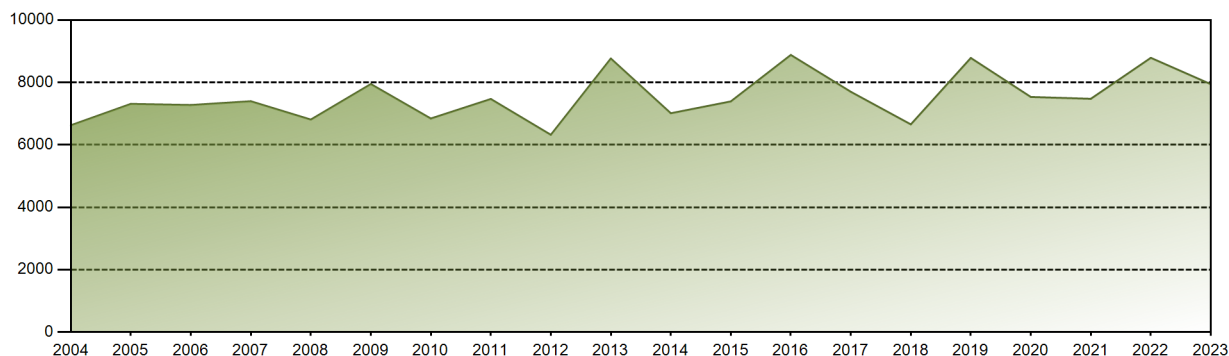


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 759.52 | 670.92 | 761.25 | 699.17 | 229.07 | 469.20 | 720.05 | 693.01 | 718.21 | 756.02 | 712.38 | 754.30 | 7943.10 |
| EAF [%] | 100.00 | 99.54 | 100.00 | 98.27 | 33.04 | 66.13 | 100.00 | 95.24 | 100.00 | 100.00 | 98.30 | 100.00 | 90.81 |
| UCF [%] | 100.00 | 99.54 | 100.00 | 100.00 | 38.71 | 66.13 | 100.00 | 95.24 | 100.00 | 100.00 | 98.30 | 100.00 | 91.43 |
| LF [%] | 107.46 | 105.09 | 107.70 | 102.22 | 32.41 | 68.60 | 101.87 | 98.05 | 105.00 | 106.96 | 104.15 | 106.72 | 95.45 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 38.71 | 66.81 | 100.00 | 99.33 | 100.00 | 100.00 | 98.47 | 100.00 | 91.88 |
| FLR [%] | 0.00 | 0.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.76 | 0.00 | 0.00 | 1.70 | 0.00 | 0.63 |
| UCL [%] | 0.00 | 0.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.76 | 0.00 | 0.00 | 1.70 | 0.00 | 0.58 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 61.29 | 33.87 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.99 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 1.73 | 5.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.62 |

Historical Summary

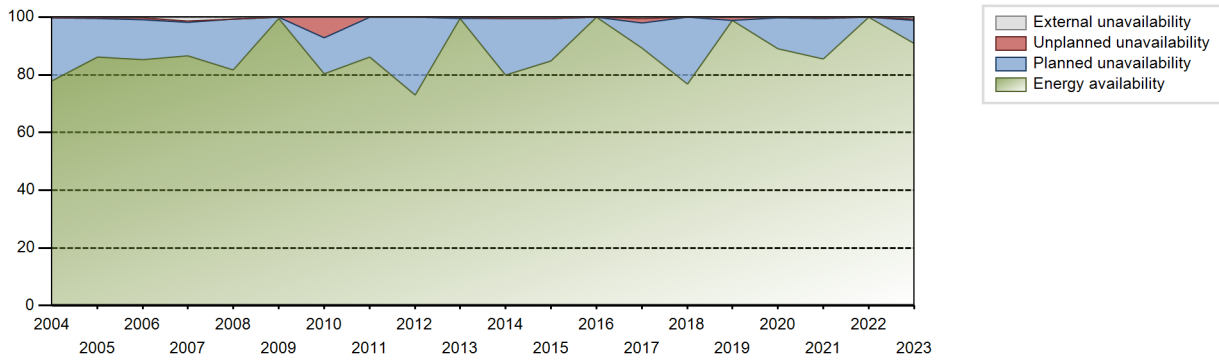
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 237935.74 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.97 % |
| Cumulative Energy Availability Factor (EAF) | : 75.63 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.98 % |
| Cumulative Unit Capability Factor (UCF) | : 77.29 % | Cumulative Planned Unavailability Factor (PUF) | : 16.73 % |
| Cumulative Load Factor (LF) | : 75.43 % | Cumulative Externally cause unavailability (XUF) | : 1.65 % |
| Cumulative Operating Factor (OF) | : 77.63 % | | |

Electricity Production (net) [GWh]

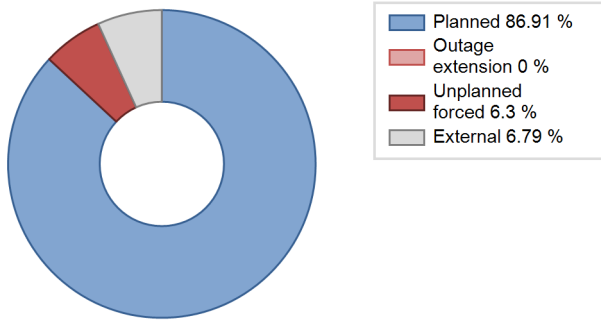


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 4868.03 | 6082 | 950 | 64.85 | 64.85 | 64.46 | 69.51 | 17.62 | 13.87 | 21.28 | 0.00 |
| 1987 | 4703.68 | 5302 | 1000 | 57.40 | 57.40 | 53.70 | 60.53 | 25.51 | 19.66 | 22.95 | 0.00 |
| 1988 | 6476.87 | 7207 | 950 | 80.93 | 80.93 | 77.62 | 82.05 | 6.99 | 6.08 | 12.99 | 0.00 |
| 1989 | 4473.90 | 5141 | 950 | 56.34 | 56.37 | 53.76 | 58.69 | 32.94 | 27.69 | 15.95 | 0.03 |
| 1990 | 739.06 | 887 | 950 | 9.09 | 9.09 | 8.88 | 10.13 | 56.91 | 12.01 | 78.90 | 0.00 |
| 1991 | 4951.60 | 5780 | 950 | 59.85 | 60.19 | 59.50 | 65.98 | 24.74 | 19.79 | 20.02 | 0.35 |
| 1992 | 6352.28 | 7666 | 950 | 76.31 | 76.38 | 76.11 | 87.26 | 23.62 | 23.62 | 0.00 | 0.07 |
| 1993 | 3326.09 | 4230 | 950 | 39.88 | 46.10 | 39.97 | 48.29 | 24.25 | 14.76 | 39.14 | 6.22 |
| 1994 | 1759.54 | 2307 | 950 | 77.30 | 77.30 | 21.14 | 26.34 | 22.70 | 22.70 | 0.00 | 0.00 |
| 1995 | 2017.98 | 4810 | 950 | 28.57 | 28.57 | 24.25 | 54.91 | 62.91 | 48.46 | 22.97 | 0.00 |
| 1996 | 4872.54 | 5913 | 950 | 59.00 | 86.47 | 58.39 | 67.32 | 0.82 | 0.72 | 12.81 | 27.47 |
| 1997 | 4728.99 | 5818 | 950 | 57.24 | 60.37 | 56.83 | 66.42 | 1.49 | 0.91 | 38.72 | 3.13 |
| 1998 | 4329.83 | 5671 | 950 | 52.16 | 55.84 | 52.03 | 64.74 | 4.87 | 2.86 | 41.30 | 3.68 |
| 1999 | 5141.31 | 6337 | 950 | 62.09 | 65.56 | 61.78 | 72.34 | 0.25 | 0.16 | 34.28 | 3.47 |
| 2000 | 7247.37 | 7705 | 950 | 86.49 | 87.54 | 86.85 | 87.72 | 2.30 | 2.06 | 10.40 | 1.05 |
| 2001 | 7407.90 | 8041 | 950 | 88.19 | 91.57 | 89.02 | 91.79 | 1.55 | 1.44 | 6.98 | 3.38 |
| 2002 | 6785.73 | 7501 | 950 | 80.48 | 86.52 | 81.54 | 85.63 | 0.00 | 0.00 | 13.48 | 6.04 |
| 2003 | 7032.19 | 7460 | 950 | 83.12 | 84.71 | 84.50 | 85.16 | 0.75 | 0.64 | 14.64 | 1.60 |
| 2004 | 6626.43 | 6901 | 950 | 78.00 | 78.22 | 79.41 | 78.56 | 0.00 | 0.00 | 21.78 | 0.22 |
| 2005 | 7312.72 | 7638 | 950 | 86.24 | 86.58 | 87.86 | 87.18 | 0.18 | 0.15 | 13.27 | 0.34 |
| 2006 | 7276.97 | 7517 | 950 | 85.24 | 85.49 | 87.44 | 85.81 | 0.70 | 0.60 | 13.91 | 0.25 |
| 2007 | 7397.29 | 7731 | 950 | 86.54 | 87.98 | 88.89 | 88.25 | 0.39 | 0.34 | 11.68 | 1.44 |
| 2008 | 6810.23 | 7283 | 950 | 81.73 | 82.41 | 81.61 | 82.91 | 0.00 | 0.00 | 17.59 | 0.68 |
| 2009 | 7948.45 | 8760 | 950 | 99.61 | 99.74 | 95.51 | 100.00 | 0.00 | 0.00 | 0.26 | 0.13 |
| 2010 | 6843.30 | 7069 | 950 | 80.31 | 80.43 | 82.23 | 80.70 | 0.00 | 7.09 | 12.48 | 0.12 |
| 2011 | 7469.27 | 7573 | 950 | 86.15 | 86.25 | 89.76 | 86.46 | 0.03 | 0.03 | 13.73 | 0.10 |
| 2012 | 6322.13 | 6424 | 950 | 72.90 | 73.02 | 75.76 | 73.13 | 0.00 | 0.00 | 26.98 | 0.12 |
| 2013 | 8766.85 | 8726 | 950 | 99.58 | 99.58 | 105.35 | 99.61 | 0.42 | 0.42 | 0.00 | 0.00 |
| 2014 | 7012.47 | 7077 | 950 | 79.98 | 80.50 | 84.25 | 80.78 | 0.09 | 0.07 | 19.43 | 0.51 |
| 2015 | 7392.01 | 7481 | 950 | 84.74 | 85.21 | 88.82 | 85.40 | 0.02 | 0.02 | 14.77 | 0.47 |
| 2016 | 8880.23 | 8784 | 950 | 99.94 | 99.94 | 106.42 | 100.00 | 0.06 | 0.06 | 0.00 | 0.00 |
| 2017 | 7699.56 | 7887 | 950 | 89.31 | 89.82 | 92.52 | 90.03 | 1.64 | 1.50 | 8.69 | 0.50 |
| 2018 | 6656.19 | 6737 | 950 | 76.80 | 76.80 | 79.98 | 76.91 | 0.00 | 0.00 | 23.20 | 0.00 |
| 2019 | 8783.41 | 8662 | 950 | 98.87 | 98.87 | 105.54 | 98.88 | 1.13 | 1.13 | 0.00 | 0.00 |
| 2020 | 7533.32 | 7842 | 950 | 88.96 | 88.96 | 90.28 | 89.28 | 0.18 | 0.16 | 10.87 | 0.00 |
| 2021 | 7475.86 | 7532 | 950 | 85.51 | 85.74 | 89.83 | 85.98 | 0.33 | 0.28 | 13.98 | 0.23 |
| 2022 | 8788.05 | 8760 | 950 | 99.96 | 99.96 | 105.60 | 100.00 | 0.04 | 0.04 | 0.00 | 0.00 |

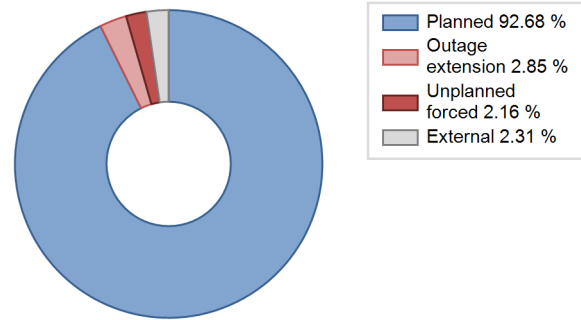
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 11 | | | 288 | |
| C. Inspection, maintenance or repair combined with refuelling | 700 | | | 1195 | 10 | |
| D. Inspection, maintenance or repair without refuelling | | | | 244 | | |
| E. Testing of plant systems or components | | | | 1 | 1 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 128 |
| L. Human factor related | | | | | 7 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 65 |
| Z. Other | | | | | 21 | |
| Subtotal | 700 | 11 | | 1440 | 327 | 194 |
| Total | | 711 | | | 1961 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 2 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 0 |
| 15. Reactor Cooling Systems | | 10 |
| 16. Steam generation systems | | 89 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 31. Turbine and auxiliaries | | 41 |
| 32. Feedwater and Main Steam System | | 11 |
| 33. Circulating Water System | | 3 |
| 34. Miscellaneous Systems | | 24 |
| 35. All other I&C Systems | | 7 |
| 41. Main Generator Systems | 11 | 79 |
| 42. Electrical Power Supply Systems | | 19 |
| Total | 11 | 290 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-April, June-December. Additional electricity generation amounted to 376796 MWh. The unit was in the intermediate maintenance outage from 2023.05.13 to 2023.06.10. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-97

BALAKOVO-2

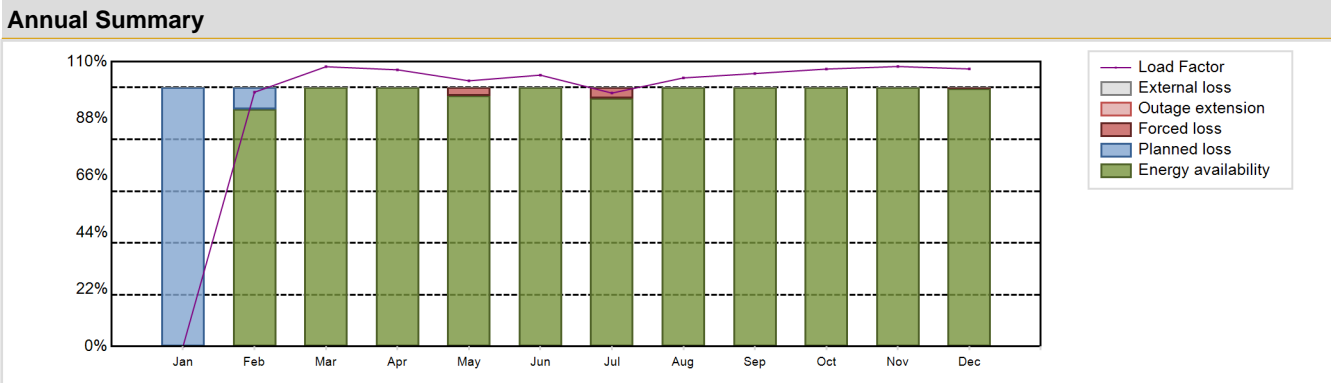
RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 1981-08-01 |
| Thermal power | : 3000 MWth | Grid Date | : 1987-10-08 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1988-01-18 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 36 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 16 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 322 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : DH / PH |

| Annual Production Results (2023) | | | |
|--|-------------------|--|-------------|
| Net Energy Production | : 7964.89 GW(e).h | Forced Loss Rate (FLR) | : 0.69 % |
| Energy Availability Factor (EAF) | : 90.25 % | Unplanned Capability Loss Factor (UCL) | : 0.63 % |
| Unit Capability Factor (UCF) | : 90.25 % | Planned Unavailability Factor (PUF) | : 9.12 % |
| Load Factor (LF) | : 95.71 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 90.95 % | Total off-line time | : 793 hours |
| Equivalent non-electrical energy generated (NEG) | : 4.77 GW(e).h | | |

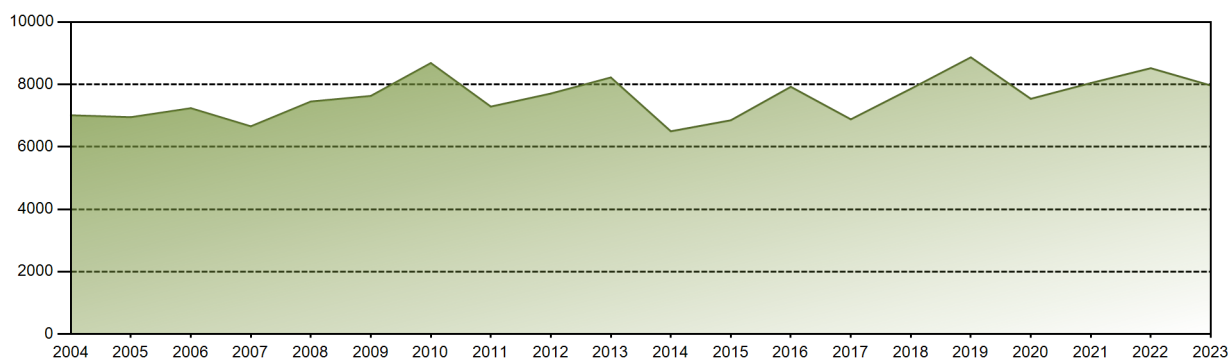


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 627.00 | 763.75 | 731.00 | 725.32 | 716.91 | 691.80 | 733.19 | 721.11 | 757.41 | 739.69 | 757.71 | 7964.89 |
| EAF [%] | 0.00 | 91.77 | 100.00 | 100.00 | 96.90 | 100.00 | 96.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.72 | 90.25 |
| UCF [%] | 0.00 | 91.77 | 100.00 | 100.00 | 96.90 | 100.00 | 96.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.72 | 90.25 |
| LF [%] | 0.00 | 98.21 | 108.06 | 106.87 | 102.62 | 104.81 | 97.88 | 103.73 | 105.43 | 107.16 | 108.14 | 107.20 | 95.71 |
| OF [%] | 0.00 | 92.71 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.95 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 3.10 | 0.00 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.28 | 0.69 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 3.10 | 0.00 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.28 | 0.63 |
| PUF [%] | 100.00 | 8.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.12 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

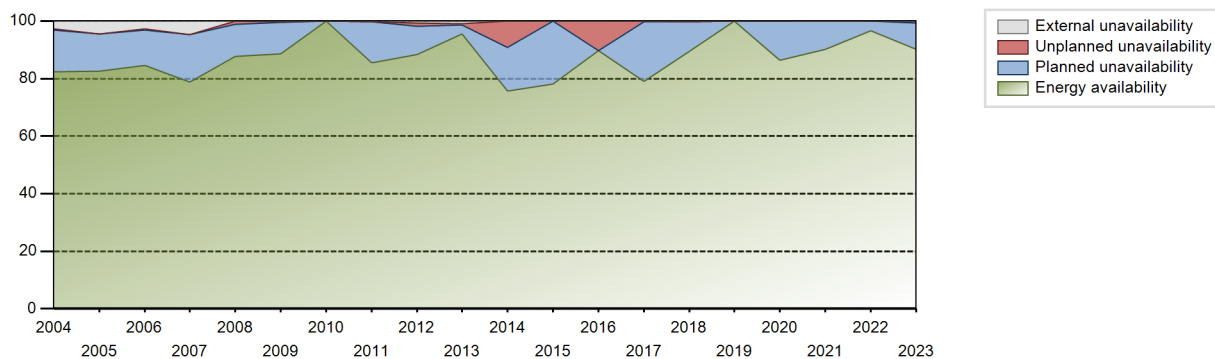
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 229692.53 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.67 % |
| Cumulative Energy Availability Factor (EAF) | : 75.13 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.53 % |
| Cumulative Unit Capability Factor (UCF) | : 77.32 % | Cumulative Planned Unavailability Factor (PUF) | : 17.15 % |
| Cumulative Load Factor (LF) | : 76.29 % | Cumulative Externally cause unavailability (XUF) | : 2.19 % |
| Cumulative Operating Factor (OF) | : 79.06 % | | |

Electricity Production (net) [GWh]

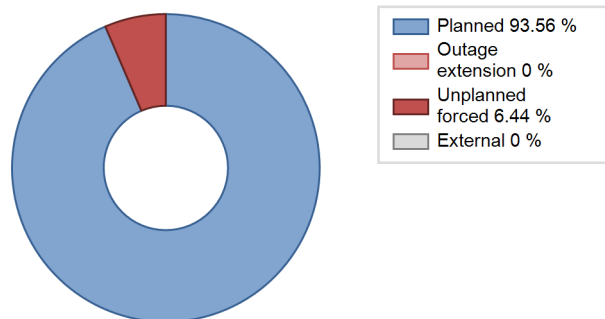


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 5978.43 | 6928 | 950 | 75.49 | 75.49 | 70.63 | 77.66 | 6.59 | 5.33 | 19.18 | 0.00 |
| 1989 | 6703.63 | 7626 | 950 | 84.75 | 84.77 | 80.55 | 87.05 | 9.33 | 8.72 | 6.51 | 0.02 |
| 1990 | 5476.67 | 6165 | 950 | 66.35 | 66.53 | 65.81 | 70.38 | 15.71 | 12.40 | 21.07 | 0.18 |
| 1991 | 4308.38 | 4845 | 950 | 51.23 | 51.52 | 51.77 | 55.31 | 10.81 | 6.25 | 42.23 | 0.29 |
| 1992 | 5958.20 | 6601 | 950 | 70.60 | 70.60 | 71.39 | 75.14 | 9.39 | 7.32 | 22.08 | 0.00 |
| 1993 | 3776.17 | 4147 | 950 | 44.25 | 46.97 | 45.38 | 47.34 | 38.44 | 29.33 | 23.69 | 2.72 |
| 1994 | 4778.52 | 8020 | 950 | 73.08 | 83.53 | 57.42 | 91.55 | 12.39 | 11.81 | 4.66 | 10.45 |
| 1995 | 2204.81 | 3261 | 950 | 30.13 | 30.13 | 26.49 | 37.23 | 27.40 | 11.37 | 58.50 | 0.00 |
| 1996 | 2227.25 | 2604 | 950 | 26.71 | 26.71 | 26.69 | 29.64 | 66.37 | 52.71 | 20.58 | 0.00 |
| 1997 | 4015.92 | 6158 | 950 | 55.66 | 63.92 | 48.26 | 70.30 | 27.93 | 24.77 | 11.31 | 8.26 |
| 1998 | 3293.76 | 4984 | 950 | 40.24 | 50.96 | 39.58 | 56.89 | 0.11 | 0.05 | 48.98 | 10.72 |
| 1999 | 2927.12 | 3942 | 950 | 35.40 | 40.27 | 35.17 | 45.00 | 0.00 | 0.00 | 59.73 | 4.87 |
| 2000 | 5730.07 | 7646 | 950 | 68.89 | 83.21 | 68.67 | 87.04 | 1.61 | 1.36 | 15.43 | 14.32 |
| 2001 | 6678.82 | 7415 | 950 | 79.86 | 83.90 | 80.25 | 84.65 | 0.82 | 0.70 | 15.40 | 4.05 |
| 2002 | 6756.53 | 7408 | 950 | 80.40 | 84.43 | 81.19 | 84.57 | 2.74 | 2.38 | 13.19 | 4.03 |
| 2003 | 6171.76 | 6467 | 950 | 72.70 | 73.99 | 74.16 | 73.82 | 0.03 | 0.02 | 25.99 | 1.29 |
| 2004 | 7010.41 | 7514 | 950 | 82.36 | 85.00 | 84.01 | 85.54 | 0.72 | 0.62 | 14.38 | 2.64 |
| 2005 | 6948.86 | 7688 | 950 | 82.48 | 86.92 | 83.49 | 87.75 | 0.00 | 0.00 | 13.08 | 4.44 |
| 2006 | 7237.48 | 7710 | 950 | 84.59 | 87.38 | 86.97 | 88.01 | 0.41 | 0.36 | 12.26 | 2.79 |
| 2007 | 6657.18 | 7327 | 950 | 78.71 | 83.46 | 79.99 | 83.64 | 0.00 | 0.00 | 16.54 | 4.75 |
| 2008 | 7451.24 | 7750 | 950 | 87.71 | 87.82 | 89.29 | 88.23 | 1.21 | 1.07 | 11.11 | 0.11 |
| 2009 | 7630.69 | 7797 | 950 | 88.63 | 88.78 | 91.69 | 89.01 | 0.28 | 0.25 | 10.97 | 0.15 |
| 2010 | 8683.93 | 8760 | 950 | 99.86 | 100.00 | 104.35 | 100.00 | 0.00 | 0.00 | 0.00 | 0.14 |
| 2011 | 7288.41 | 7531 | 950 | 85.42 | 85.76 | 87.59 | 85.98 | 0.00 | 0.00 | 14.24 | 0.35 |
| 2012 | 7706.49 | 7829 | 950 | 88.30 | 88.99 | 92.35 | 89.13 | 1.35 | 1.22 | 9.79 | 0.70 |
| 2013 | 8222.79 | 8509 | 950 | 95.56 | 96.54 | 98.81 | 97.13 | 0.45 | 0.44 | 3.02 | 0.98 |
| 2014 | 6497.72 | 6672 | 950 | 75.62 | 75.62 | 78.07 | 76.16 | 10.92 | 9.27 | 15.11 | 0.00 |
| 2015 | 6850.26 | 6845 | 950 | 78.02 | 78.03 | 82.32 | 78.14 | 0.00 | 0.00 | 21.97 | 0.01 |
| 2016 | 7922.42 | 7900 | 950 | 89.79 | 89.79 | 94.94 | 89.94 | 10.21 | 10.21 | 0.00 | 0.00 |
| 2017 | 6880.73 | 6972 | 950 | 79.07 | 79.07 | 82.68 | 79.59 | 0.40 | 0.31 | 20.61 | 0.00 |
| 2018 | 7858.92 | 7874 | 950 | 89.46 | 89.82 | 94.44 | 89.89 | 0.00 | 0.00 | 10.18 | 0.36 |
| 2019 | 8867.45 | 8760 | 950 | 100.00 | 100.00 | 106.55 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 7538.45 | 7590 | 950 | 86.37 | 86.37 | 90.34 | 86.41 | 0.00 | 0.00 | 13.63 | 0.00 |
| 2021 | 8043.86 | 7913 | 950 | 90.15 | 90.25 | 96.66 | 90.33 | 0.00 | 0.00 | 9.75 | 0.11 |
| 2022 | 8519.78 | 8472 | 950 | 96.64 | 96.64 | 102.38 | 96.71 | 0.02 | 0.02 | 3.33 | 0.00 |
| 2023 | 7964.89 | 7967 | 950 | 90.25 | 90.25 | 95.71 | 90.95 | 0.69 | 0.63 | 9.12 | 0.00 |

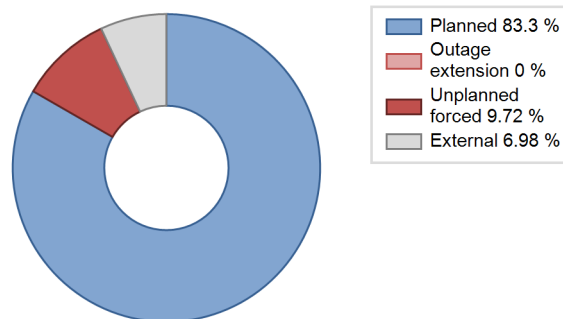
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|--|------------|------------|-----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 318 | |
| C. Inspection, maintenance or repair combined with refuelling | 793 | | | 1336 | 76 | |
| D. Inspection, maintenance or repair without refuelling | | | | 83 | | |
| J. Grid limitation, failure or grid unavailability | | | 24 | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 6 |
| L. Human factor related | | | | | 3 | |
| Z. Other | | | | | 12 | |
| Subtotal | 793 | | 24 | 1419 | 409 | 7 |
| Total | | 817 | | | 1835 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 6 |
| 15. Reactor Cooling Systems | | 6 |
| 16. Steam generation systems | | 222 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 1 |
| 32. Feedwater and Main Steam System | | 15 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 63 |
| 42. Electrical Power Supply Systems | | 1 |
| Total | | 318 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in February-December. Additional electricity generation amounted to 402761 MWh. The unit was in the overhaul outage from 2023.01.01 to 2023.02.03. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

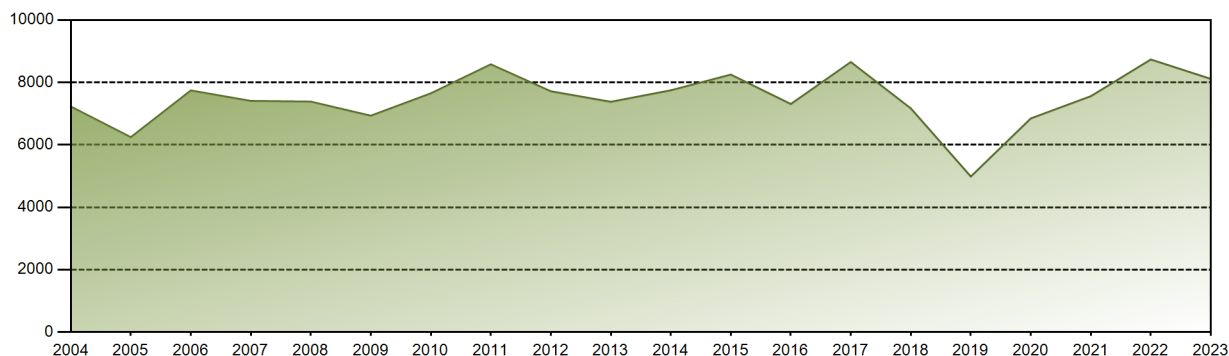
2023 Operating Experience

| RU-98 | BALAKOVO-3 | RUSSIA | | | | | | | | | | | |
|--|--|--|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : REA (Joint Stock Company 'Concern Rosenergoatom') | | | | | | | | | | | | |
| Owner | : REA (Joint Stock Company 'Concern Rosenergoatom') | | | | | | | | | | | | |
| Reactor Supplier | : AEM (Atomenergomash) | | | | | | | | | | | | |
| Turbine Supplier | : KALUGA (JSC "Kaluga turbine plant" 32, Glagoleva Street, Kaluga, 248021, Russia) | | | | | | | | | | | | |
| Reactor Unit Details | | Key Dates | | | | | | | | | | | |
| Reactor type and model | : PWR / VVER V-320 | Construction Date : 1982-11-01 | | | | | | | | | | | |
| Thermal power | : 3000 MWth | Grid Date : 1988-12-25 | | | | | | | | | | | |
| Gross electrical power | : 1000 MWe | Commercial Date : 1989-04-08 | | | | | | | | | | | |
| Reference unit power (net) | : 950 MWe | Age at end of year : 35 years | | | | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | Operating coolant pressure [MPa] : 16 | | | | | | | | | | | |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] : 322 | | | | | | | | | | | |
| Fuel material | : UO2 | Number of SG : 4 | | | | | | | | | | | |
| Refuelling type | : OFF-line | Containment type : Single | | | | | | | | | | | |
| Moderator material | : H2O | Containment design pressure [MPa] : 5 | | | | | | | | | | | |
| Average fuel enrichment [% of U235] | : - | Secondary systems | | | | | | | | | | | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor : 1 | | | | | | | | | | | |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] : 1500 | | | | | | | | | | | |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine : - | | | | | | | | | | | |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] : 6 | | | | | | | | | | | |
| Active core height/length [m] | : 3.53 | Output voltage [kV] : - | | | | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling : Lake (once-through) | | | | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps : - | | | | | | | | | | | |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation : 2 | | | | | | | | | | | |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators : 3 | | | | | | | | | | | |
| Coolant type | : H2O | Non-electrical applications : DH / PH | | | | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : 8113.04 GW(e).h | Forced Loss Rate (FLR) : 0 % | | | | | | | | | | | |
| Energy Availability Factor (EAF) | : 91.47 % | Unplanned Capability Loss Factor (UCL) : 0 % | | | | | | | | | | | |
| Unit Capability Factor (UCF) | : 91.61 % | Planned Unavailability Factor (PUF) : 8.39 % | | | | | | | | | | | |
| Load Factor (LF) | : 97.49 % | Externally cause unavailability (XUF) : 0.14 % | | | | | | | | | | | |
| Operating Factor (OF) | : 91.67 % | Total off-line time : 730 hours | | | | | | | | | | | |
| Equivalent non-electrical energy generated (NEG) | : 4.22 GW(e).h | | | | | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 764.07 | 555.34 | 98.54 | 735.96 | 755.97 | 729.89 | 740.74 | 738.68 | 730.09 | 758.88 | 739.87 | 765.03 | 8113.04 |
| EAF [%] | 100.00 | 83.93 | 14.13 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.47 |
| UCF [%] | 100.00 | 85.72 | 14.13 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.61 |
| LF [%] | 108.10 | 86.99 | 13.94 | 107.60 | 106.96 | 106.71 | 104.80 | 104.51 | 106.74 | 107.37 | 108.17 | 108.24 | 97.49 |
| OF [%] | 100.00 | 85.71 | 14.78 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.67 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 14.28 | 85.87 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.39 |
| XUF [%] | 0.00 | 1.78 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 |

Historical Summary

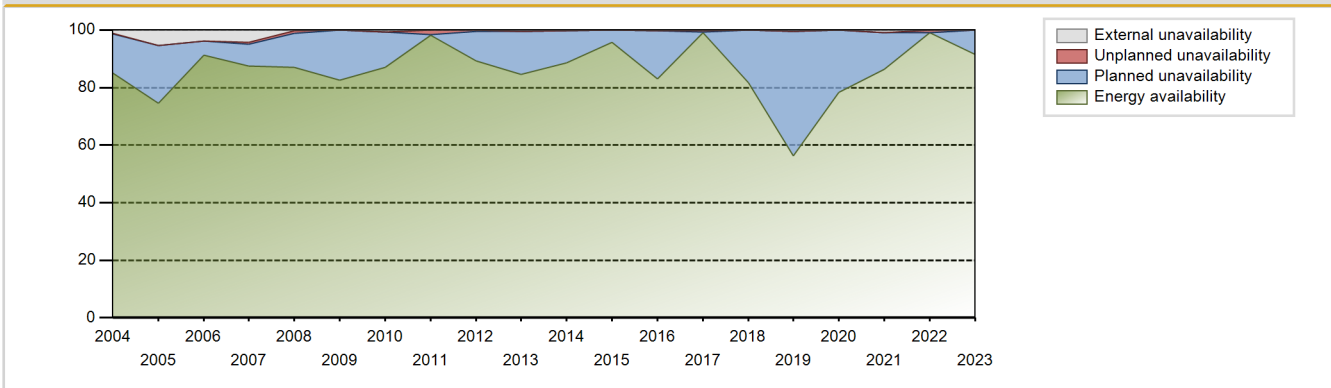
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 227995.02 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.77 % |
| Cumulative Energy Availability Factor (EAF) | : 77.55 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.28 % |
| Cumulative Unit Capability Factor (UCF) | : 80.27 % | Cumulative Planned Unavailability Factor (PUF) | : 17.44 % |
| Cumulative Load Factor (LF) | : 78.38 % | Cumulative Externally cause unavailability (XUF) | : 2.72 % |
| Cumulative Operating Factor (OF) | : 81.46 % | | |

Electricity Production (net) [GWh]

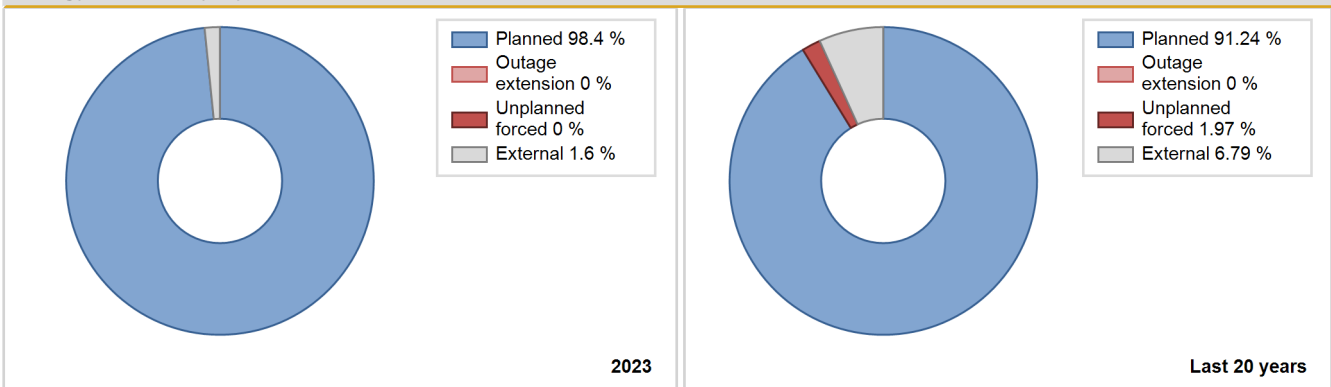


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|-------|--------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 6621.41 | 7792 | 950 | 88.36 | 88.36 | 87.44 | 91.12 | 6.11 | 5.75 | 5.90 | 0.00 |
| 1990 | 5718.71 | 6696 | 950 | 67.84 | 68.04 | 68.72 | 76.44 | 13.53 | 10.65 | 21.31 | 0.19 |
| 1991 | 5403.35 | 6124 | 950 | 64.23 | 67.13 | 64.93 | 69.91 | 12.68 | 9.75 | 23.13 | 2.90 |
| 1992 | 5545.43 | 6202 | 950 | 64.77 | 66.42 | 66.45 | 70.60 | 17.40 | 14.00 | 19.59 | 1.65 |
| 1993 | 4378.64 | 5461 | 950 | 52.73 | 61.63 | 52.62 | 62.34 | 13.51 | 9.63 | 28.74 | 8.90 |
| 1994 | 3340.14 | 5389 | 950 | 70.66 | 70.69 | 40.14 | 61.52 | 10.93 | 8.68 | 20.64 | 0.03 |
| 1995 | 2674.65 | 5511 | 950 | 47.52 | 53.12 | 32.14 | 62.91 | 20.77 | 13.93 | 32.95 | 5.60 |
| 1996 | 5315.40 | 7085 | 950 | 64.26 | 75.94 | 63.70 | 80.66 | 1.93 | 1.49 | 22.57 | 11.68 |
| 1997 | 2058.79 | 3395 | 950 | 25.29 | 38.78 | 24.74 | 38.76 | 0.58 | 0.22 | 60.99 | 13.49 |
| 1998 | 5348.52 | 7136 | 950 | 64.42 | 73.01 | 64.27 | 81.46 | 0.09 | 0.06 | 26.93 | 8.59 |
| 1999 | 5457.98 | 6552 | 950 | 65.61 | 71.98 | 65.59 | 74.79 | 0.16 | 0.12 | 27.91 | 6.37 |
| 2000 | 6482.85 | 7327 | 950 | 77.18 | 82.00 | 77.69 | 83.41 | 1.10 | 0.91 | 17.09 | 4.82 |
| 2001 | 6050.74 | 6927 | 950 | 72.10 | 78.65 | 72.71 | 79.08 | 0.15 | 0.12 | 21.23 | 6.55 |
| 2002 | 6926.31 | 7478 | 950 | 81.99 | 85.35 | 83.23 | 85.37 | 0.01 | 0.01 | 14.64 | 3.36 |
| 2003 | 7016.14 | 7471 | 950 | 83.19 | 85.05 | 84.31 | 85.29 | 0.10 | 0.09 | 14.86 | 1.86 |
| 2004 | 7227.76 | 7607 | 950 | 85.13 | 86.38 | 86.61 | 86.60 | 0.07 | 0.06 | 13.56 | 1.25 |
| 2005 | 6244.44 | 7060 | 950 | 74.50 | 79.90 | 75.04 | 80.59 | 0.00 | 0.00 | 20.10 | 5.40 |
| 2006 | 7741.84 | 8354 | 950 | 91.38 | 95.30 | 93.03 | 95.37 | 0.00 | 0.00 | 4.70 | 3.92 |
| 2007 | 7407.10 | 8050 | 950 | 87.59 | 91.82 | 89.01 | 91.89 | 0.68 | 0.63 | 7.56 | 4.23 |
| 2008 | 7384.34 | 7693 | 950 | 86.99 | 87.15 | 88.49 | 87.58 | 1.09 | 0.96 | 11.89 | 0.16 |
| 2009 | 6932.73 | 7276 | 950 | 82.56 | 82.63 | 83.31 | 83.06 | 0.00 | 0.00 | 17.37 | 0.08 |
| 2010 | 7649.62 | 7710 | 950 | 87.13 | 87.75 | 91.92 | 88.01 | 0.00 | 0.00 | 12.25 | 0.63 |
| 2011 | 8579.15 | 8627 | 950 | 98.26 | 98.26 | 103.10 | 98.49 | 1.61 | 1.61 | 0.13 | 0.00 |
| 2012 | 7716.23 | 7854 | 950 | 89.32 | 89.34 | 92.47 | 89.41 | 0.59 | 0.53 | 10.13 | 0.02 |
| 2013 | 7378.17 | 7481 | 950 | 84.53 | 84.94 | 88.66 | 85.40 | 0.11 | 0.10 | 14.97 | 0.41 |
| 2014 | 7746.92 | 7827 | 950 | 88.55 | 88.82 | 93.08 | 89.34 | 0.00 | 0.00 | 11.18 | 0.26 |
| 2015 | 8250.27 | 8415 | 950 | 95.78 | 95.78 | 99.14 | 96.06 | 0.06 | 0.06 | 4.16 | 0.00 |
| 2016 | 7307.38 | 7331 | 950 | 82.96 | 83.26 | 87.57 | 83.46 | 0.00 | 0.00 | 16.74 | 0.30 |
| 2017 | 8653.43 | 8727 | 950 | 99.16 | 99.48 | 103.98 | 99.62 | 0.41 | 0.40 | 0.11 | 0.32 |
| 2018 | 7167.75 | 7163 | 950 | 81.59 | 81.71 | 86.13 | 81.77 | 0.00 | 0.00 | 18.29 | 0.12 |
| 2019 | 4983.36 | 4979 | 950 | 56.33 | 56.84 | 59.88 | 56.84 | 0.00 | 0.00 | 43.16 | 0.51 |
| 2020 | 6845.49 | 6880 | 950 | 78.34 | 78.34 | 82.03 | 78.32 | 0.00 | 0.00 | 21.66 | 0.00 |
| 2021 | 7559.14 | 7634 | 950 | 86.26 | 87.09 | 90.83 | 87.15 | 0.00 | 0.00 | 12.91 | 0.82 |
| 2022 | 8734.40 | 8674 | 950 | 98.99 | 98.99 | 104.96 | 99.02 | 1.01 | 1.01 | 0.00 | 0.00 |
| 2023 | 8113.04 | 8030 | 950 | 91.47 | 91.61 | 97.49 | 91.67 | 0.00 | 0.00 | 8.39 | 0.14 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 70 | |
| C. Inspection, maintenance or repair combined with refuelling | 731 | | | 1328 | 19 | |
| D. Inspection, maintenance or repair without refuelling | | | | 154 | | |
| E. Testing of plant systems or components | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 42 |
| L. Human factor related | | | | | 5 | |
| Z. Other | | | | | 2 | |
| Subtotal | 731 | | | 1482 | 97 | 43 |
| Total | | 731 | | | 1622 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 22 |
| 13. Reactor Auxiliary Systems | | 0 |
| 15. Reactor Cooling Systems | | 4 |
| 16. Steam generation systems | | 1 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 8 |
| 32. Feedwater and Main Steam System | | 6 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | | 5 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 4 |
| 42. Electrical Power Supply Systems | | 11 |
| Total | | 73 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-December. Additional electricity generation amounted to 433342 MWh. The unit was in the intermediate maintenance outage from 2023.02.25 to 2023.03.27. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

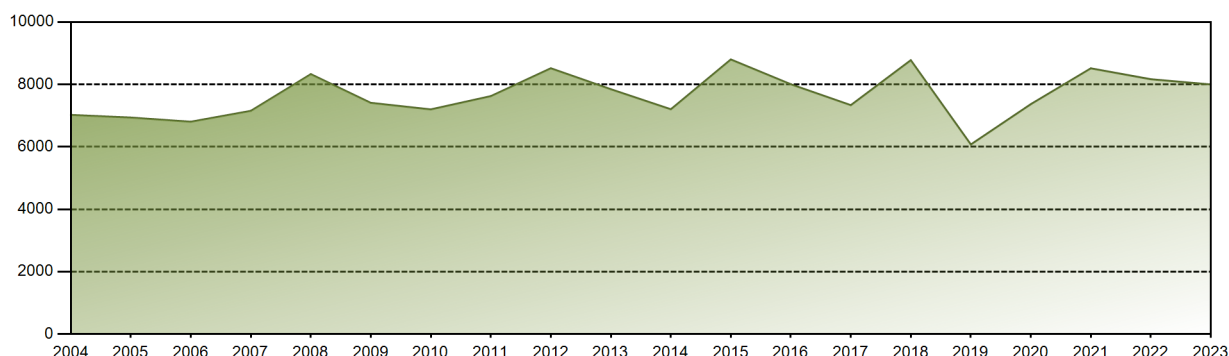
2023 Operating Experience

| RU-99 | | BALAKOVO-4 | | RUSSIA | | | | | | | | | |
|---|--|--|---------------------------------------|-----------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : REA (Joint Stock Company 'Concern Rosenergoatom') | | | | | | | | | | | | |
| Owner | : REA (Joint Stock Company 'Concern Rosenergoatom') | | | | | | | | | | | | |
| Reactor Supplier | : AEM (Atomenergomash) | | | | | | | | | | | | |
| Turbine Supplier | : KALUGA (JSC "Kaluga turbine plant" 32, Glagoleva Street, Kaluga, 248021, Russia) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 1984-04-01 | | | | | | | | | | |
| Thermal power | : 3200 MWth | Grid Date | : 1993-04-11 | | | | | | | | | | |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1993-12-22 | | | | | | | | | | |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 30 years | | | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] : 16 | | | | | | | | | | |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 322 | | | | | | | | | | |
| Fuel material | : UO2 | Number of SG | : 4 | | | | | | | | | | |
| Refuelling type | : OFF-line | Containment type | : Single | | | | | | | | | | |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 | | | | | | | | | | |
| Average fuel enrichment [% of U235] | : - | Secondary systems | | | | | | | | | | | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 | | | | | | | | | | |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1500 | | | | | | | | | | |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine | : - | | | | | | | | | | |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6 | | | | | | | | | | |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : - | | | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : Lake (once-through) | | | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps | : - | | | | | | | | | | |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 | | | | | | | | | | |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 | | | | | | | | | | |
| Coolant type | : H2O | Non-electrical applications | | : DH / PH | | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : 7999.26 GW(e).h | Forced Loss Rate (FLR) | : 0.01 % | | | | | | | | | | |
| Energy Availability Factor (EAF) | : 88.81 % | Unplanned Capability Loss Factor (UCL) | : 0.01 % | | | | | | | | | | |
| Unit Capability Factor (UCF) | : 88.81 % | Planned Unavailability Factor (PUF) | : 11.18 % | | | | | | | | | | |
| Load Factor (LF) | : 96.12 % | Externally cause unavailability (XUF) | : 0 % | | | | | | | | | | |
| Operating Factor (OF) | : 89.01 % | Total off-line time | : 963 hours | | | | | | | | | | |
| Equivalent non-electrical energy generated (NEG) | : 3.96 GW(e).h | | | | | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| <p>Legend: Load Factor (purple line), External loss (grey), Outage extension (orange), Forced loss (red), Planned loss (blue), Energy availability (green).</p> | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 771.79 | 695.33 | 775.58 | 744.71 | 768.14 | 738.14 | 743.25 | 752.73 | 744.26 | 656.39 | 0.00 | 608.94 | 7999.26 |
| EAF [%] | 99.85 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.44 | 0.00 | 78.70 | 88.81 |
| UCF [%] | 99.85 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.44 | 0.00 | 78.70 | 88.81 |
| LF [%] | 109.20 | 108.92 | 109.73 | 108.88 | 108.68 | 107.92 | 105.16 | 106.50 | 108.81 | 92.87 | 0.00 | 86.15 | 96.12 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.10 | 0.00 | 80.24 | 89.01 |
| FLR [%] | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| UCL [%] | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.56 | 100.00 | 21.30 | 11.18 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

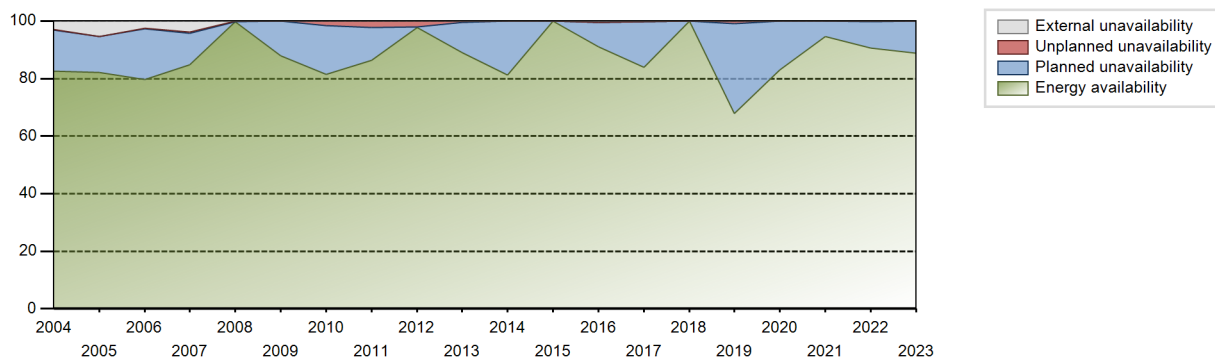
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 213006.56 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.27 % |
| Cumulative Energy Availability Factor (EAF) | : 81.59 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.09 % |
| Cumulative Unit Capability Factor (UCF) | : 84.48 % | Cumulative Planned Unavailability Factor (PUF) | : 14.43 % |
| Cumulative Load Factor (LF) | : 83.79 % | Cumulative Externally cause unavailability (XUF) | : 2.89 % |
| Cumulative Operating Factor (OF) | : 85.61 % | | |

Electricity Production (net) [GWh]

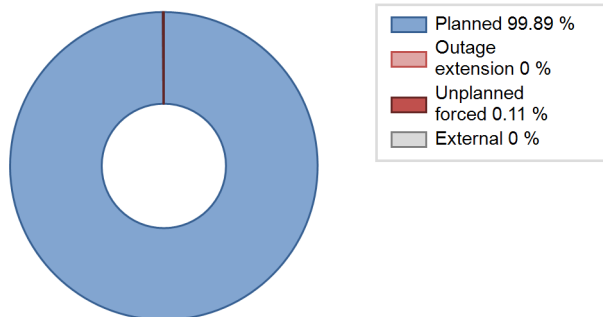


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1993 | 3676.28 | 5206 | 950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1994 | 3828.53 | 4604 | 950 | 48.45 | 69.54 | 46.00 | 52.56 | 1.58 | 1.12 | 29.34 | 21.09 |
| 1995 | 5609.99 | 8760 | 950 | 86.46 | 88.72 | 67.41 | 100.00 | 11.28 | 11.28 | 0.00 | 2.26 |
| 1996 | 4545.55 | 6652 | 950 | 55.47 | 59.85 | 54.47 | 75.73 | 13.90 | 9.66 | 30.49 | 4.39 |
| 1997 | 4637.72 | 6637 | 950 | 59.64 | 71.29 | 55.73 | 75.76 | 0.16 | 0.11 | 28.60 | 11.65 |
| 1998 | 5042.49 | 6936 | 950 | 60.89 | 71.31 | 60.59 | 79.18 | 0.00 | 0.00 | 28.69 | 10.42 |
| 1999 | 5803.91 | 7268 | 950 | 69.59 | 77.55 | 69.74 | 82.97 | 0.37 | 0.29 | 22.17 | 7.95 |
| 2000 | 6665.85 | 7216 | 950 | 78.95 | 80.96 | 79.88 | 82.15 | 0.78 | 0.63 | 18.40 | 2.01 |
| 2001 | 6578.09 | 7354 | 950 | 78.30 | 83.91 | 79.04 | 83.95 | 0.47 | 0.40 | 15.69 | 5.61 |
| 2002 | 6292.92 | 6723 | 950 | 72.80 | 77.28 | 75.62 | 76.75 | 0.20 | 0.16 | 22.57 | 4.47 |
| 2003 | 7223.84 | 7541 | 950 | 84.64 | 85.84 | 86.80 | 86.08 | 0.50 | 0.43 | 13.73 | 1.20 |
| 2004 | 7022.94 | 7540 | 950 | 82.51 | 85.37 | 84.16 | 85.84 | 0.45 | 0.39 | 14.24 | 2.86 |
| 2005 | 6938.28 | 7699 | 950 | 82.14 | 87.62 | 83.36 | 87.88 | 0.00 | 0.00 | 12.38 | 5.48 |
| 2006 | 6805.35 | 7230 | 950 | 79.61 | 82.20 | 81.78 | 82.53 | 0.08 | 0.07 | 17.74 | 2.58 |
| 2007 | 7153.35 | 7787 | 950 | 84.70 | 88.53 | 85.96 | 88.89 | 0.40 | 0.36 | 11.11 | 3.83 |
| 2008 | 8330.42 | 8779 | 950 | 99.71 | 99.73 | 99.83 | 99.94 | 0.14 | 0.14 | 0.13 | 0.02 |
| 2009 | 7409.95 | 7727 | 950 | 87.83 | 87.83 | 89.02 | 88.19 | 0.00 | 0.00 | 12.17 | 0.00 |
| 2010 | 7199.69 | 7168 | 950 | 81.35 | 81.35 | 86.51 | 81.83 | 2.02 | 1.68 | 16.97 | 0.00 |
| 2011 | 7625.20 | 7619 | 950 | 86.42 | 86.42 | 91.64 | 86.98 | 2.50 | 2.22 | 11.36 | 0.00 |
| 2012 | 8517.84 | 8608 | 950 | 97.72 | 97.72 | 102.07 | 98.00 | 2.08 | 2.07 | 0.20 | 0.00 |
| 2013 | 7847.25 | 7847 | 950 | 89.13 | 89.13 | 94.30 | 89.58 | 0.61 | 0.54 | 10.33 | 0.00 |
| 2014 | 7204.52 | 7173 | 950 | 81.27 | 81.36 | 86.56 | 81.87 | 0.00 | 0.00 | 18.64 | 0.09 |
| 2015 | 8800.05 | 8757 | 950 | 100.00 | 100.00 | 105.74 | 99.97 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 8006.24 | 8045 | 950 | 91.07 | 91.58 | 95.94 | 91.59 | 0.00 | 0.00 | 8.42 | 0.52 |
| 2017 | 7336.59 | 7386 | 950 | 83.99 | 84.24 | 88.16 | 84.32 | 0.00 | 0.00 | 15.76 | 0.25 |
| 2018 | 8777.02 | 8760 | 950 | 99.97 | 99.97 | 105.47 | 100.00 | 0.00 | 0.00 | 0.03 | 0.00 |
| 2019 | 6075.81 | 5952 | 950 | 67.76 | 67.76 | 73.01 | 67.95 | 1.15 | 0.88 | 31.36 | 0.00 |
| 2020 | 7368.35 | 7307 | 950 | 83.11 | 83.11 | 88.30 | 83.19 | 0.03 | 0.02 | 16.87 | 0.00 |
| 2021 | 8516.23 | 8296 | 950 | 94.64 | 94.64 | 102.33 | 94.70 | 0.00 | 0.00 | 5.36 | 0.00 |
| 2022 | 8167.11 | 7962 | 950 | 90.70 | 90.76 | 98.14 | 90.89 | 0.15 | 0.13 | 9.11 | 0.05 |
| 2023 | 7999.26 | 7797 | 950 | 88.81 | 88.81 | 96.12 | 89.01 | 0.01 | 0.01 | 11.18 | 0.00 |

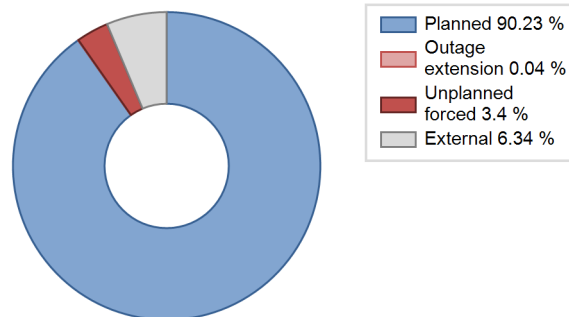
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1993 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 25 | |
| C. Inspection, maintenance or repair combined with refuelling | 971 | | | 1153 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 15 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 11 |
| L. Human factor related | | | | | 0 | |
| Z. Other | | | | | | 56 |
| Subtotal | 971 | | | 1168 | 25 | 67 |
| Total | | 971 | | | 1260 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1993 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 1 |
| 15. Reactor Cooling Systems | | 1 |
| 16. Steam generation systems | | 7 |
| 31. Turbine and auxiliaries | | 2 |
| 32. Feedwater and Main Steam System | | 9 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | | 27 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. Unit operation at power level above installed capacity took place in January-October, December. Additional electricity generation amounted to 543695 MWh. The unit was in the overhaul outage from 2023.10.08 to 2023.12.07. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-21

BELOYARSK-3

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : LMZ (JOINT-STOCK COMPANY "LENINGRADSKIY METALLICHESKIY ZAVOD")



Reactor Unit Details

Reactor type and model : FBR / BN-600
 Thermal power : 1470 MWth
 Gross electrical power : 600 MWe
 Reference unit power (net) : 560 MWe

Key Dates

Construction Date : 1969-01-01
 Grid Date : 1980-04-08
 Commercial Date : 1981-11-01
 Age at end of year : 43 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : -
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : -
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 5
 Part of the core refuelled [%] : 30
 Average discharge burnup [MWd/t] : 100000
 Active core diameter [m] : 2.05
 Active core height/length [m] : 1.03
 Number of fissile fuel assemblies/bundles : 369
 Fuel linear heat generation rate [kW/m] : 38
 Number of control rod assemblies : 19
 Number of external reactor coolant loops : 3
 Coolant type : Na

Operating coolant pressure [MPa] : 8.8
 Reactor outlet temperature [°C] : 550
 Number of SG : 3
 Containment type : -
 Containment design pressure [MPa] : -

Secondary systems

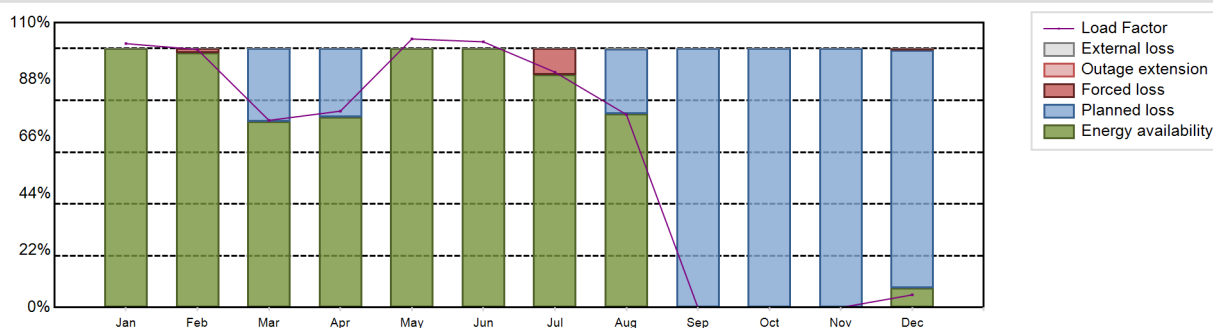
Number of turbine-generators per unit/reactor : 3
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 13
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 2961.93 GW(e).h
 Energy Availability Factor (EAF) : 59.52 %
 Unit Capability Factor (UCF) : 59.52 %
 Load Factor (LF) : 60.38 %
 Operating Factor (OF) : 61.14 %
 Equivalent non-electrical energy generated (NEG) : 52.61 GW(e).h

Forced Loss Rate (FLR) : 1.73 %
 Unplanned Capability Loss Factor (UCL) : 1.05 %
 Planned Unavailability Factor (PUF) : 39.44 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 3404 hours

Annual Summary

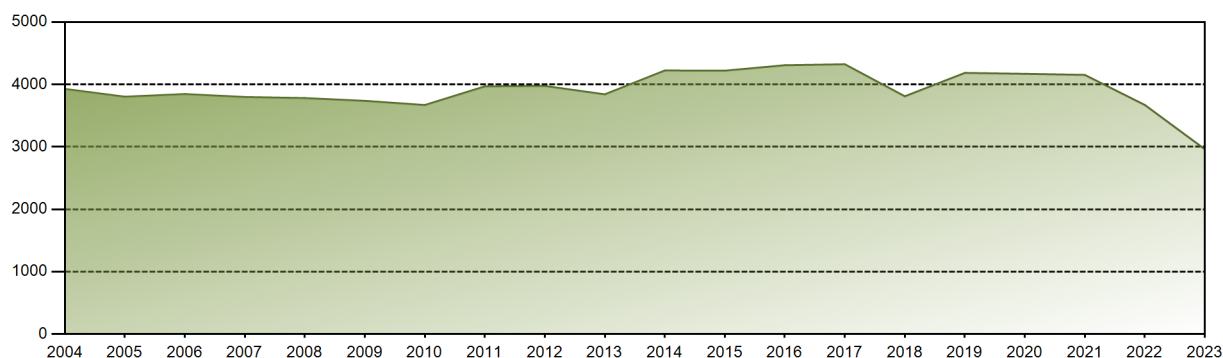


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|-------|-------|---------|
| GW(e)-h | 424.65 | 374.94 | 301.12 | 305.82 | 432.11 | 413.72 | 378.71 | 310.47 | 0.00 | 0.00 | 0.00 | 20.39 | 2961.93 |
| EAF [%] | 100.00 | 98.41 | 71.76 | 73.45 | 100.00 | 100.00 | 89.84 | 74.74 | 0.04 | 0.04 | 0.04 | 7.57 | 59.52 |
| UCF [%] | 100.00 | 98.41 | 71.76 | 73.45 | 100.00 | 100.00 | 89.84 | 74.76 | 0.04 | 0.04 | 0.04 | 7.57 | 59.52 |
| LF [%] | 101.92 | 99.63 | 72.27 | 75.85 | 103.71 | 102.61 | 90.90 | 74.52 | 0.00 | 0.00 | 0.00 | 4.89 | 60.38 |
| OF [%] | 100.00 | 100.00 | 73.12 | 75.00 | 100.00 | 100.00 | 100.00 | 76.21 | 0.00 | 0.00 | 0.00 | 10.89 | 61.14 |
| FLR [%] | 0.00 | 1.59 | 0.00 | 0.00 | 0.00 | 0.00 | 10.16 | 0.00 | 0.00 | 0.00 | 0.00 | 8.84 | 1.73 |
| UCL [%] | 0.00 | 1.59 | 0.00 | 0.00 | 0.00 | 0.00 | 10.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.73 | 1.05 |
| PUF [%] | 0.00 | 0.00 | 28.24 | 26.55 | 0.00 | 0.00 | 0.00 | 25.24 | 99.96 | 99.96 | 99.96 | 91.70 | 39.44 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 159916.04 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.59 % |
| Cumulative Energy Availability Factor (EAF) | : 75.43 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.89 % |
| Cumulative Unit Capability Factor (UCF) | : 75.92 % | Cumulative Planned Unavailability Factor (PUF) | : 21.18 % |
| Cumulative Load Factor (LF) | : 75.95 % | Cumulative Externally cause unavailability (XUF) | : 0.49 % |
| Cumulative Operating Factor (OF) | : 78.43 % | | |

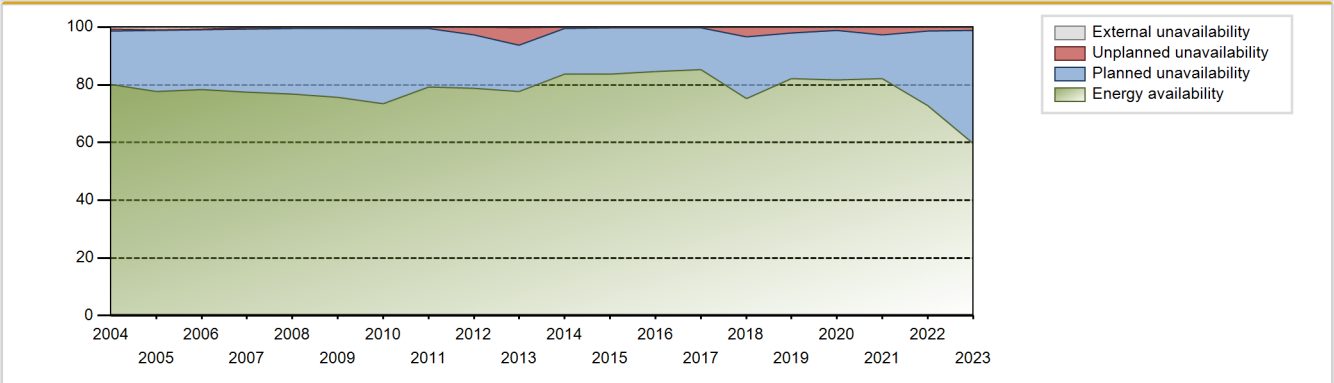
Electricity Production (net) [GWh]



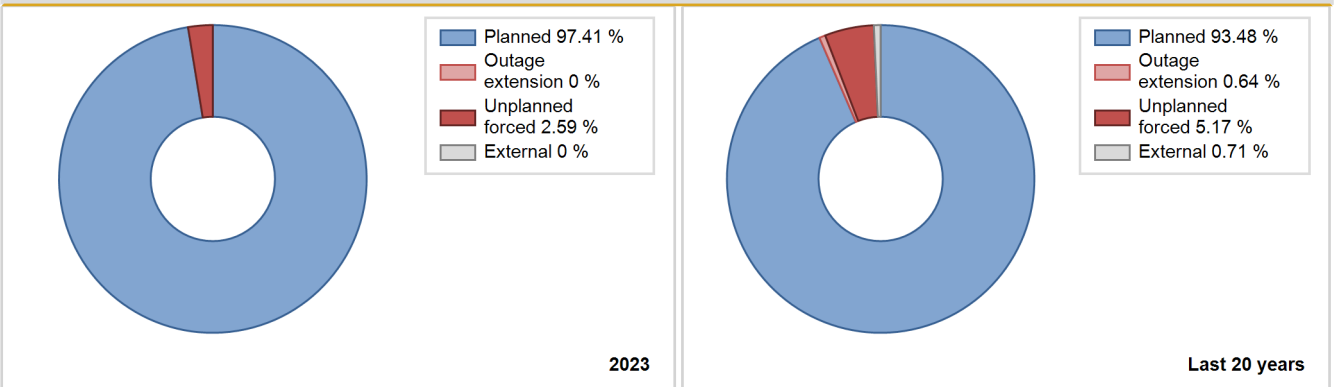
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | | | | Data not provided | | | | | | | |
| 1982 | 2771.00 | 5555 | 560 | 59.25 | 59.25 | 56.49 | 63.41 | 11.50 | 7.70 | 33.05 | 0.00 |
| 1983 | 3545.21 | 6737 | 560 | 72.72 | 73.35 | 72.27 | 76.91 | 3.71 | 2.82 | 23.83 | 0.63 |
| 1984 | 3584.11 | 6848 | 560 | 73.29 | 73.29 | 72.86 | 77.96 | 5.70 | 4.43 | 22.28 | 0.00 |
| 1985 | 3561.83 | 6544 | 560 | 72.85 | 72.85 | 72.61 | 74.70 | 2.47 | 1.85 | 25.30 | 0.00 |
| 1986 | 3600.73 | 6818 | 560 | 73.82 | 74.28 | 73.40 | 77.83 | 4.78 | 3.73 | 21.99 | 0.46 |
| 1987 | 3894.99 | 6714 | 600 | 75.93 | 75.93 | 74.11 | 76.64 | 2.64 | 2.05 | 22.02 | 0.00 |
| 1988 | 3762.19 | 6810 | 560 | 76.97 | 76.97 | 76.48 | 77.53 | 0.38 | 0.30 | 22.74 | 0.00 |
| 1989 | 3694.43 | 6800 | 560 | 76.95 | 76.95 | 75.31 | 77.63 | 1.21 | 0.94 | 22.10 | 0.00 |
| 1990 | 3198.00 | 6627 | 560 | 65.85 | 66.65 | 65.19 | 75.65 | 11.05 | 8.28 | 25.07 | 0.79 |
| 1991 | 3394.00 | 6631 | 560 | 63.57 | 63.57 | 69.19 | 75.70 | 13.75 | 10.14 | 26.29 | 0.00 |
| 1992 | 4094.97 | 7449 | 560 | 82.82 | 83.06 | 83.26 | 84.81 | 0.34 | 0.28 | 16.66 | 0.24 |
| 1993 | 3914.92 | 7065 | 560 | 79.49 | 79.57 | 79.81 | 80.65 | 7.18 | 6.15 | 14.28 | 0.07 |
| 1994 | 3810.67 | 6977 | 560 | 78.78 | 78.92 | 77.68 | 79.65 | 0.90 | 0.71 | 20.37 | 0.14 |
| 1995 | 3413.27 | 6953 | 560 | 70.70 | 72.28 | 69.58 | 79.37 | 9.36 | 7.46 | 20.26 | 1.57 |
| 1996 | 3722.33 | 7010 | 560 | 76.32 | 78.07 | 75.67 | 79.80 | 1.72 | 1.37 | 20.57 | 1.75 |
| 1997 | 3545.80 | 6596 | 560 | 72.97 | 74.58 | 72.28 | 75.30 | 0.00 | 0.00 | 25.42 | 1.61 |
| 1998 | 2335.33 | 4385 | 560 | 47.67 | 49.23 | 47.61 | 50.06 | 38.80 | 31.21 | 19.55 | 1.56 |
| 1999 | 3720.99 | 6972 | 560 | 76.18 | 77.96 | 75.85 | 79.59 | 4.10 | 3.34 | 18.71 | 1.78 |
| 2000 | 3565.82 | 6820 | 560 | 72.49 | 75.49 | 72.49 | 77.64 | 0.31 | 0.23 | 24.27 | 3.00 |
| 2001 | 3891.10 | 7214 | 560 | 79.90 | 80.72 | 79.32 | 82.35 | 1.24 | 1.01 | 18.27 | 0.82 |
| 2002 | 3774.40 | 7069 | 560 | 77.30 | 79.34 | 76.94 | 80.70 | 2.14 | 1.74 | 18.93 | 2.04 |
| 2003 | 3693.28 | 6836 | 560 | 75.74 | 76.81 | 75.29 | 78.04 | 0.91 | 0.71 | 22.48 | 1.07 |
| 2004 | 3927.64 | 7185 | 560 | 80.02 | 80.81 | 79.85 | 81.80 | 0.78 | 0.64 | 18.56 | 0.78 |
| 2005 | 3802.75 | 6977 | 560 | 77.76 | 78.77 | 77.52 | 79.65 | 0.09 | 0.07 | 21.16 | 1.02 |
| 2006 | 3844.94 | 7001 | 560 | 78.38 | 79.02 | 78.38 | 79.92 | 0.36 | 0.29 | 20.69 | 0.65 |
| 2007 | 3798.42 | 7089 | 560 | 77.52 | 77.80 | 77.43 | 80.92 | 0.46 | 0.36 | 21.84 | 0.28 |
| 2008 | 3781.03 | 6918 | 560 | 76.85 | 76.95 | 76.87 | 78.76 | 0.47 | 0.36 | 22.69 | 0.10 |
| 2009 | 3736.60 | 6734 | 560 | 75.58 | 75.61 | 76.17 | 76.87 | 0.49 | 0.37 | 24.01 | 0.03 |
| 2010 | 3669.75 | 6541 | 560 | 73.51 | 73.56 | 74.81 | 74.67 | 0.73 | 0.54 | 25.90 | 0.05 |
| 2011 | 3968.73 | 7141 | 560 | 79.17 | 79.17 | 80.91 | 81.53 | 0.71 | 0.57 | 20.26 | 0.00 |
| 2012 | 3975.50 | 7250 | 560 | 78.84 | 78.84 | 80.82 | 82.54 | 1.62 | 2.69 | 18.47 | 0.00 |
| 2013 | 3841.06 | 7398 | 560 | 77.62 | 77.80 | 78.30 | 84.45 | 7.27 | 6.10 | 16.11 | 0.18 |
| 2014 | 4222.91 | 7455 | 560 | 83.77 | 83.77 | 86.07 | 85.09 | 0.58 | 0.49 | 15.75 | 0.00 |
| 2015 | 4220.16 | 7414 | 560 | 83.78 | 83.78 | 86.03 | 84.63 | 0.39 | 0.33 | 15.89 | 0.00 |
| 2016 | 4307.17 | 7517 | 560 | 84.66 | 84.66 | 87.56 | 85.58 | 0.41 | 0.35 | 14.98 | 0.00 |
| 2017 | 4323.23 | 7548 | 560 | 85.36 | 85.36 | 88.13 | 86.16 | 0.32 | 0.27 | 14.36 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2018 | 3809.52 | 6911 | 560 | 75.28 | 75.28 | 77.66 | 78.89 | 3.23 | 3.38 | 21.34 | 0.00 |
| 2019 | 4184.26 | 7453 | 560 | 82.22 | 82.22 | 85.30 | 85.08 | 1.95 | 2.15 | 15.63 | 0.00 |
| 2020 | 4169.76 | 7338 | 560 | 81.60 | 81.60 | 84.77 | 83.54 | 1.47 | 1.22 | 17.19 | 0.00 |
| 2021 | 4152.25 | 7484 | 560 | 82.23 | 82.23 | 84.64 | 85.43 | 3.10 | 2.63 | 15.14 | 0.00 |
| 2022 | 3670.83 | 6590 | 560 | 72.84 | 72.84 | 74.83 | 75.23 | 1.80 | 1.33 | 25.83 | 0.00 |
| 2023 | 2961.93 | 5356 | 560 | 59.52 | 59.52 | 60.38 | 61.14 | 1.73 | 1.05 | 39.44 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 113 | |
| C. Inspection, maintenance or repair combined with refuelling | 3405 | | | 1343 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 400 | 5 | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 1 | |
| T. Heat supply (on-site to support next unit or desalination and off-site distribution) | | | | | | 0 |
| Subtotal | 3405 | | | 1743 | 120 | 3 |
| Total | | 3405 | | | 1866 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 2 |
| 13. Reactor Auxiliary Systems | | 11 |
| 15. Reactor Cooling Systems | | 27 |
| 21. Fuel Handling and Storage Facilities | | 63 |
| 31. Turbine and auxiliaries | | 2 |
| 32. Feedwater and Main Steam System | | 2 |
| 35. All other I&C Systems | | 4 |
| 42. Electrical Power Supply Systems | | 1 |
| Total | | 115 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. Unit operation at power level above installed capacity took place in January-August. Additional electricity generation amounted to 56623 MWh. The unit was in the routine maintenance outage from 2023.03.23 to 2023.04.08 and the intermediate maintenance outage from 2023.08.24 to 2023.12.28. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-116

BELOYARSK-4

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : AEM (Atomenergomash)



Reactor Unit Details

Reactor type and model : FBR / BN-800
 Thermal power : 2100 MWth
 Gross electrical power : 885 MWe
 Reference unit power (net) : 820 MWe

Key Dates

Construction Date : 2006-07-18
 Grid Date : 2015-12-10
 Commercial Date : 2016-10-31
 Age at end of year : 8 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : -
 Fuel material : UO2/PuO2
 Refuelling type : OFF-line
 Moderator material : -
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 6
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : -
 Active core diameter [m] : 2.56
 Active core height/length [m] : 0.88
 Number of fissile fuel assemblies/bundles : 565
 Fuel linear heat generation rate [kW/m] : 38
 Number of control rod assemblies : 16
 Number of external reactor coolant loops : 3
 Coolant type : NA

Operating coolant pressure [MPa] : 1.65
 Reactor outlet temperature [°C] : 547
 Number of SG : 3
 Containment type : -
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 13
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

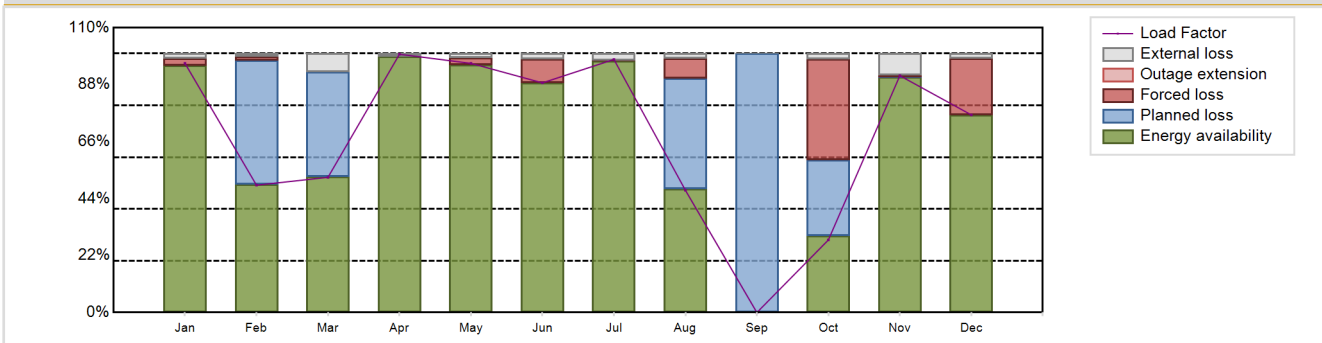
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 4937.4 GW(e).h
 Energy Availability Factor (EAF) : 68.68 %
 Unit Capability Factor (UCF) : 71.35 %
 Load Factor (LF) : 68.74 %
 Operating Factor (OF) : 76.45 %

Forced Loss Rate (FLR) : 9.2 %
 Unplanned Capability Loss Factor (UCL) : 7.23 %
 Planned Unavailability Factor (PUF) : 21.42 %
 Externally cause unavailability (XUF) : 2.67 %
 Total off-line time : 2063 hours

Annual Summary

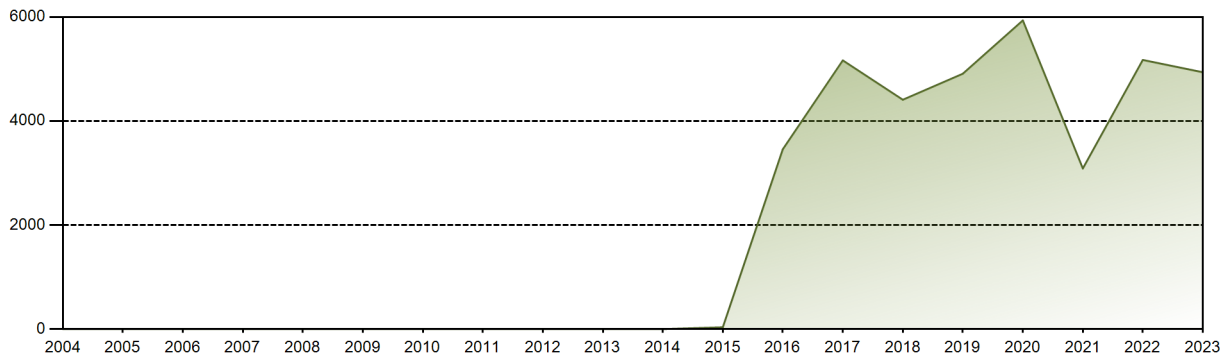


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|---------|
| GW(e)-h | 587.10 | 270.98 | 318.55 | 588.93 | 587.05 | 523.67 | 596.28 | 288.09 | 0.00 | 171.05 | 540.04 | 465.65 | 4937.40 |
| EAF [%] | 95.42 | 49.53 | 52.58 | 98.86 | 95.59 | 88.62 | 97.18 | 47.87 | 0.06 | 29.58 | 90.85 | 76.30 | 68.68 |
| UCF [%] | 97.18 | 50.68 | 59.75 | 100.00 | 97.18 | 90.86 | 99.90 | 49.74 | 0.06 | 31.75 | 99.18 | 78.08 | 71.35 |
| LF [%] | 96.23 | 49.18 | 52.21 | 99.75 | 96.23 | 88.70 | 97.74 | 47.22 | 0.00 | 28.04 | 91.47 | 76.33 | 68.74 |
| OF [%] | 100.00 | 53.87 | 61.29 | 100.00 | 100.00 | 92.78 | 100.00 | 58.33 | 0.00 | 48.52 | 100.00 | 100.00 | 76.45 |
| FLR [%] | 2.82 | 2.71 | 0.00 | 0.00 | 2.82 | 9.14 | 0.10 | 13.57 | 0.00 | 55.09 | 0.64 | 21.92 | 9.20 |
| UCL [%] | 2.82 | 1.41 | 0.00 | 0.00 | 2.82 | 9.14 | 0.10 | 7.81 | 0.00 | 38.96 | 0.64 | 21.92 | 7.23 |
| PUF [%] | 0.00 | 47.91 | 40.25 | 0.00 | 0.00 | 0.00 | 0.00 | 42.45 | 99.94 | 29.29 | 0.18 | 0.00 | 21.42 |
| XUF [%] | 1.76 | 1.15 | 7.16 | 1.14 | 1.60 | 2.24 | 2.72 | 1.87 | 0.00 | 2.18 | 8.33 | 1.78 | 2.67 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 37108.78 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.01 % |
| Cumulative Energy Availability Factor (EAF) | : 67.06 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.93 % |
| Cumulative Unit Capability Factor (UCF) | : 68.44 % | Cumulative Planned Unavailability Factor (PUF) | : 25.63 % |
| Cumulative Load Factor (LF) | : 67.18 % | Cumulative Externally cause unavailability (XUF) | : 1.38 % |
| Cumulative Operating Factor (OF) | : 71.12 % | | |

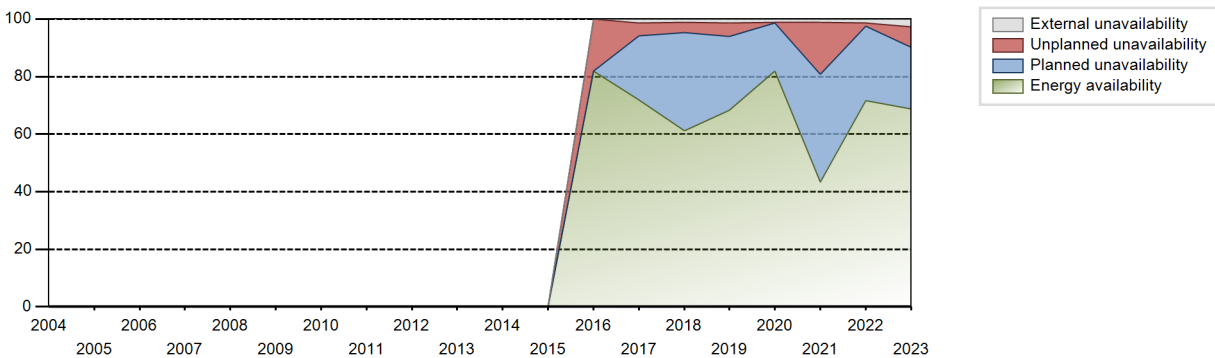
Electricity Production (net) [GWh]



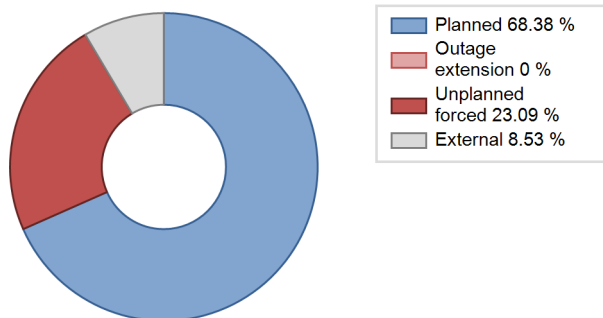
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 3456.96 | 5453 | 820 | 81.92 | 81.92 | 81.96 | 96.45 | 18.08 | 18.08 | 0.00 | 0.00 |
| 2017 | 5165.75 | 6551 | 820 | 71.81 | 73.11 | 71.91 | 74.78 | 1.71 | 4.59 | 22.30 | 1.29 |
| 2018 | 4408.98 | 5680 | 820 | 61.25 | 62.29 | 61.38 | 64.84 | 5.45 | 3.59 | 34.12 | 1.04 |
| 2019 | 4909.25 | 6196 | 820 | 68.26 | 69.65 | 68.34 | 70.73 | 3.35 | 4.61 | 25.74 | 1.39 |
| 2020 | 5934.14 | 7373 | 820 | 81.92 | 82.98 | 82.39 | 83.94 | 0.45 | 0.38 | 16.64 | 1.06 |
| 2021 | 3087.27 | 4049 | 820 | 43.31 | 44.47 | 42.98 | 46.22 | 28.75 | 17.95 | 37.58 | 1.15 |
| 2022 | 5174.47 | 6710 | 820 | 71.64 | 72.91 | 72.04 | 76.60 | 1.54 | 1.14 | 25.95 | 1.28 |
| 2023 | 4937.40 | 6697 | 820 | 68.68 | 71.35 | 68.74 | 76.45 | 9.20 | 7.23 | 21.42 | 2.67 |

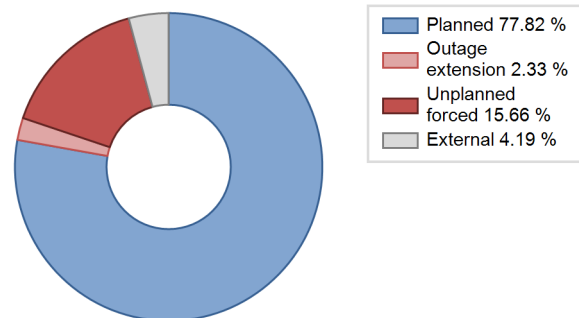
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 225 | | | 352 | |
| C. Inspection, maintenance or repair combined with refuelling | 1832 | | | 1816 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 370 | | |
| Subtotal | 1832 | 225 | | 2186 | 352 | |
| Total | | 2057 | | | 2538 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|-------------------------------------|------------|------------|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 177 | | 22 |
| 12. Reactor I&C Systems | | 48 | | 30 |
| 14. Safety Systems | | | | 9 |
| 15. Reactor Cooling Systems | | | | 155 |
| 31. Turbine and auxiliaries | | | | 57 |
| 32. Feedwater and Main Steam System | | | | 7 |
| 41. Main Generator Systems | | | | 29 |
| 42. Electrical Power Supply Systems | | | | 7 |
| Total | | 225 | | 316 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. The unit was in the routine maintenance outage from 2023.02.16 to 2023.03.12 and the overhaul from 2023.08.19 to 2023.10.09. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-142

BILIBINO-2

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : LWGR / EGP-6
 Thermal power : 62 MWth
 Gross electrical power : 12 MWe
 Reference unit power (net) : 11 MWe

Key Dates

Construction Date : 1970-01-01
 Grid Date : 1974-12-30
 Commercial Date : 1975-02-01
 Age at end of year : 49 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : GRAPHITE
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 3000
 Active core diameter [m] : 4.1
 Active core height/length [m] : 3
 Number of fissile fuel assemblies/bundles : 273
 Fuel linear heat generation rate [kW/m] : 27
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 6
 Reactor outlet temperature [°C] : 280
 Number of SG : NA
 Containment type : NA
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

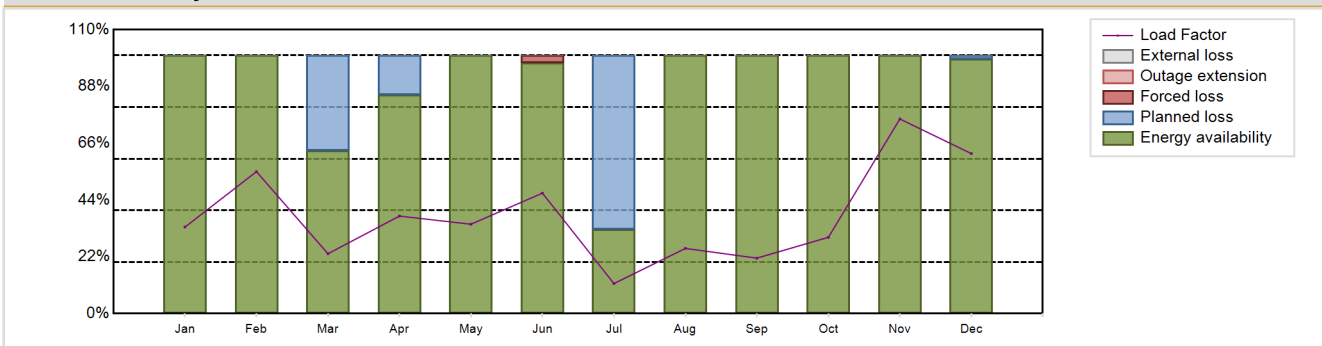
Non-electrical applications : DH

Annual Production Results (2023)

Net Energy Production : 36.43 GW(e).h
 Energy Availability Factor (EAF) : 89.52 %
 Unit Capability Factor (UCF) : 89.52 %
 Load Factor (LF) : 37.8 %
 Operating Factor (OF) : 88.81 %
 Equivalent non-electrical energy generated (NEG) : 13.35 GW(e).h

Forced Loss Rate (FLR) : 0.26 %
 Unplanned Capability Loss Factor (UCL) : 0.23 %
 Planned Unavailability Factor (PUF) : 10.25 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 980 hours

Annual Summary

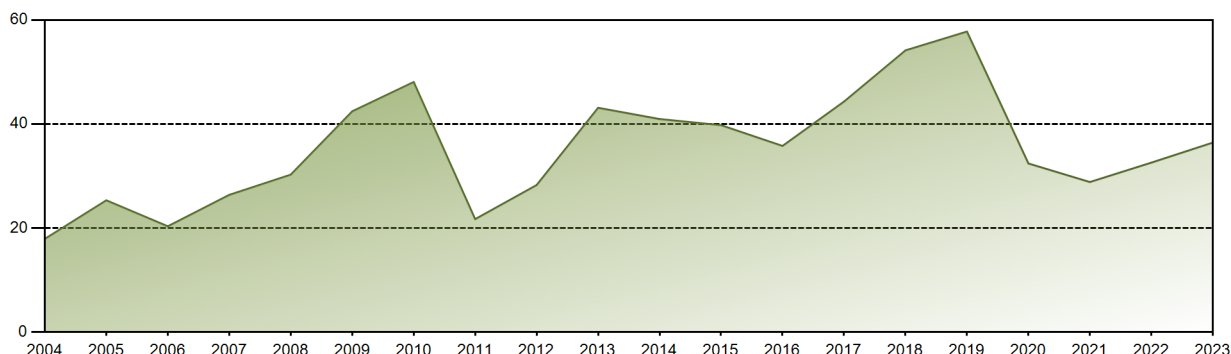


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|-------|--------|-------|-------|--------|--------|--------|--------|-------|--------|
| GW(e)-h | 2.75 | 4.07 | 1.90 | 2.99 | 2.83 | 3.70 | 0.95 | 2.07 | 1.70 | 2.42 | 5.97 | 5.07 | 36.43 |
| EAF [%] | 100.00 | 100.00 | 63.14 | 84.68 | 100.00 | 97.15 | 32.49 | 100.00 | 100.00 | 100.00 | 100.00 | 98.55 | 89.52 |
| UCF [%] | 100.00 | 100.00 | 63.14 | 84.68 | 100.00 | 97.15 | 32.49 | 100.00 | 100.00 | 100.00 | 100.00 | 98.55 | 89.52 |
| LF [%] | 33.54 | 55.01 | 23.22 | 37.79 | 34.64 | 46.68 | 11.66 | 25.27 | 21.50 | 29.57 | 75.40 | 61.99 | 37.80 |
| OF [%] | 100.00 | 100.00 | 61.42 | 84.03 | 100.00 | 94.31 | 29.30 | 100.00 | 100.00 | 100.00 | 100.00 | 98.52 | 88.81 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 |
| PUF [%] | 0.00 | 0.00 | 36.86 | 15.32 | 0.00 | 0.00 | 67.51 | 0.00 | 0.00 | 0.00 | 0.00 | 1.45 | 10.25 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|-------------------|---|-----------|
| Lifetime energy generation | : 2344.32 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.73 % |
| Cumulative Energy Availability Factor (EAF) | : 73.49 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.44 % |
| Cumulative Unit Capability Factor (UCF) | : 81.81 % | Cumulative Planned Unavailability Factor (PUF) | : 16.75 % |
| Cumulative Load Factor (LF) | : 51.13 % | Cumulative Externally cause unavailability (XUF) | : 8.32 % |
| Cumulative Operating Factor (OF) | : 79.66 % | | |

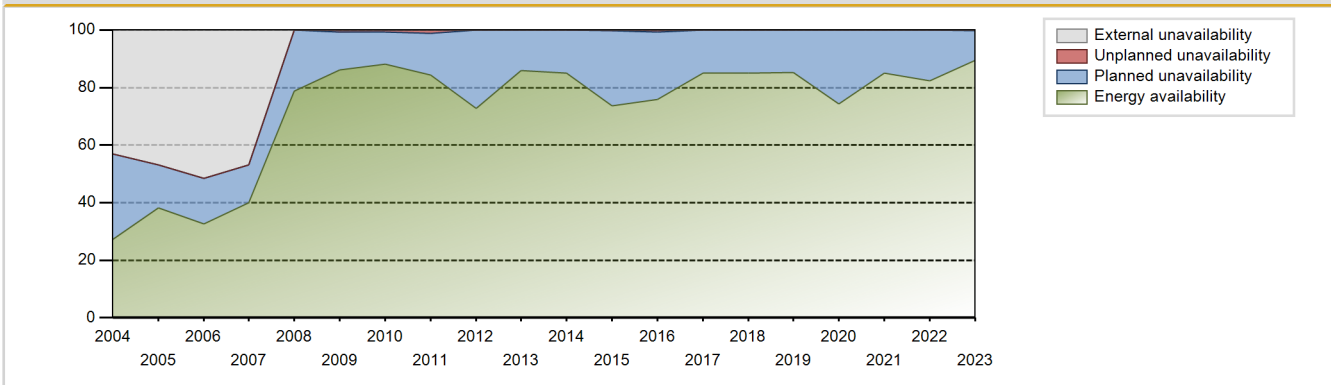
Electricity Production (net) [GWh]



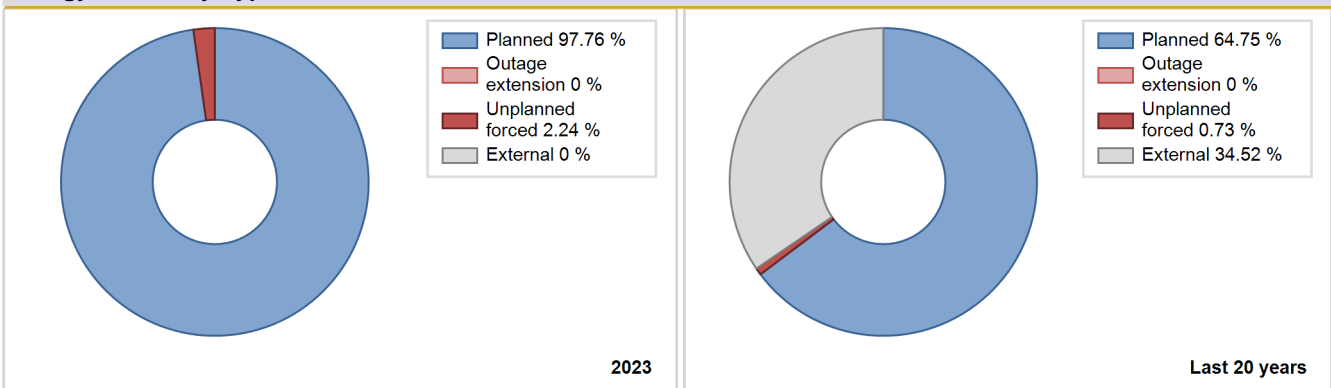
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 63.76 | 7365 | 10 | 88.97 | 94.67 | 78.14 | 90.14 | 1.31 | 1.26 | 4.07 | 5.70 |
| 1976 | 66.10 | 7901 | 10 | 83.67 | 89.44 | 75.25 | 89.95 | 1.10 | 0.99 | 9.56 | 5.77 |
| 1977 | 57.04 | 7865 | 10 | 81.34 | 90.50 | 65.12 | 89.78 | 0.05 | 0.05 | 9.46 | 9.16 |
| 1978 | 60.61 | 7929 | 10 | 94.81 | 94.81 | 69.19 | 90.51 | 0.00 | 0.00 | 5.19 | 0.00 |
| 1979 | 69.85 | 8170 | 10 | 88.17 | 92.93 | 79.74 | 93.26 | 0.08 | 0.07 | 7.00 | 4.76 |
| 1980 | 44.05 | 5666 | 10 | 59.82 | 62.73 | 50.15 | 64.50 | 35.24 | 34.13 | 3.14 | 2.91 |
| 1981 | 41.36 | 6520 | 10 | 70.39 | 73.15 | 47.21 | 74.43 | 4.87 | 3.74 | 23.11 | 2.76 |
| 1982 | 63.92 | 7028 | 10 | 79.24 | 79.24 | 72.97 | 80.23 | 0.00 | 0.00 | 20.76 | 0.00 |
| 1983 | 73.76 | 7880 | 10 | 86.92 | 90.06 | 84.20 | 89.95 | 1.96 | 1.80 | 8.14 | 3.14 |
| 1984 | 77.63 | 7891 | 10 | 88.51 | 89.32 | 88.38 | 89.83 | 0.29 | 0.26 | 10.41 | 0.81 |
| 1985 | 78.00 | 7940 | 10 | 88.57 | 90.29 | 89.04 | 90.64 | 0.46 | 0.42 | 9.29 | 1.73 |
| 1986 | 76.34 | 7679 | 10 | 84.69 | 87.04 | 87.14 | 87.66 | 0.03 | 0.02 | 12.93 | 2.35 |
| 1987 | 88.42 | 7794 | 12 | 89.10 | 89.10 | 84.12 | 88.97 | 0.00 | 0.00 | 10.90 | 0.00 |
| 1988 | 75.07 | 7927 | 11 | 90.84 | 90.84 | 77.69 | 90.24 | 0.64 | 0.58 | 8.57 | 0.00 |
| 1989 | 74.81 | 7943 | 11 | 91.38 | 91.38 | 77.64 | 90.67 | 0.34 | 0.31 | 8.31 | 0.00 |
| 1990 | 72.62 | 7274 | 11 | 84.57 | 84.57 | 75.36 | 83.04 | 3.23 | 2.83 | 12.61 | 0.00 |
| 1991 | 57.83 | 4821 | 11 | 64.92 | 64.92 | 60.02 | 55.03 | 20.10 | 16.33 | 18.74 | 0.00 |
| 1992 | 68.24 | 7857 | 11 | 89.91 | 89.91 | 70.63 | 89.45 | 0.10 | 0.09 | 9.99 | 0.00 |
| 1993 | 52.45 | 7072 | 11 | 62.17 | 81.86 | 54.43 | 80.73 | 1.69 | 1.41 | 16.73 | 19.69 |
| 1994 | 47.83 | 6763 | 11 | 77.31 | 78.74 | 49.64 | 77.20 | 2.81 | 2.28 | 18.98 | 1.43 |
| 1995 | 45.45 | 8677 | 11 | 97.19 | 99.19 | 47.16 | 99.05 | 0.69 | 0.69 | 0.12 | 2.00 |
| 1996 | 16.83 | 2894 | 11 | 33.47 | 33.47 | 17.42 | 32.95 | 2.84 | 0.98 | 65.55 | 0.00 |
| 1997 | 44.11 | 8050 | 11 | 87.71 | 92.70 | 45.78 | 91.89 | 0.36 | 0.34 | 6.97 | 4.99 |
| 1998 | 18.16 | 3727 | 11 | 23.30 | 42.91 | 18.85 | 42.55 | 0.07 | 0.03 | 57.06 | 19.61 |
| 1999 | 54.16 | 7355 | 11 | 64.09 | 84.73 | 56.21 | 83.96 | 0.45 | 0.39 | 14.88 | 20.64 |
| 2000 | 48.46 | 6656 | 11 | 56.35 | 78.15 | 50.15 | 75.77 | 0.22 | 0.17 | 21.68 | 21.80 |
| 2001 | 56.71 | 7439 | 11 | 65.81 | 85.23 | 58.86 | 84.92 | 0.00 | 0.00 | 14.77 | 19.42 |
| 2002 | 30.02 | 5744 | 11 | 38.39 | 66.40 | 31.16 | 65.57 | 0.00 | 0.00 | 33.60 | 28.01 |
| 2003 | 33.25 | 7162 | 11 | 44.48 | 82.22 | 34.51 | 81.76 | 0.00 | 0.00 | 17.78 | 37.74 |
| 2004 | 17.92 | 5851 | 11 | 27.23 | 70.29 | 18.55 | 66.61 | 0.00 | 0.00 | 29.71 | 43.05 |
| 2005 | 25.33 | 7351 | 11 | 38.19 | 84.94 | 26.29 | 83.92 | 0.03 | 0.03 | 15.03 | 46.76 |
| 2006 | 20.34 | 7248 | 11 | 32.71 | 84.22 | 21.11 | 82.74 | 0.00 | 0.00 | 15.78 | 51.52 |
| 2007 | 26.38 | 7478 | 11 | 39.89 | 86.70 | 27.37 | 85.37 | 0.00 | 0.00 | 13.30 | 46.80 |
| 2008 | 30.27 | 6490 | 11 | 78.78 | 78.78 | 31.33 | 73.88 | 0.00 | 0.00 | 21.22 | 0.00 |
| 2009 | 42.44 | 7388 | 11 | 86.12 | 86.12 | 44.04 | 84.34 | 0.89 | 0.78 | 13.10 | 0.00 |
| 2010 | 48.08 | 7627 | 11 | 88.09 | 88.09 | 49.89 | 87.07 | 0.75 | 0.66 | 11.25 | 0.00 |
| 2011 | 21.71 | 4977 | 11 | 84.38 | 84.38 | 22.53 | 56.82 | 1.45 | 1.24 | 14.38 | 0.00 |

| | | | | | | | | | | | |
|------|-------|------|----|-------|-------|-------|-------|------|------|-------|------|
| 2012 | 28.27 | 5461 | 11 | 72.73 | 72.73 | 29.26 | 62.17 | 0.05 | 0.04 | 27.24 | 0.00 |
| 2013 | 43.12 | 6904 | 11 | 85.84 | 85.84 | 44.75 | 78.81 | 0.00 | 0.00 | 14.16 | 0.00 |
| 2014 | 40.96 | 6457 | 11 | 84.92 | 84.92 | 42.51 | 73.71 | 0.00 | 0.00 | 15.08 | 0.00 |
| 2015 | 39.78 | 6331 | 11 | 73.73 | 73.73 | 41.28 | 72.27 | 0.44 | 0.32 | 25.95 | 0.00 |
| 2016 | 35.79 | 6506 | 11 | 75.88 | 75.88 | 37.04 | 74.07 | 0.86 | 0.66 | 23.46 | 0.00 |
| 2017 | 44.31 | 7393 | 11 | 85.12 | 85.12 | 45.98 | 84.39 | 0.00 | 0.00 | 14.88 | 0.00 |
| 2018 | 54.16 | 7383 | 11 | 84.99 | 84.99 | 56.20 | 84.28 | 0.00 | 0.00 | 15.01 | 0.00 |
| 2019 | 57.78 | 7398 | 11 | 85.16 | 85.16 | 59.97 | 84.45 | 0.00 | 0.00 | 14.84 | 0.00 |
| 2020 | 32.42 | 6429 | 11 | 74.40 | 74.40 | 33.55 | 73.19 | 0.00 | 0.00 | 25.60 | 0.00 |
| 2021 | 28.85 | 7051 | 11 | 85.10 | 85.10 | 29.94 | 80.49 | 0.00 | 0.00 | 14.90 | 0.00 |
| 2022 | 32.58 | 7214 | 11 | 82.42 | 82.42 | 33.81 | 82.35 | 0.00 | 0.00 | 17.58 | 0.00 |
| 2023 | 36.43 | 7780 | 11 | 89.52 | 89.52 | 37.80 | 88.81 | 0.26 | 0.23 | 10.25 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 41 | | | 101 | |
| B. Refuelling without maintenance | | | | 8 | | |
| C. Inspection, maintenance or repair combined with refuelling | 929 | | | 1414 | 61 | |
| D. Inspection, maintenance or repair without refuelling | | | | 97 | | |
| E. Testing of plant systems or components | 11 | | | 7 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 12 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 109 |
| L. Human factor related | | | | | 5 | |
| Z. Other | | | | 4 | | |
| Subtotal | 940 | 41 | | 1530 | 167 | 121 |
| Total | | 981 | | | 1818 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 52 |
| 12. Reactor I&C Systems | | 9 |
| 14. Safety Systems | | 0 |
| 15. Reactor Cooling Systems | | 5 |
| 16. Steam generation systems | 41 | 5 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 15 |
| 32. Feedwater and Main Steam System | | 6 |
| 33. Circulating Water System | | 0 |
| 34. Miscellaneous Systems | | 3 |
| 41. Main Generator Systems | | 5 |
| Total | 41 | 101 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. The unit was in the intermediate maintenance outage from 2023.07.08 to 2023.07.30 and routine maintenance from 2023.03.19 to 2023.04.05. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-143

BILIBINO-3

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : LWGR / EGP-6
 Thermal power : 62 MWth
 Gross electrical power : 12 MWe
 Reference unit power (net) : 11 MWe

Key Dates

Construction Date : 1970-01-01
 Grid Date : 1975-12-22
 Commercial Date : 1976-02-01
 Age at end of year : 48 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : GRAPHITE
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 3000
 Active core diameter [m] : 4.1
 Active core height/length [m] : 3
 Number of fissile fuel assemblies/bundles : 273
 Fuel linear heat generation rate [kW/m] : 27
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 6
 Reactor outlet temperature [°C] : 280
 Number of SG : NA
 Containment type : NA
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

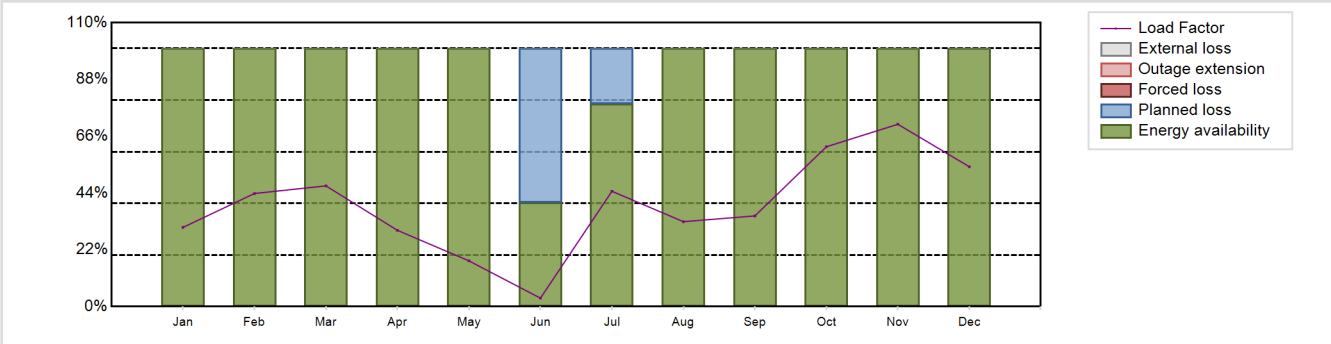
Non-electrical applications : DH

Annual Production Results (2023)

Net Energy Production : 37.87 GW(e).h
 Energy Availability Factor (EAF) : 93.28 %
 Unit Capability Factor (UCF) : 93.28 %
 Load Factor (LF) : 39.3 %
 Operating Factor (OF) : 92.85 %
 Equivalent non-electrical energy generated (NEG) : 23.79 GW(e).h

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 6.72 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 626 hours

Annual Summary

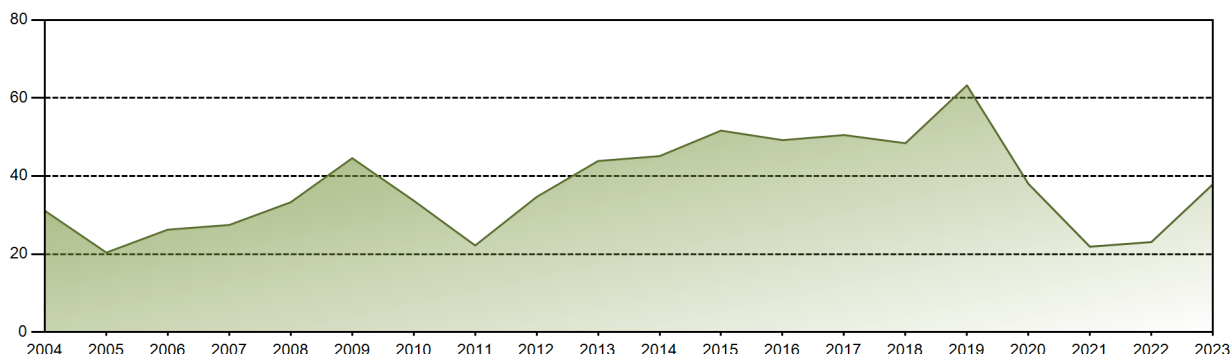


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|-------|--------|--------|--------|--------|--------|--------|
| GW(e)-h | 2.51 | 3.24 | 3.83 | 2.34 | 1.45 | 0.26 | 3.66 | 2.69 | 2.78 | 5.07 | 5.59 | 4.43 | 37.87 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 40.38 | 78.62 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.28 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 40.38 | 78.62 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.28 |
| LF [%] | 30.71 | 43.83 | 46.77 | 29.56 | 17.74 | 3.30 | 44.70 | 32.92 | 35.15 | 61.93 | 70.64 | 54.19 | 39.30 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 37.50 | 77.55 | 100.00 | 100.00 | 100.00 | 98.75 | 100.00 | 92.85 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 59.62 | 21.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.72 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|-------------------|---|-----------|
| Lifetime energy generation | : 2376.01 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.6 % |
| Cumulative Energy Availability Factor (EAF) | : 73.61 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.49 % |
| Cumulative Unit Capability Factor (UCF) | : 81.96 % | Cumulative Planned Unavailability Factor (PUF) | : 17.54 % |
| Cumulative Load Factor (LF) | : 52.84 % | Cumulative Externally cause unavailability (XUF) | : 8.36 % |
| Cumulative Operating Factor (OF) | : 80.31 % | | |

Electricity Production (net) [GWh]

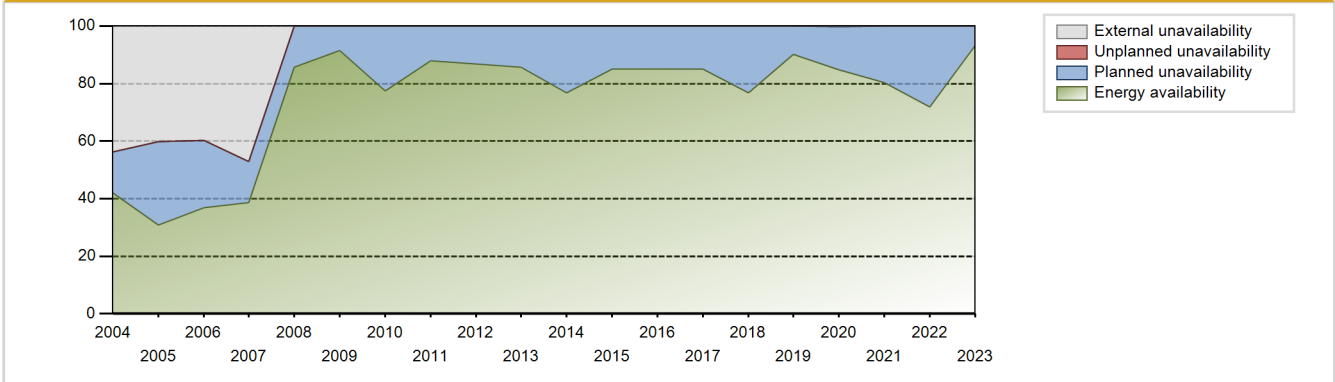


Performance for Years of Commercial Operation

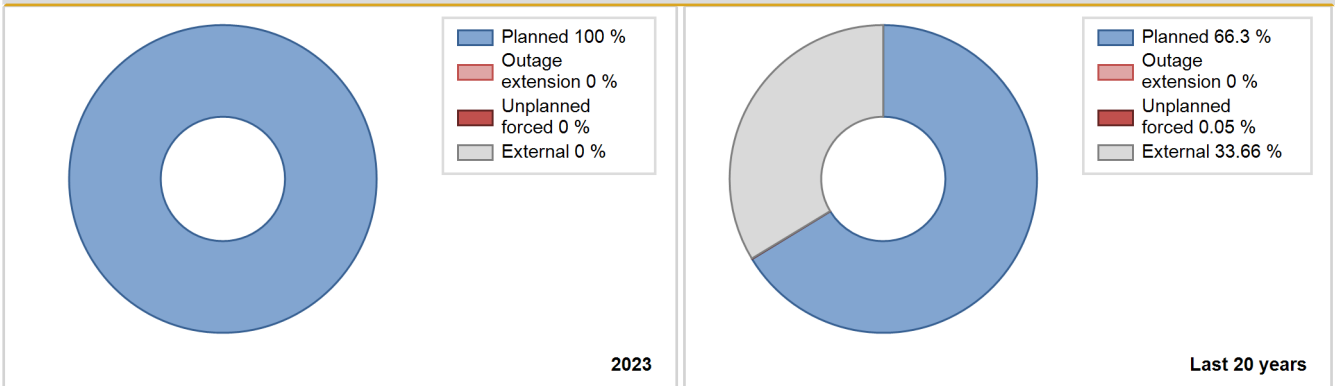
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|-------|------|------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1976 | 51.20 | 6655 | 10 | 83.33 | 90.55 | 62.19 | 77.39 | 2.85 | 2.65 | 6.80 | 7.21 |
| 1977 | 46.50 | 7533 | 10 | 78.21 | 92.83 | 53.08 | 85.99 | 0.39 | 0.36 | 6.81 | 14.62 |
| 1978 | 61.86 | 7514 | 10 | 86.25 | 86.25 | 70.61 | 85.78 | 0.01 | 0.01 | 13.74 | 0.00 |
| 1979 | 62.12 | 7837 | 10 | 82.45 | 88.94 | 70.92 | 89.46 | 0.16 | 0.14 | 10.92 | 6.49 |
| 1980 | 79.43 | 8130 | 10 | 90.99 | 92.18 | 90.42 | 92.55 | 0.00 | 0.00 | 7.82 | 1.20 |
| 1981 | 89.78 | 8480 | 10 | 96.64 | 96.64 | 102.49 | 96.80 | 0.13 | 0.12 | 3.24 | 0.00 |
| 1982 | 79.34 | 8323 | 10 | 94.83 | 94.83 | 90.57 | 95.01 | 0.00 | 0.00 | 5.17 | 0.00 |
| 1983 | 72.81 | 7782 | 10 | 85.31 | 88.85 | 83.11 | 88.84 | 0.34 | 0.31 | 10.85 | 3.54 |
| 1984 | 76.48 | 7876 | 10 | 87.36 | 89.14 | 87.07 | 89.66 | 0.48 | 0.43 | 10.42 | 1.79 |
| 1985 | 69.83 | 7119 | 10 | 78.48 | 80.33 | 79.72 | 81.27 | 0.00 | 0.00 | 19.67 | 1.85 |
| 1986 | 77.11 | 8001 | 10 | 87.71 | 91.02 | 88.03 | 91.34 | 0.66 | 0.60 | 8.38 | 3.31 |
| 1987 | 89.09 | 7801 | 12 | 89.09 | 89.09 | 84.75 | 89.05 | 0.00 | 0.00 | 10.91 | 0.00 |
| 1988 | 76.71 | 7815 | 11 | 89.47 | 89.47 | 79.39 | 88.97 | 0.57 | 0.51 | 10.02 | 0.00 |
| 1989 | 74.26 | 7756 | 11 | 89.05 | 89.46 | 77.06 | 88.54 | 0.00 | 0.00 | 10.54 | 0.40 |
| 1990 | 73.74 | 8024 | 11 | 91.12 | 91.98 | 76.53 | 91.60 | 6.83 | 6.75 | 1.28 | 0.86 |
| 1991 | 66.19 | 6749 | 11 | 76.59 | 78.08 | 68.69 | 77.04 | 1.34 | 1.06 | 20.86 | 1.50 |
| 1992 | 70.92 | 7727 | 11 | 79.70 | 79.70 | 73.40 | 87.97 | 0.40 | 0.32 | 19.98 | 0.00 |
| 1993 | 52.59 | 7218 | 11 | 61.50 | 83.21 | 54.58 | 82.40 | 0.16 | 0.13 | 16.66 | 21.71 |
| 1994 | 44.71 | 6342 | 11 | 71.96 | 73.69 | 46.39 | 72.40 | 0.00 | 0.00 | 26.31 | 1.73 |
| 1995 | 17.30 | 3293 | 11 | 34.90 | 38.15 | 17.95 | 37.59 | 9.46 | 3.99 | 57.86 | 3.26 |
| 1996 | 52.62 | 7142 | 11 | 82.27 | 82.27 | 54.46 | 81.31 | 6.51 | 5.73 | 12.00 | 0.00 |
| 1997 | 25.83 | 3769 | 11 | 42.86 | 42.86 | 26.80 | 43.03 | 0.86 | 0.37 | 56.77 | 0.00 |
| 1998 | 23.16 | 4200 | 11 | 29.11 | 49.13 | 24.04 | 47.95 | 0.00 | 0.00 | 50.87 | 20.02 |
| 1999 | 51.44 | 6607 | 11 | 59.91 | 75.85 | 53.38 | 75.42 | 0.12 | 0.09 | 24.06 | 15.94 |
| 2000 | 45.23 | 7569 | 11 | 54.84 | 86.83 | 46.81 | 86.17 | 0.00 | 0.00 | 13.17 | 31.99 |
| 2001 | 53.94 | 7383 | 11 | 62.96 | 84.88 | 55.98 | 84.28 | 0.00 | 0.00 | 15.12 | 21.91 |
| 2002 | 30.73 | 6250 | 11 | 39.39 | 71.50 | 31.90 | 71.35 | 0.00 | 0.00 | 28.50 | 32.11 |
| 2003 | 35.42 | 7097 | 11 | 46.72 | 81.51 | 36.75 | 81.02 | 0.00 | 0.00 | 18.49 | 34.79 |
| 2004 | 31.09 | 7166 | 11 | 42.00 | 85.77 | 32.18 | 81.58 | 0.00 | 0.00 | 14.23 | 43.77 |
| 2005 | 20.37 | 6102 | 11 | 30.86 | 71.09 | 21.14 | 69.66 | 0.00 | 0.00 | 28.91 | 40.23 |
| 2006 | 26.25 | 6542 | 11 | 36.94 | 76.74 | 27.24 | 74.68 | 0.00 | 0.00 | 23.26 | 39.80 |
| 2007 | 27.45 | 7257 | 11 | 38.64 | 85.73 | 28.49 | 82.84 | 0.00 | 0.00 | 14.27 | 47.09 |
| 2008 | 33.28 | 7335 | 11 | 85.73 | 85.73 | 34.44 | 83.50 | 0.07 | 0.06 | 14.20 | 0.00 |
| 2009 | 44.57 | 7972 | 11 | 91.43 | 91.43 | 46.25 | 91.00 | 0.00 | 0.00 | 8.57 | 0.00 |
| 2010 | 33.69 | 6035 | 11 | 77.50 | 77.50 | 34.96 | 68.89 | 0.00 | 0.00 | 22.50 | 0.00 |
| 2011 | 22.19 | 4885 | 11 | 87.96 | 87.96 | 23.03 | 55.76 | 0.00 | 0.00 | 12.04 | 0.00 |
| 2012 | 34.63 | 7253 | 11 | 86.71 | 86.71 | 35.84 | 82.57 | 0.00 | 0.00 | 13.29 | 0.00 |

| | | | | | | | | | | | |
|------|-------|------|----|-------|-------|-------|-------|------|------|-------|------|
| 2013 | 43.85 | 7436 | 11 | 85.64 | 85.64 | 45.51 | 84.89 | 0.00 | 0.00 | 14.36 | 0.00 |
| 2014 | 45.10 | 6615 | 11 | 76.67 | 76.67 | 46.80 | 75.51 | 0.00 | 0.00 | 23.33 | 0.00 |
| 2015 | 51.64 | 7337 | 11 | 85.10 | 85.10 | 53.60 | 83.76 | 0.00 | 0.00 | 14.90 | 0.00 |
| 2016 | 49.20 | 7410 | 11 | 85.10 | 85.10 | 50.92 | 84.36 | 0.00 | 0.00 | 14.90 | 0.00 |
| 2017 | 50.50 | 7377 | 11 | 84.93 | 84.93 | 52.41 | 84.21 | 0.00 | 0.00 | 15.07 | 0.00 |
| 2018 | 48.41 | 6626 | 11 | 76.75 | 76.75 | 50.24 | 75.64 | 0.00 | 0.00 | 23.25 | 0.00 |
| 2019 | 63.23 | 7849 | 11 | 90.08 | 90.08 | 65.62 | 89.60 | 0.00 | 0.00 | 9.92 | 0.00 |
| 2020 | 38.00 | 7380 | 11 | 84.73 | 84.73 | 39.33 | 84.02 | 0.21 | 0.18 | 15.09 | 0.00 |
| 2021 | 21.89 | 6747 | 11 | 80.29 | 80.29 | 22.72 | 77.02 | 0.00 | 0.00 | 19.71 | 0.00 |
| 2022 | 23.07 | 6294 | 11 | 71.85 | 71.85 | 23.94 | 71.85 | 0.00 | 0.00 | 28.15 | 0.00 |
| 2023 | 37.87 | 8134 | 11 | 93.28 | 93.28 | 39.30 | 92.85 | 0.00 | 0.00 | 6.72 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1976 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 43 | |
| C. Inspection, maintenance or repair combined with refuelling | 616 | | | 1328 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 237 | | |
| E. Testing of plant systems or components | 9 | | | 6 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 32 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 96 |
| Z. Other | | | | 11 | 1 | |
| Subtotal | 625 | | | 1582 | 44 | 128 |
| Total | | 625 | | | 1754 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1976 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 13. Reactor Auxiliary Systems | | 1 |
| 15. Reactor Cooling Systems | | 12 |
| 31. Turbine and auxiliaries | | 10 |
| 32. Feedwater and Main Steam System | | 7 |
| 33. Circulating Water System | | 0 |
| 34. Miscellaneous Systems | | 13 |
| Total | | 43 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. The unit was in the intermediate maintenance outage from 2023.06.11 to 2023.07.07. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-144

BILIBINO-4

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : LWGR / EGP-6
 Thermal power : 62 MWth
 Gross electrical power : 12 MWe
 Reference unit power (net) : 11 MWe

Key Dates

Construction Date : 1970-01-01
 Grid Date : 1976-12-27
 Commercial Date : 1977-01-01
 Age at end of year : 47 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : GRAPHITE
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 3000
 Active core diameter [m] : 4.1
 Active core height/length [m] : 3
 Number of fissile fuel assemblies/bundles : 273
 Fuel linear heat generation rate [kW/m] : 27
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 6
 Reactor outlet temperature [°C] : 280
 Number of SG : NA
 Containment type : NA
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

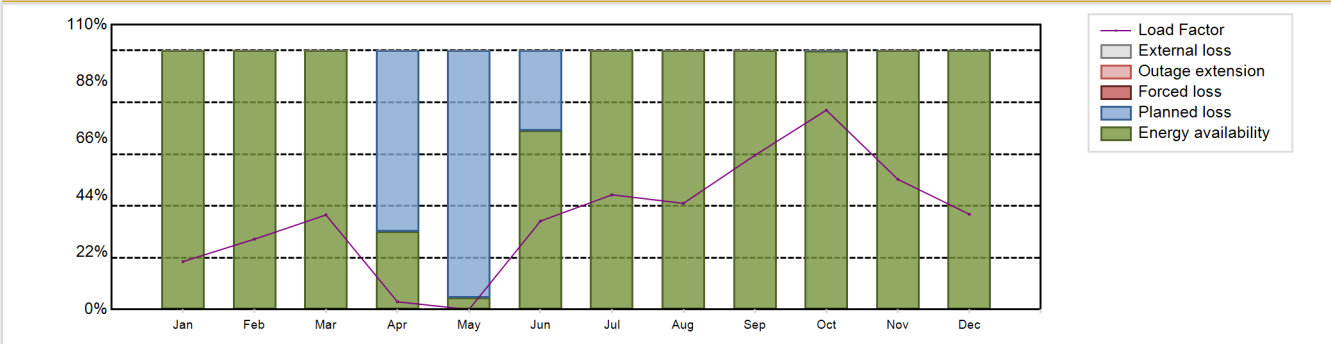
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Annual Production Results (2023)

Net Energy Production : 34.45 GW(e).h
 Energy Availability Factor (EAF) : 83.59 %
 Unit Capability Factor (UCF) : 83.59 %
 Load Factor (LF) : 35.75 %
 Operating Factor (OF) : 82.8 %
 Equivalent non-electrical energy generated (NEG) : 21.56 GW(e).h

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 16.41 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1507 hours

Annual Summary

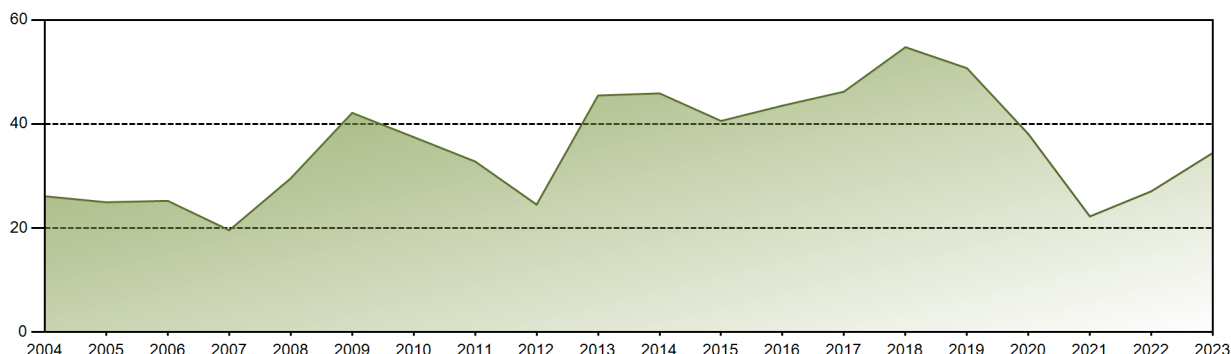


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|-------|-------|--------|--------|--------|-------|--------|--------|--------|
| GW(e)-h | 1.52 | 2.01 | 2.99 | 0.24 | 0.00 | 2.71 | 3.63 | 3.36 | 4.72 | 6.30 | 3.98 | 3.01 | 34.45 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 30.18 | 4.55 | 69.00 | 100.00 | 100.00 | 100.00 | 99.77 | 100.00 | 100.00 | 83.59 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 30.18 | 4.55 | 69.00 | 100.00 | 100.00 | 100.00 | 99.77 | 100.00 | 100.00 | 83.59 |
| LF [%] | 18.52 | 27.18 | 36.52 | 2.99 | 0.00 | 34.15 | 44.32 | 41.01 | 59.57 | 76.99 | 50.28 | 36.80 | 35.75 |
| OF [%] | 100.00 | 100.00 | 100.00 | 26.81 | 0.00 | 67.50 | 100.00 | 100.00 | 100.00 | 99.73 | 100.00 | 100.00 | 82.80 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 69.82 | 95.45 | 31.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.00 | 0.00 | 16.41 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|-------------------|---|-----------|
| Lifetime energy generation | : 2216.12 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.61 % |
| Cumulative Energy Availability Factor (EAF) | : 72.3 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.5 % |
| Cumulative Unit Capability Factor (UCF) | : 80.27 % | Cumulative Planned Unavailability Factor (PUF) | : 19.23 % |
| Cumulative Load Factor (LF) | : 51.19 % | Cumulative Externally cause unavailability (XUF) | : 7.98 % |
| Cumulative Operating Factor (OF) | : 78.21 % | | |

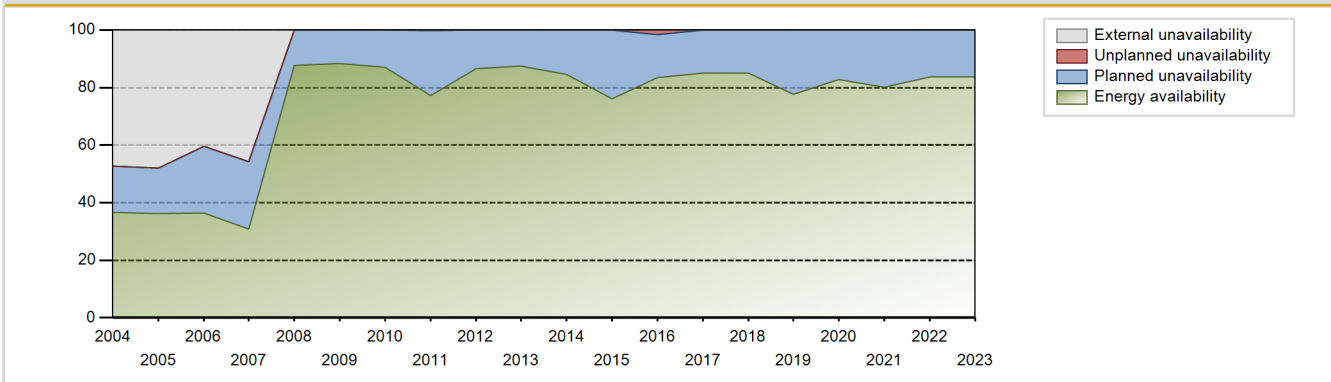
Electricity Production (net) [GWh]



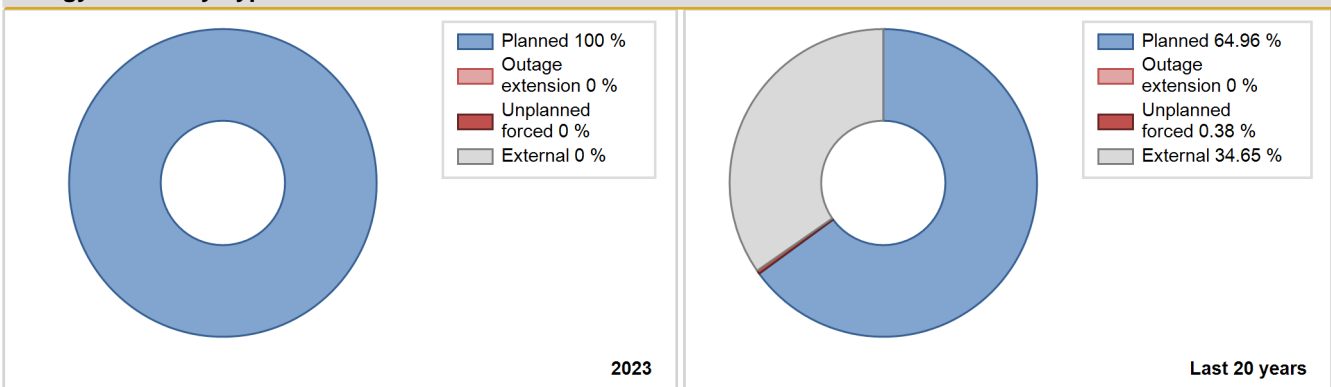
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1977 | 52.65 | 7392 | 10 | 82.89 | 93.56 | 60.10 | 84.38 | 0.28 | 0.27 | 6.17 | 10.67 |
| 1978 | 58.30 | 7827 | 10 | 91.06 | 91.06 | 66.55 | 89.35 | 0.01 | 0.01 | 8.93 | 0.00 |
| 1979 | 74.46 | 7552 | 10 | 83.88 | 85.52 | 85.00 | 86.21 | 0.20 | 0.17 | 14.31 | 1.64 |
| 1980 | 77.62 | 8347 | 10 | 92.91 | 94.77 | 88.37 | 95.03 | 0.05 | 0.05 | 5.18 | 1.86 |
| 1981 | 78.26 | 7734 | 10 | 86.61 | 87.69 | 89.33 | 88.29 | 0.80 | 0.71 | 11.60 | 1.08 |
| 1982 | 77.61 | 7976 | 10 | 90.71 | 90.71 | 88.59 | 91.05 | 0.00 | 0.00 | 9.29 | 0.00 |
| 1983 | 75.53 | 7923 | 10 | 86.88 | 89.97 | 86.23 | 90.45 | 0.11 | 0.10 | 9.94 | 3.09 |
| 1984 | 79.01 | 7744 | 10 | 86.77 | 87.57 | 89.95 | 88.16 | 0.08 | 0.07 | 12.36 | 0.80 |
| 1985 | 81.23 | 7919 | 10 | 89.53 | 90.33 | 92.73 | 90.40 | 1.23 | 1.13 | 8.55 | 0.79 |
| 1986 | 74.54 | 7083 | 10 | 79.84 | 79.90 | 85.09 | 80.86 | 0.01 | 0.01 | 20.09 | 0.06 |
| 1987 | 95.55 | 8154 | 12 | 93.26 | 93.26 | 90.89 | 93.08 | 0.22 | 0.20 | 6.54 | 0.00 |
| 1988 | 75.85 | 7617 | 11 | 87.34 | 87.34 | 78.50 | 86.71 | 0.86 | 0.76 | 11.90 | 0.00 |
| 1989 | 71.37 | 7853 | 11 | 93.22 | 93.22 | 74.06 | 89.65 | 0.25 | 0.24 | 6.54 | 0.00 |
| 1990 | 75.29 | 7588 | 11 | 86.36 | 87.22 | 78.13 | 86.62 | 5.48 | 5.06 | 7.73 | 0.86 |
| 1991 | 61.32 | 6139 | 11 | 69.89 | 71.43 | 63.64 | 70.08 | 0.00 | 0.00 | 28.57 | 1.54 |
| 1992 | 69.84 | 7756 | 11 | 87.82 | 87.82 | 72.28 | 88.30 | 1.22 | 1.08 | 11.10 | 0.00 |
| 1993 | 56.00 | 6918 | 11 | 64.39 | 80.22 | 58.12 | 78.97 | 0.82 | 0.66 | 19.11 | 15.83 |
| 1994 | 38.46 | 5266 | 11 | 61.82 | 61.99 | 39.91 | 60.11 | 9.18 | 6.27 | 31.75 | 0.17 |
| 1995 | 29.88 | 5083 | 11 | 62.73 | 63.94 | 31.01 | 58.03 | 0.53 | 0.34 | 35.72 | 1.21 |
| 1996 | 35.18 | 5109 | 11 | 59.13 | 59.13 | 36.41 | 58.16 | 1.36 | 0.81 | 40.06 | 0.00 |
| 1997 | 15.13 | 2490 | 11 | 28.42 | 37.04 | 15.70 | 28.42 | 0.00 | 0.00 | 62.96 | 8.61 |
| 1998 | 37.29 | 5510 | 11 | 44.52 | 63.14 | 38.70 | 62.90 | 0.00 | 0.00 | 36.86 | 18.62 |
| 1999 | 28.69 | 3993 | 11 | 34.77 | 46.74 | 29.77 | 45.58 | 6.39 | 3.19 | 50.07 | 11.97 |
| 2000 | 55.85 | 7740 | 11 | 64.20 | 88.68 | 57.80 | 88.11 | 0.04 | 0.03 | 11.29 | 24.48 |
| 2001 | 35.44 | 5931 | 11 | 43.17 | 68.01 | 36.78 | 67.71 | 0.00 | 0.00 | 31.99 | 24.84 |
| 2002 | 33.12 | 6419 | 11 | 46.34 | 73.76 | 34.37 | 73.28 | 0.00 | 0.00 | 26.24 | 27.42 |
| 2003 | 24.52 | 5849 | 11 | 34.04 | 67.51 | 25.45 | 66.77 | 0.00 | 0.00 | 32.49 | 33.47 |
| 2004 | 26.10 | 7303 | 11 | 36.71 | 83.90 | 27.01 | 83.14 | 0.00 | 0.00 | 16.10 | 47.19 |
| 2005 | 24.95 | 7300 | 11 | 36.29 | 84.32 | 25.89 | 83.33 | 0.00 | 0.00 | 15.68 | 48.03 |
| 2006 | 25.22 | 6626 | 11 | 36.44 | 76.86 | 26.18 | 75.64 | 0.00 | 0.00 | 23.14 | 40.42 |
| 2007 | 19.57 | 5983 | 11 | 30.89 | 76.55 | 20.31 | 68.30 | 0.00 | 0.00 | 23.45 | 45.65 |
| 2008 | 29.55 | 7023 | 11 | 87.66 | 87.66 | 30.59 | 79.95 | 0.10 | 0.09 | 12.25 | 0.00 |
| 2009 | 42.14 | 7663 | 11 | 88.40 | 88.40 | 43.74 | 87.48 | 0.14 | 0.12 | 11.48 | 0.00 |
| 2010 | 37.48 | 7272 | 11 | 86.93 | 86.93 | 38.90 | 83.01 | 0.00 | 0.00 | 13.07 | 0.00 |
| 2011 | 32.79 | 5944 | 11 | 77.29 | 77.29 | 34.03 | 67.85 | 0.21 | 0.16 | 22.55 | 0.00 |
| 2012 | 24.50 | 5886 | 11 | 86.69 | 86.69 | 25.36 | 67.01 | 0.03 | 0.03 | 13.28 | 0.00 |
| 2013 | 45.48 | 7472 | 11 | 87.40 | 87.40 | 47.19 | 85.30 | 0.00 | 0.00 | 12.60 | 0.00 |

| | | | | | | | | | | | |
|------|-------|------|----|-------|-------|-------|-------|------|------|-------|------|
| 2014 | 45.89 | 7187 | 11 | 84.56 | 84.56 | 47.63 | 82.04 | 0.00 | 0.00 | 15.44 | 0.00 |
| 2015 | 40.59 | 6307 | 11 | 76.02 | 76.02 | 42.12 | 72.00 | 0.00 | 0.00 | 23.98 | 0.00 |
| 2016 | 43.53 | 7163 | 11 | 83.57 | 83.57 | 45.05 | 81.55 | 1.87 | 1.59 | 14.84 | 0.00 |
| 2017 | 46.22 | 7395 | 11 | 85.13 | 85.13 | 47.97 | 84.42 | 0.00 | 0.00 | 14.87 | 0.00 |
| 2018 | 54.77 | 7392 | 11 | 85.09 | 85.09 | 56.84 | 84.38 | 0.00 | 0.00 | 14.91 | 0.00 |
| 2019 | 50.73 | 6705 | 11 | 77.60 | 77.60 | 52.65 | 76.54 | 0.00 | 0.00 | 22.40 | 0.00 |
| 2020 | 38.06 | 7194 | 11 | 82.72 | 82.72 | 39.39 | 81.90 | 0.00 | 0.00 | 17.28 | 0.00 |
| 2021 | 22.23 | 6890 | 11 | 80.19 | 80.19 | 23.07 | 78.65 | 0.00 | 0.00 | 19.81 | 0.00 |
| 2022 | 27.07 | 7324 | 11 | 83.61 | 83.61 | 28.09 | 83.61 | 0.00 | 0.00 | 16.39 | 0.00 |
| 2023 | 34.45 | 7253 | 11 | 83.59 | 83.59 | 35.75 | 82.80 | 0.00 | 0.00 | 16.41 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1977 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 47 | |
| C. Inspection, maintenance or repair combined with refuelling | 1505 | | | 1426 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 329 | | |
| E. Testing of plant systems or components | 2 | | | 7 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 41 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 100 |
| L. Human factor related | | | | | 0 | |
| Z. Other | | | | | 1 | |
| Subtotal | 1507 | | | 1762 | 48 | 141 |
| Total | | 1507 | | | 1951 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1977 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 10 |
| 13. Reactor Auxiliary Systems | | 6 |
| 15. Reactor Cooling Systems | | 1 |
| 31. Turbine and auxiliaries | | 4 |
| 32. Feedwater and Main Steam System | | 11 |
| 33. Circulating Water System | | 4 |
| 41. Main Generator Systems | | 12 |
| Total | | 48 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. The unit was in the intermediate maintenance outage from 2023.04.08 to 2023.06.10. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-30

KALININ-1

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)



Reactor Unit Details

Reactor type and model : PWR / VVER V-338
 Thermal power : 3000 MWth
 Gross electrical power : 1000 MWe
 Reference unit power (net) : 950 MWe

Key Dates

Construction Date : 1977-02-01
 Grid Date : 1984-05-09
 Commercial Date : 1985-06-12
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 40000
 Active core diameter [m] : 3.16
 Active core height/length [m] : 3.53
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : 17.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 16
 Reactor outlet temperature [°C] : 322
 Number of SG : 4
 Containment type : Confinement
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

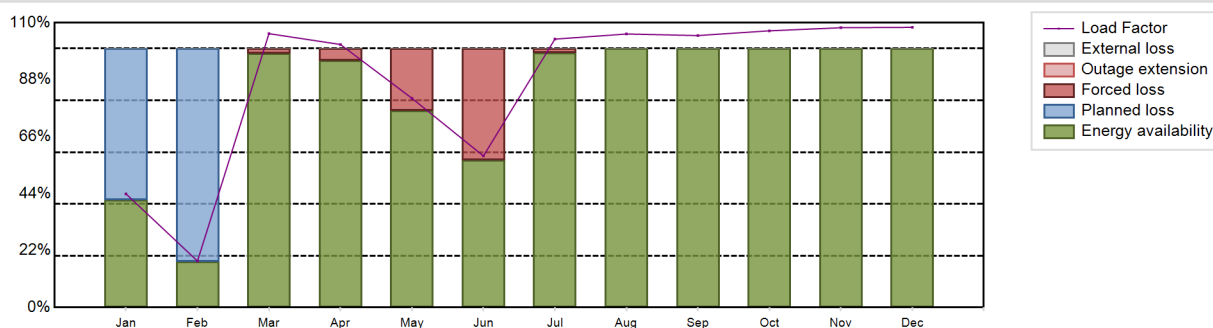
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 7295.91 GW(e).h
 Energy Availability Factor (EAF) : 82.46 %
 Unit Capability Factor (UCF) : 82.46 %
 Load Factor (LF) : 87.67 %
 Operating Factor (OF) : 83.32 %
 Equivalent non-electrical energy generated (NEG) : 34.11 GW(e).h

Forced Loss Rate (FLR) : 7.06 %
 Unplanned Capability Loss Factor (UCL) : 6.26 %
 Planned Unavailability Factor (PUF) : 11.28 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1461 hours

Annual Summary

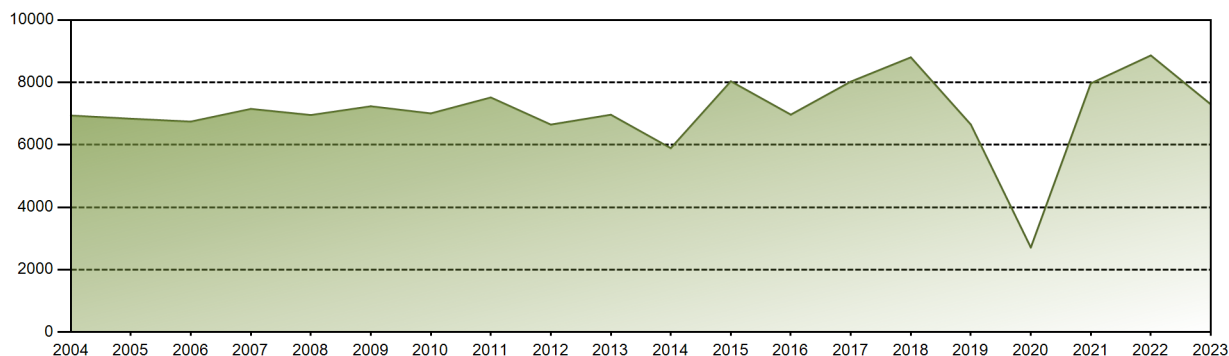


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 310.26 | 114.61 | 747.60 | 694.92 | 571.16 | 400.45 | 732.65 | 746.61 | 718.47 | 755.37 | 739.11 | 764.70 | 7295.91 |
| EAF [%] | 41.52 | 17.72 | 98.12 | 95.41 | 76.00 | 56.89 | 98.28 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 82.46 |
| UCF [%] | 41.52 | 17.72 | 98.12 | 95.41 | 76.00 | 56.89 | 98.28 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 82.46 |
| LF [%] | 43.90 | 17.95 | 105.77 | 101.60 | 80.81 | 58.55 | 103.66 | 105.63 | 105.04 | 106.87 | 108.06 | 108.19 | 87.67 |
| OF [%] | 42.07 | 18.30 | 100.00 | 100.00 | 77.96 | 57.50 | 98.52 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 83.32 |
| FLR [%] | 0.00 | 0.00 | 1.88 | 4.59 | 24.00 | 43.11 | 1.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.06 |
| UCL [%] | 0.00 | 0.00 | 1.88 | 4.59 | 24.00 | 43.11 | 1.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.26 |
| PUF [%] | 58.48 | 82.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.28 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 252023.13 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.37 % |
| Cumulative Energy Availability Factor (EAF) | : 75.37 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.5 % |
| Cumulative Unit Capability Factor (UCF) | : 76 % | Cumulative Planned Unavailability Factor (PUF) | : 18.5 % |
| Cumulative Load Factor (LF) | : 77.55 % | Cumulative Externally cause unavailability (XUF) | : 0.63 % |
| Cumulative Operating Factor (OF) | : 77.94 % | | |

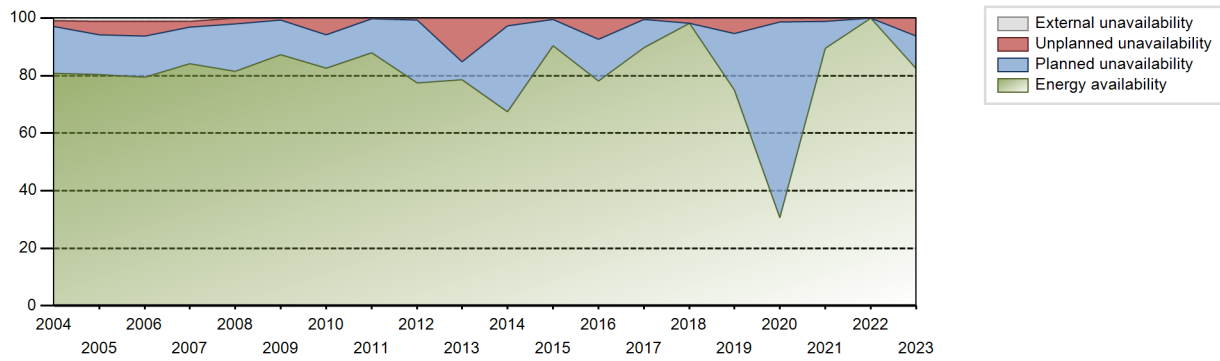
Electricity Production (net) [GWh]



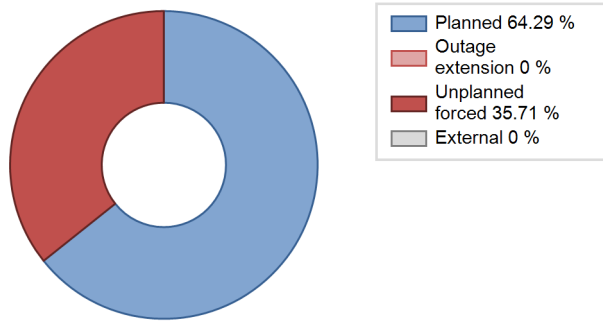
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|-------|--------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 4487.64 | 5824 | 950 | 58.28 | 58.28 | 57.38 | 60.38 | 10.99 | 7.20 | 34.52 | 0.00 |
| 1986 | 5297.73 | 5946 | 950 | 62.85 | 62.85 | 63.66 | 67.88 | 28.18 | 24.65 | 12.50 | 0.00 |
| 1987 | 6842.49 | 6972 | 1000 | 78.71 | 78.71 | 78.11 | 79.59 | 7.76 | 6.62 | 14.67 | 0.00 |
| 1988 | 5891.61 | 6187 | 950 | 70.12 | 70.12 | 70.60 | 70.43 | 9.61 | 7.45 | 22.43 | 0.00 |
| 1989 | 6129.71 | 6396 | 950 | 71.91 | 71.94 | 73.66 | 73.01 | 10.20 | 8.17 | 19.89 | 0.03 |
| 1990 | 5192.31 | 5435 | 950 | 61.53 | 61.56 | 62.39 | 62.04 | 3.54 | 2.26 | 36.18 | 0.03 |
| 1991 | 6482.72 | 7161 | 950 | 77.09 | 78.06 | 77.90 | 81.75 | 11.66 | 10.30 | 11.64 | 0.97 |
| 1992 | 6781.35 | 7388 | 950 | 80.33 | 80.36 | 81.27 | 84.12 | 12.02 | 10.98 | 8.66 | 0.03 |
| 1993 | 4927.21 | 6133 | 950 | 59.38 | 66.61 | 59.21 | 70.01 | 5.55 | 3.91 | 29.48 | 7.23 |
| 1994 | 4437.58 | 5440 | 950 | 54.09 | 54.37 | 53.32 | 62.10 | 16.02 | 10.37 | 35.26 | 0.29 |
| 1995 | 4699.05 | 6265 | 950 | 56.75 | 57.00 | 56.47 | 71.52 | 26.12 | 20.15 | 22.85 | 0.25 |
| 1996 | 4431.67 | 5628 | 950 | 53.22 | 53.31 | 53.11 | 64.07 | 19.08 | 12.57 | 34.11 | 0.09 |
| 1997 | 5197.08 | 6195 | 950 | 63.23 | 65.00 | 62.45 | 70.72 | 5.59 | 3.85 | 31.16 | 1.77 |
| 1998 | 6100.97 | 6937 | 950 | 73.04 | 73.33 | 73.31 | 79.19 | 6.48 | 5.08 | 21.59 | 0.29 |
| 1999 | 5775.11 | 6589 | 950 | 69.32 | 73.06 | 69.40 | 75.22 | 5.65 | 4.37 | 22.56 | 3.74 |
| 2000 | 6289.72 | 6784 | 950 | 75.00 | 76.79 | 75.37 | 77.23 | 3.54 | 2.82 | 20.39 | 1.79 |
| 2001 | 6627.54 | 7020 | 950 | 78.18 | 79.37 | 79.64 | 80.14 | 5.67 | 4.77 | 15.86 | 1.19 |
| 2002 | 7248.38 | 7568 | 950 | 84.66 | 86.10 | 87.10 | 86.39 | 0.27 | 0.23 | 13.66 | 1.44 |
| 2003 | 7155.92 | 7408 | 950 | 83.10 | 83.75 | 85.99 | 84.57 | 4.40 | 3.85 | 12.40 | 0.65 |
| 2004 | 6936.97 | 7179 | 950 | 80.69 | 81.55 | 83.13 | 81.73 | 2.57 | 2.15 | 16.30 | 0.86 |
| 2005 | 6836.33 | 7219 | 950 | 80.39 | 81.50 | 82.14 | 82.40 | 4.45 | 4.78 | 13.72 | 1.11 |
| 2006 | 6743.58 | 7112 | 950 | 79.48 | 80.58 | 81.03 | 81.19 | 4.77 | 5.16 | 14.26 | 1.10 |
| 2007 | 7150.35 | 7491 | 950 | 84.04 | 85.24 | 85.92 | 85.51 | 2.14 | 1.87 | 12.90 | 1.20 |
| 2008 | 6953.55 | 7209 | 950 | 81.53 | 81.53 | 83.33 | 82.07 | 2.44 | 2.04 | 16.43 | 0.00 |
| 2009 | 7234.70 | 7669 | 950 | 87.27 | 87.27 | 86.93 | 87.55 | 0.70 | 0.62 | 12.11 | 0.00 |
| 2010 | 7006.14 | 7175 | 950 | 82.65 | 82.74 | 84.19 | 81.91 | 6.45 | 5.71 | 11.55 | 0.09 |
| 2011 | 7516.88 | 7727 | 950 | 87.91 | 87.91 | 90.34 | 88.22 | 0.22 | 0.19 | 11.89 | 0.00 |
| 2012 | 6648.33 | 6833 | 950 | 77.49 | 77.49 | 79.67 | 77.79 | 0.94 | 0.74 | 21.77 | 0.00 |
| 2013 | 6963.99 | 6915 | 950 | 78.67 | 78.67 | 83.68 | 78.94 | 6.17 | 15.31 | 6.03 | 0.00 |
| 2014 | 5892.14 | 6035 | 950 | 67.51 | 67.51 | 70.79 | 68.88 | 3.79 | 2.66 | 29.83 | 0.00 |
| 2015 | 8036.64 | 7931 | 950 | 90.46 | 90.46 | 96.57 | 90.54 | 0.64 | 0.58 | 8.96 | 0.00 |
| 2016 | 6966.43 | 6876 | 950 | 78.17 | 78.17 | 83.48 | 78.28 | 8.56 | 7.32 | 14.52 | 0.00 |
| 2017 | 8025.20 | 7856 | 950 | 89.63 | 89.63 | 96.43 | 89.68 | 0.00 | 0.53 | 9.84 | 0.00 |
| 2018 | 8802.94 | 8643 | 950 | 98.20 | 98.21 | 105.78 | 98.66 | 1.79 | 1.79 | 0.00 | 0.01 |
| 2019 | 6650.32 | 6595 | 950 | 75.05 | 75.10 | 79.91 | 75.29 | 6.64 | 5.34 | 19.56 | 0.05 |
| 2020 | 2709.37 | 2703 | 950 | 30.56 | 30.56 | 32.47 | 30.77 | 4.41 | 1.41 | 68.03 | 0.00 |
| 2021 | 7970.06 | 7849 | 950 | 89.44 | 89.49 | 95.77 | 89.60 | 1.34 | 1.21 | 9.30 | 0.05 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2022 | 8863.93 | 8760 | 950 | 100.00 | 100.00 | 106.51 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 7295.91 | 7299 | 950 | 82.46 | 82.46 | 87.67 | 83.32 | 7.06 | 6.26 | 11.28 | 0.00 |

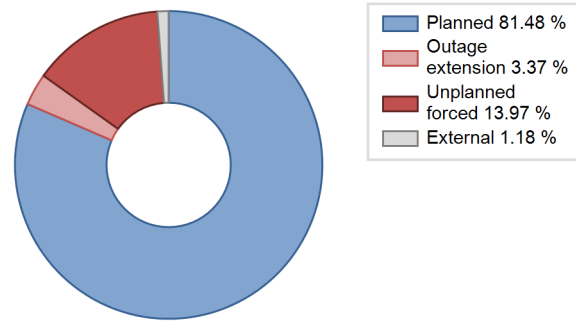
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 504 | | | 274 | |
| C. Inspection, maintenance or repair combined with refuelling | 982 | | | 1488 | 28 | |
| D. Inspection, maintenance or repair without refuelling | | | | 99 | 1 | |
| E. Testing of plant systems or components | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 6 | |
| Z. Other | | | | | 33 | |
| Subtotal | 982 | 504 | | 1587 | 343 | 3 |
| Total | | 1486 | | | 1933 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1985 to 2023 | |
|--|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 33 |
| 12. Reactor I&C Systems | | | | 13 |
| 13. Reactor Auxiliary Systems | | | | 3 |
| 15. Reactor Cooling Systems | | | 139 | 9 |
| 16. Steam generation systems | | | | 35 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 5 |
| 31. Turbine and auxiliaries | | | 34 | 24 |
| 32. Feedwater and Main Steam System | | | | 19 |
| 34. Miscellaneous Systems | | | | 2 |
| 35. All other I&C Systems | | | | 6 |
| 41. Main Generator Systems | | | | 117 |
| 42. Electrical Power Supply Systems | | | 331 | 15 |
| Total | | | 504 | 281 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-December. Additional electricity generation amounted to 431205MWh. The unit was in the overhaul from 2023.01.14 to 2023.02.23. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-31

KALININ-2

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)



Reactor Unit Details

Reactor type and model : PWR / VVER V-338
 Thermal power : 3000 MWth
 Gross electrical power : 1000 MWe
 Reference unit power (net) : 950 MWe

Key Dates

Construction Date : 1982-02-01
 Grid Date : 1986-12-03
 Commercial Date : 1987-03-03
 Age at end of year : 37 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 40000
 Active core diameter [m] : 3.16
 Active core height/length [m] : 3.53
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : 17.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 16
 Reactor outlet temperature [°C] : 322
 Number of SG : 4
 Containment type : Confinement
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

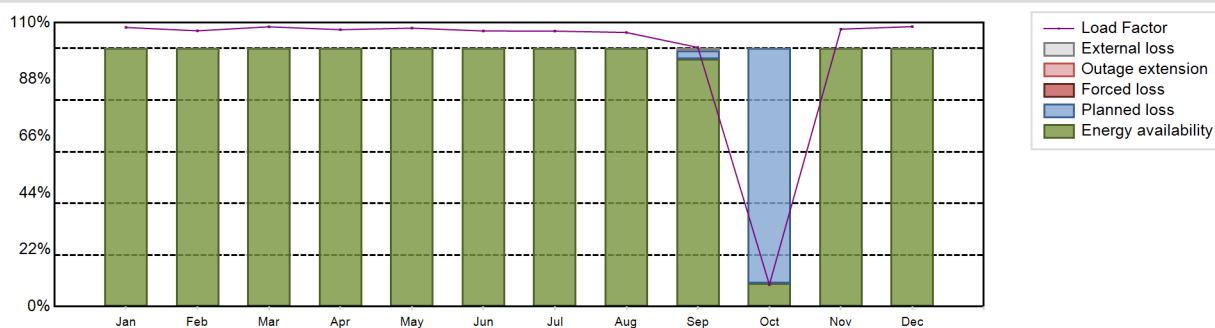
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 8191.96 GW(e).h
 Energy Availability Factor (EAF) : 91.93 %
 Unit Capability Factor (UCF) : 92.01 %
 Load Factor (LF) : 98.44 %
 Operating Factor (OF) : 92.09 %
 Equivalent non-electrical energy generated (NEG) : 43.1 GW(e).h

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 7.99 %
 Externally cause unavailability (XUF) : 0.08 %
 Total off-line time : 693 hours

Annual Summary

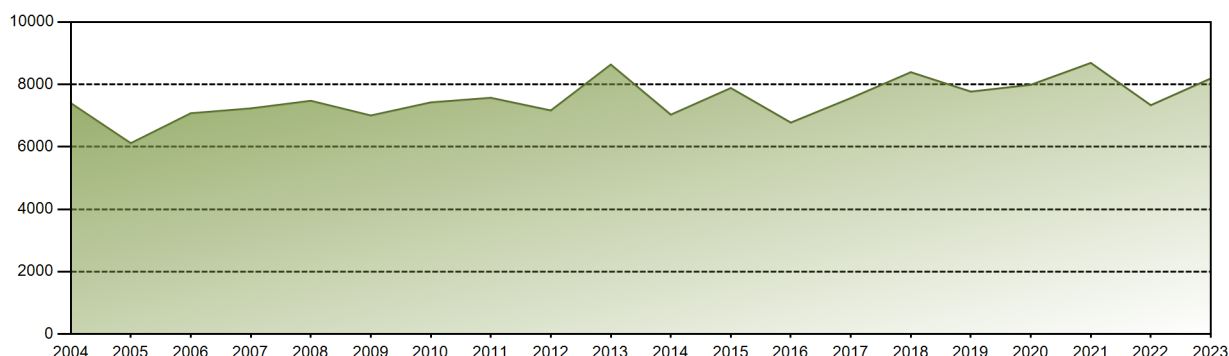


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 764.15 | 682.00 | 766.11 | 733.71 | 762.40 | 730.28 | 754.29 | 750.48 | 686.65 | 60.16 | 735.12 | 766.60 | 8191.96 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.78 | 9.05 | 100.00 | 100.00 | 91.93 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.74 | 9.05 | 100.00 | 100.00 | 92.01 |
| LF [%] | 108.11 | 106.83 | 108.39 | 107.27 | 107.87 | 106.77 | 106.72 | 106.18 | 100.39 | 8.51 | 107.47 | 108.46 | 98.44 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.81 | 9.95 | 100.00 | 100.00 | 92.09 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.26 | 90.95 | 0.00 | 0.00 | 7.99 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.96 | 0.00 | 0.00 | 0.00 | 0.08 |

Historical Summary

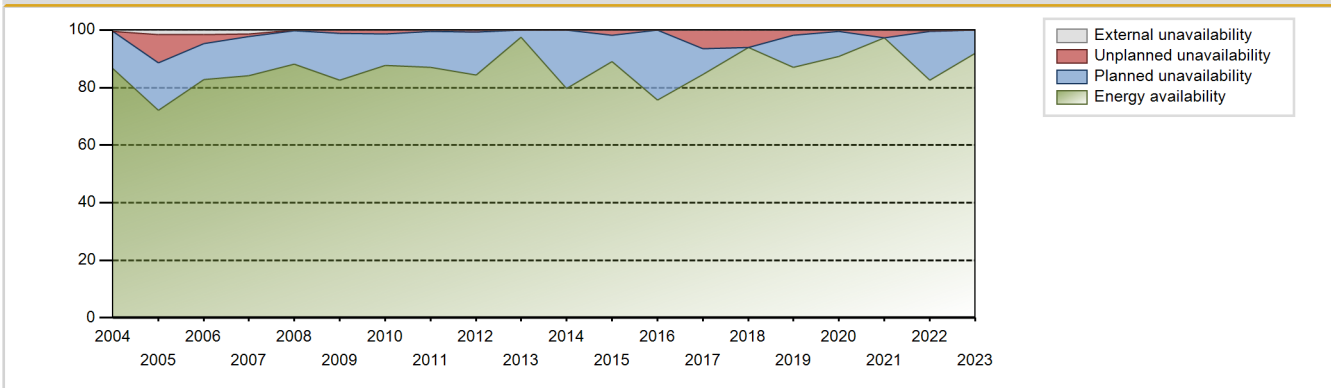
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 249736.21 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.6 % |
| Cumulative Energy Availability Factor (EAF) | : 78.23 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.88 % |
| Cumulative Unit Capability Factor (UCF) | : 80.04 % | Cumulative Planned Unavailability Factor (PUF) | : 15.09 % |
| Cumulative Load Factor (LF) | : 81.17 % | Cumulative Externally cause unavailability (XUF) | : 1.8 % |
| Cumulative Operating Factor (OF) | : 83.34 % | | |

Electricity Production (net) [GWh]

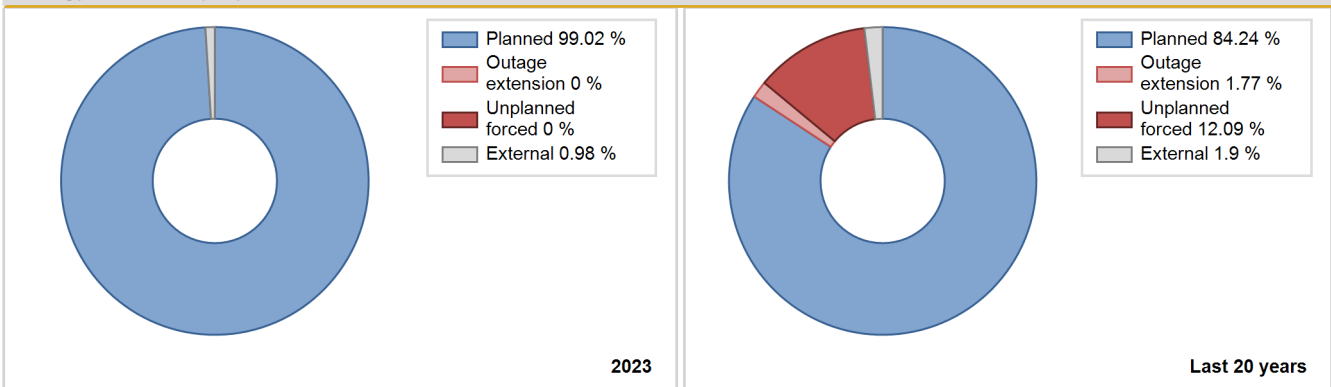


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 6494.00 | 7605 | 1000 | 86.27 | 86.27 | 79.18 | 87.96 | 9.13 | 8.67 | 5.07 | 0.00 |
| 1988 | 5829.43 | 6446 | 950 | 71.67 | 71.67 | 69.86 | 73.38 | 9.64 | 7.64 | 20.68 | 0.00 |
| 1989 | 6580.49 | 7034 | 950 | 78.45 | 78.45 | 79.07 | 80.30 | 5.86 | 4.88 | 16.67 | 0.00 |
| 1990 | 6788.16 | 7083 | 950 | 79.45 | 79.45 | 81.57 | 80.86 | 5.85 | 4.94 | 15.61 | 0.00 |
| 1991 | 4729.67 | 5154 | 950 | 49.79 | 49.79 | 56.83 | 58.84 | 30.08 | 21.42 | 28.79 | 0.00 |
| 1992 | 5496.31 | 6145 | 950 | 65.70 | 65.70 | 65.87 | 69.96 | 5.58 | 3.88 | 30.42 | 0.00 |
| 1993 | 5862.30 | 7078 | 950 | 51.91 | 56.45 | 70.44 | 80.80 | 28.07 | 22.03 | 21.52 | 4.54 |
| 1994 | 4463.77 | 6989 | 950 | 54.87 | 54.87 | 53.64 | 79.78 | 31.92 | 25.73 | 19.41 | 0.00 |
| 1995 | 5769.75 | 7283 | 950 | 69.48 | 72.40 | 69.33 | 83.14 | 15.96 | 13.75 | 13.85 | 2.92 |
| 1996 | 4595.17 | 7501 | 950 | 56.02 | 78.42 | 55.07 | 85.39 | 2.81 | 2.26 | 19.31 | 22.40 |
| 1997 | 3880.64 | 6117 | 950 | 47.25 | 62.67 | 46.63 | 69.83 | 2.47 | 1.59 | 35.74 | 15.42 |
| 1998 | 4946.65 | 6839 | 950 | 59.67 | 59.98 | 59.44 | 78.07 | 26.91 | 22.08 | 17.93 | 0.31 |
| 1999 | 6379.25 | 7155 | 950 | 76.21 | 80.03 | 76.66 | 81.68 | 0.26 | 0.21 | 19.76 | 3.82 |
| 2000 | 6418.74 | 7441 | 950 | 76.26 | 83.57 | 76.92 | 84.71 | 0.55 | 0.46 | 15.97 | 7.32 |
| 2001 | 6708.99 | 7070 | 950 | 79.16 | 80.00 | 80.62 | 80.71 | 2.26 | 1.85 | 18.15 | 0.84 |
| 2002 | 7003.43 | 7554 | 950 | 82.66 | 85.76 | 84.16 | 86.23 | 1.00 | 0.86 | 13.37 | 3.10 |
| 2003 | 7329.54 | 7541 | 950 | 85.33 | 85.89 | 88.07 | 86.08 | 0.77 | 0.67 | 13.45 | 0.55 |
| 2004 | 7398.23 | 7674 | 950 | 86.68 | 87.11 | 88.66 | 87.36 | 0.11 | 0.10 | 12.79 | 0.44 |
| 2005 | 6116.27 | 6476 | 950 | 72.11 | 73.62 | 73.49 | 73.92 | 11.86 | 9.90 | 16.48 | 1.51 |
| 2006 | 7074.89 | 7400 | 950 | 82.73 | 84.26 | 85.01 | 84.47 | 3.63 | 3.18 | 12.56 | 1.53 |
| 2007 | 7231.43 | 7539 | 950 | 84.16 | 85.49 | 86.90 | 86.06 | 1.16 | 1.00 | 13.51 | 1.33 |
| 2008 | 7474.79 | 7756 | 950 | 88.19 | 88.19 | 89.57 | 88.30 | 0.25 | 0.22 | 11.59 | 0.00 |
| 2009 | 7004.16 | 7248 | 950 | 82.51 | 82.51 | 84.16 | 82.74 | 1.50 | 1.26 | 16.23 | 0.00 |
| 2010 | 7423.50 | 7595 | 950 | 87.77 | 87.77 | 89.20 | 86.70 | 1.51 | 1.34 | 10.89 | 0.00 |
| 2011 | 7570.61 | 7675 | 950 | 86.98 | 86.98 | 90.98 | 87.62 | 0.63 | 0.55 | 12.47 | 0.00 |
| 2012 | 7164.85 | 7464 | 950 | 84.47 | 84.47 | 85.86 | 84.97 | 0.93 | 0.79 | 14.74 | 0.00 |
| 2013 | 8635.13 | 8552 | 950 | 97.57 | 97.57 | 103.76 | 97.63 | 0.00 | 0.00 | 2.43 | 0.00 |
| 2014 | 7030.39 | 6984 | 950 | 79.59 | 79.59 | 84.47 | 79.72 | 0.00 | 0.00 | 20.41 | 0.00 |
| 2015 | 7883.15 | 7805 | 950 | 88.94 | 88.94 | 94.73 | 89.10 | 2.10 | 1.90 | 9.16 | 0.00 |
| 2016 | 6776.88 | 6664 | 950 | 75.75 | 75.75 | 81.21 | 75.87 | 0.00 | 0.00 | 24.25 | 0.00 |
| 2017 | 7562.08 | 7439 | 950 | 84.68 | 84.71 | 90.87 | 84.92 | 1.93 | 6.54 | 8.75 | 0.03 |
| 2018 | 8390.72 | 8224 | 950 | 93.84 | 93.86 | 100.83 | 93.88 | 6.14 | 6.14 | 0.00 | 0.01 |
| 2019 | 7769.30 | 7721 | 950 | 87.05 | 87.05 | 93.36 | 88.14 | 1.94 | 1.73 | 11.23 | 0.00 |
| 2020 | 7987.59 | 8031 | 950 | 90.80 | 90.80 | 95.72 | 91.43 | 0.52 | 0.48 | 8.73 | 0.00 |
| 2021 | 8688.57 | 8645 | 950 | 97.24 | 97.24 | 104.40 | 98.69 | 2.76 | 2.76 | 0.00 | 0.00 |
| 2022 | 7334.10 | 7262 | 950 | 82.50 | 82.78 | 88.13 | 82.90 | 0.21 | 0.18 | 17.04 | 0.28 |
| 2023 | 8191.96 | 8067 | 950 | 91.93 | 92.01 | 98.44 | 92.09 | 0.00 | 0.00 | 7.99 | 0.08 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 170 | |
| C. Inspection, maintenance or repair combined with refuelling | 695 | | | 1193 | 6 | |
| D. Inspection, maintenance or repair without refuelling | | | | 63 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 15 | |
| Z. Other | | | | | 3 | |
| Subtotal | 695 | | | 1256 | 194 | 3 |
| Total | | 695 | | | 1453 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 6 |
| 12. Reactor I&C Systems | | 17 |
| 15. Reactor Cooling Systems | | 31 |
| 16. Steam generation systems | | 4 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 28 |
| 32. Feedwater and Main Steam System | | 6 |
| 34. Miscellaneous Systems | | 7 |
| 35. All other I&C Systems | | 6 |
| 41. Main Generator Systems | | 67 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | | 178 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-December. Additional electricity generation amounted to 511203 MWh. The unit was in the intermediate maintenance outage from 2023.09.30 to 2023.10.28. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-36

KALININ-3

RUSSIA

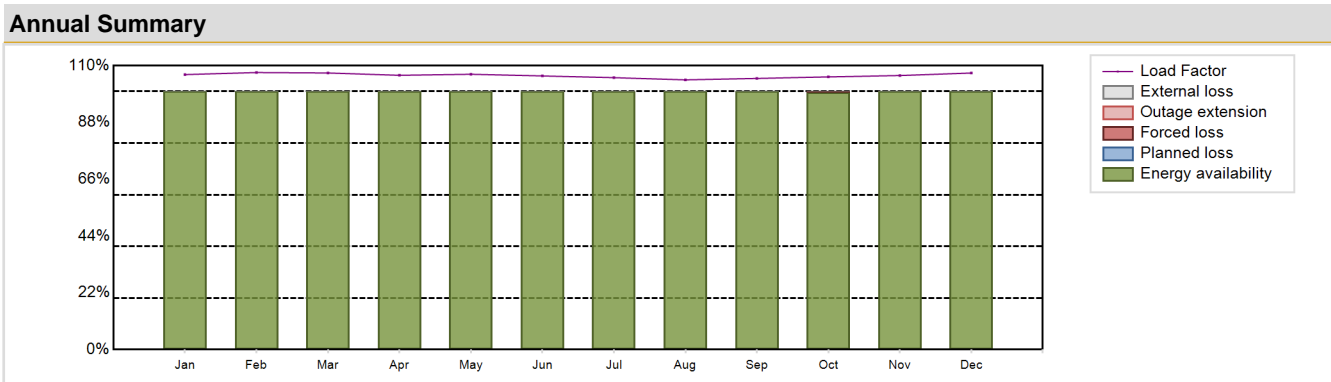
Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : FAEA (Federal Atomic Energy Agency)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 1985-10-01 |
| Thermal power | : 3200 MWth | Grid Date | : 2004-12-16 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 2005-11-08 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 19 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 16 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 322 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : DH / PH |

| Annual Production Results (2023) | | | |
|--|-------------------|--|-----------|
| Net Energy Production | : 8833.38 GW(e).h | Forced Loss Rate (FLR) | : 0.03 % |
| Energy Availability Factor (EAF) | : 99.97 % | Unplanned Capability Loss Factor (UCL) | : 0.03 % |
| Unit Capability Factor (UCF) | : 99.97 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 106.14 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |
| Equivalent non-electrical energy generated (NEG) | : 30.74 GW(e).h | | |

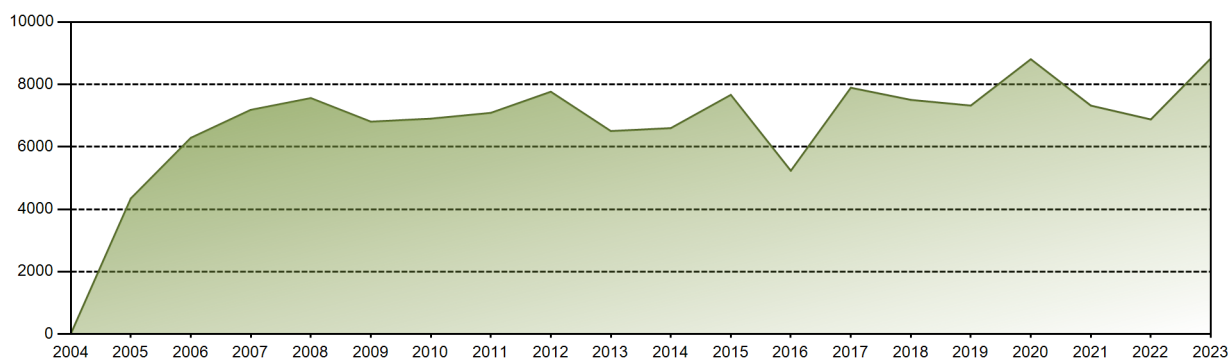


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 753.00 | 685.23 | 757.39 | 726.87 | 753.93 | 725.13 | 744.59 | 738.51 | 718.55 | 746.65 | 726.22 | 757.30 | 8833.38 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.70 | 100.00 | 100.00 | 99.97 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.70 | 100.00 | 100.00 | 99.97 |
| LF [%] | 106.54 | 107.34 | 107.16 | 106.27 | 106.67 | 106.01 | 105.35 | 104.49 | 105.05 | 105.64 | 106.17 | 107.15 | 106.14 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 | 0.00 | 0.03 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 | 0.00 | 0.03 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 134503.78 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.57 % |
| Cumulative Energy Availability Factor (EAF) | : 84.85 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.29 % |
| Cumulative Unit Capability Factor (UCF) | : 84.93 % | Cumulative Planned Unavailability Factor (PUF) | : 10.78 % |
| Cumulative Load Factor (LF) | : 86.97 % | Cumulative Externally cause unavailability (XUF) | : 0.08 % |
| Cumulative Operating Factor (OF) | : 85.34 % | | |

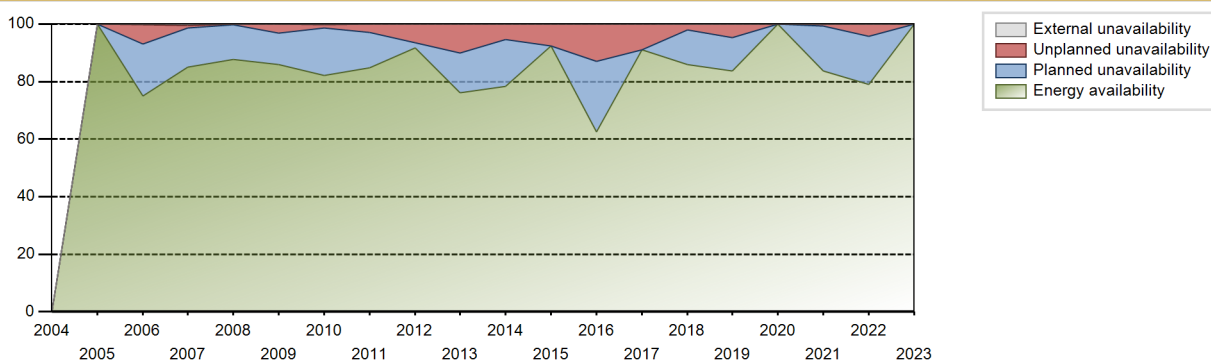
Electricity Production (net) [GWh]



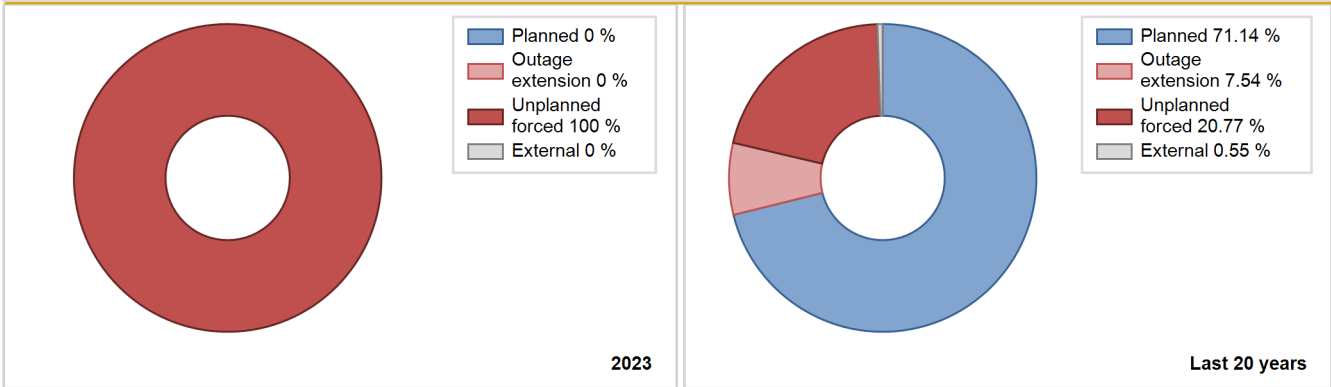
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|--------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2005 | 4345.70 | 5686 | 950 | 100.00 | 100.00 | 100.84 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2006 | 6287.23 | 6692 | 950 | 74.90 | 75.20 | 75.55 | 76.39 | 5.71 | 6.62 | 18.18 | 0.29 |
| 2007 | 7185.22 | 7505 | 950 | 84.96 | 85.51 | 86.34 | 85.67 | 0.91 | 0.81 | 13.68 | 0.55 |
| 2008 | 7561.73 | 7737 | 950 | 87.74 | 87.78 | 90.62 | 88.08 | 0.18 | 0.16 | 12.06 | 0.03 |
| 2009 | 6806.52 | 7553 | 950 | 85.96 | 85.96 | 81.79 | 86.22 | 3.61 | 3.22 | 10.82 | 0.00 |
| 2010 | 6902.21 | 7248 | 950 | 82.13 | 82.44 | 82.94 | 82.74 | 1.25 | 1.04 | 16.52 | 0.31 |
| 2011 | 7088.32 | 7427 | 950 | 84.82 | 84.85 | 85.19 | 84.79 | 0.59 | 2.84 | 12.31 | 0.04 |
| 2012 | 7765.07 | 8091 | 950 | 91.78 | 91.78 | 93.05 | 92.11 | 6.68 | 6.57 | 1.65 | 0.01 |
| 2013 | 6505.71 | 6698 | 950 | 76.18 | 76.18 | 78.17 | 76.46 | 1.31 | 10.15 | 13.67 | 0.00 |
| 2014 | 6599.48 | 6918 | 950 | 78.27 | 78.27 | 79.29 | 78.96 | 5.79 | 5.33 | 16.40 | 0.00 |
| 2015 | 7665.20 | 8196 | 950 | 92.28 | 92.28 | 92.11 | 93.56 | 7.67 | 7.67 | 0.05 | 0.00 |
| 2016 | 5233.15 | 5612 | 950 | 62.43 | 62.43 | 62.71 | 63.89 | 10.35 | 13.02 | 24.55 | 0.00 |
| 2017 | 7892.37 | 7990 | 950 | 91.11 | 91.11 | 94.84 | 91.21 | 8.89 | 8.89 | 0.00 | 0.00 |
| 2018 | 7504.45 | 7558 | 950 | 85.85 | 85.95 | 90.18 | 86.28 | 2.29 | 2.01 | 12.04 | 0.10 |
| 2019 | 7322.22 | 7362 | 950 | 83.69 | 83.76 | 87.99 | 84.04 | 4.44 | 4.74 | 11.50 | 0.07 |
| 2020 | 8807.69 | 8784 | 950 | 100.00 | 100.00 | 105.55 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 7321.23 | 7369 | 950 | 83.73 | 83.78 | 87.97 | 84.12 | 0.70 | 0.59 | 15.64 | 0.05 |
| 2022 | 6877.28 | 6929 | 950 | 78.94 | 79.00 | 82.64 | 79.10 | 5.09 | 4.24 | 16.76 | 0.06 |
| 2023 | 8833.38 | 8760 | 950 | 99.97 | 99.97 | 106.14 | 100.00 | 0.03 | 0.03 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2005 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 322 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 931 | 10 | |
| D. Inspection, maintenance or repair without refuelling | | | | 16 | | |
| E. Testing of plant systems or components | | | | 0 | 2 | |
| H. Nuclear regulatory requirements | | | | | 4 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 2 | |
| Z. Other | | | | | 11 | |
| Subtotal | | | | 947 | 351 | 2 |
| Total | | 0 | | | 1300 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2005 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 11 |
| 13. Reactor Auxiliary Systems | | 9 |
| 15. Reactor Cooling Systems | | 4 |
| 16. Steam generation systems | | 3 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 52 |
| 32. Feedwater and Main Steam System | | 10 |
| 33. Circulating Water System | | 1 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 143 |
| 42. Electrical Power Supply Systems | | 101 |
| Total | | 336 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-December. Additional electricity generation amounted to 509006 MWh. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-37

KALININ-4

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KALUGA (JSC "Kaluga turbine plant" 32, Glagoleva Street, Kaluga, 248021, Russia)



Reactor Unit Details

Reactor type and model : PWR / VVER V-320
 Thermal power : 3200 MWth
 Gross electrical power : 1000 MWe
 Reference unit power (net) : 950 MWe

Key Dates

Construction Date : 1986-08-01
 Grid Date : 2011-11-24
 Commercial Date : 2012-12-25
 Age at end of year : 12 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 40000
 Active core diameter [m] : 3.16
 Active core height/length [m] : 3.53
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : 17.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 1.05
 Reactor outlet temperature [°C] : 322
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

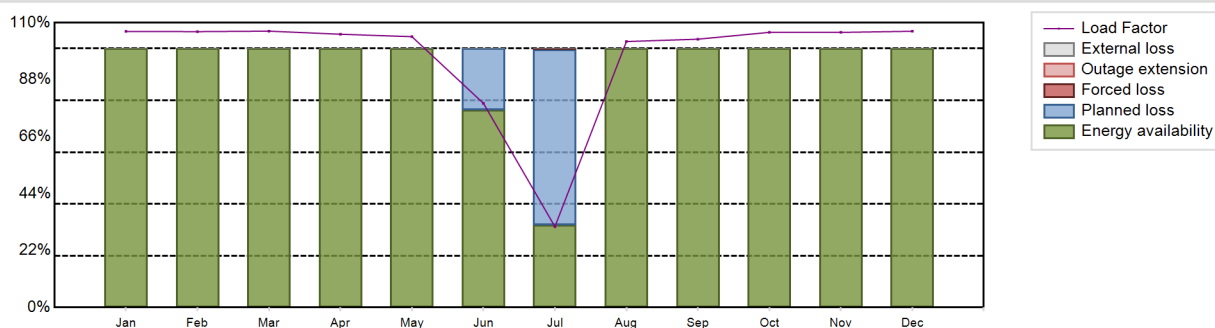
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 8076.94 GW(e).h
 Energy Availability Factor (EAF) : 92.27 %
 Unit Capability Factor (UCF) : 92.27 %
 Load Factor (LF) : 97.06 %
 Operating Factor (OF) : 92.47 %
 Equivalent non-electrical energy generated (NEG) : 15.36 GW(e).h

Forced Loss Rate (FLR) : 0.03 %
 Unplanned Capability Loss Factor (UCL) : 0.02 %
 Planned Unavailability Factor (PUF) : 7.71 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 660 hours

Annual Summary

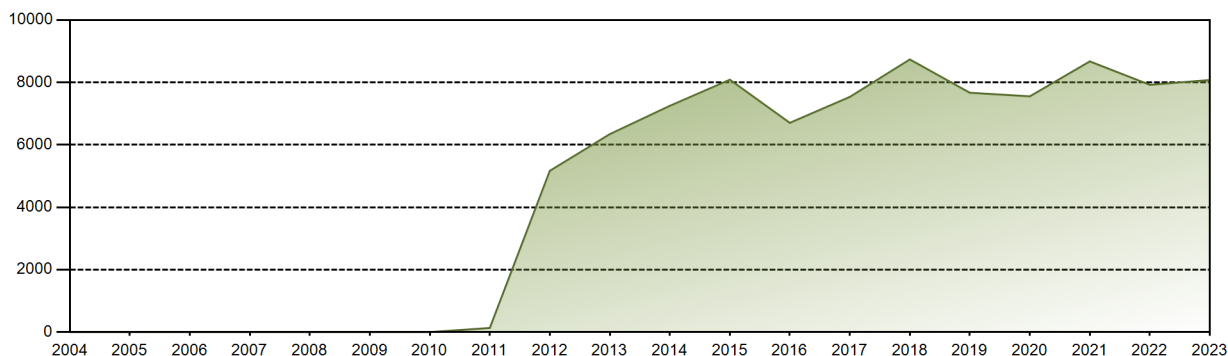


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 753.73 | 680.19 | 754.43 | 721.96 | 739.32 | 539.52 | 220.81 | 726.09 | 708.89 | 751.14 | 726.78 | 754.07 | 8076.94 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 76.34 | 31.88 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.27 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 76.34 | 31.88 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.27 |
| LF [%] | 106.64 | 106.55 | 106.74 | 105.55 | 104.60 | 78.88 | 31.24 | 102.73 | 103.64 | 106.27 | 106.25 | 106.69 | 97.06 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 76.81 | 33.74 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.47 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 23.66 | 67.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.71 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 89888.52 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.5 % |
| Cumulative Energy Availability Factor (EAF) | : 89.13 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.7 % |
| Cumulative Unit Capability Factor (UCF) | : 89.13 % | Cumulative Planned Unavailability Factor (PUF) | : 8.17 % |
| Cumulative Load Factor (LF) | : 92.32 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 89.55 % | | |

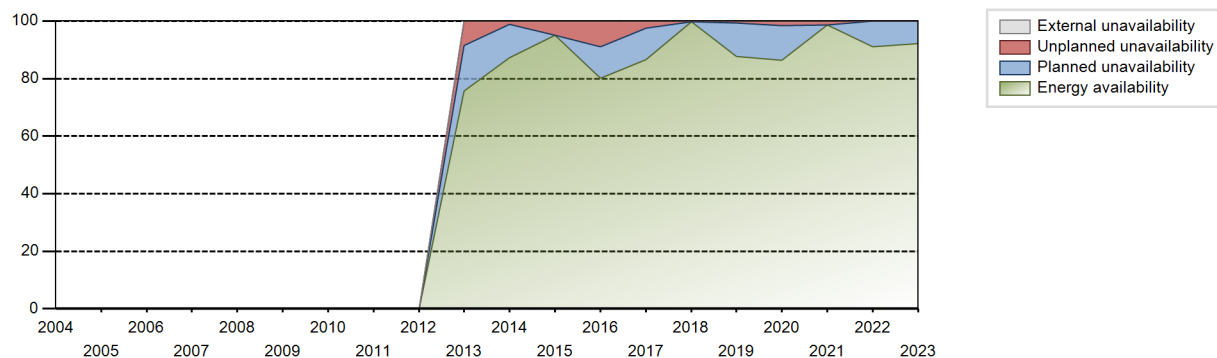
Electricity Production (net) [GWh]



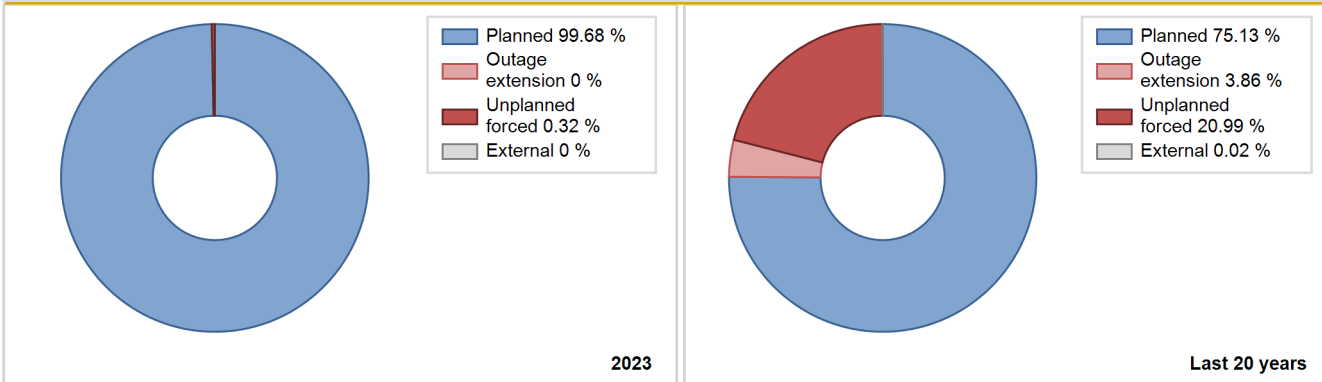
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|------------------------|------------------------------|-------|-------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2012 | 5166.49 | 6858 | 950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 6342.91 | 6662 | 950 | 75.72 | 75.73 | 76.22 | 76.05 | 6.89 | 8.42 | 15.85 | 0.02 |
| 2014 | 7249.38 | 7691 | 950 | 87.21 | 87.21 | 87.10 | 87.79 | 1.23 | 1.08 | 11.71 | 0.00 |
| 2015 | 8086.65 | 8346 | 950 | 95.01 | 95.01 | 97.17 | 95.27 | 4.99 | 4.99 | 0.00 | 0.00 |
| 2016 | 6704.20 | 7255 | 950 | 80.15 | 80.15 | 80.34 | 82.59 | 9.83 | 8.96 | 10.89 | 0.00 |
| 2017 | 7535.97 | 7490 | 950 | 86.52 | 86.52 | 90.55 | 85.50 | 0.92 | 2.39 | 11.09 | 0.00 |
| 2018 | 8736.46 | 8760 | 950 | 99.76 | 99.76 | 104.98 | 100.00 | 0.24 | 0.24 | 0.00 | 0.00 |
| 2019 | 7668.87 | 7745 | 950 | 87.66 | 87.66 | 92.15 | 88.41 | 0.70 | 0.61 | 11.72 | 0.00 |
| 2020 | 7553.71 | 7638 | 950 | 86.28 | 86.28 | 90.52 | 86.95 | 1.93 | 1.69 | 12.02 | 0.00 |
| 2021 | 8673.29 | 8657 | 950 | 98.71 | 98.71 | 104.22 | 98.82 | 1.29 | 1.29 | 0.00 | 0.00 |
| 2022 | 7923.02 | 7987 | 950 | 91.15 | 91.15 | 95.21 | 91.18 | 0.02 | 0.02 | 8.84 | 0.00 |
| 2023 | 8076.94 | 8100 | 950 | 92.27 | 92.27 | 97.06 | 92.47 | 0.03 | 0.02 | 7.71 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2012 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 194 | |
| C. Inspection, maintenance or repair combined with refuelling | 661 | | | 702 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 12 | | |
| L. Human factor related | | | | | 7 | |
| Subtotal | 661 | | | 714 | 201 | |
| Total | | 661 | | | 915 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2012 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 12 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 31. Turbine and auxiliaries | | 63 |
| 32. Feedwater and Main Steam System | | 8 |
| 33. Circulating Water System | | 2 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 59 |
| 42. Electrical Power Supply Systems | | 36 |
| Total | | 184 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-December. Additional electricity generation amounted to 433342 MWh. The unit was in the intermediate maintenance outage from 2023.06.24 to 2023.07.21. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-12

KOLA-1

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

Reactor Unit Details

Reactor type and model : PWR / VVER V-230
 Thermal power : 1375 MWth
 Gross electrical power : 440 MWe
 Reference unit power (net) : 411 MWe

Key Dates

Construction Date : 1970-05-01
 Grid Date : 1973-06-29
 Commercial Date : 1973-12-28
 Age at end of year : 50 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 28600
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.5
 Reactor outlet temperature [°C] : 300
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 4.4
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

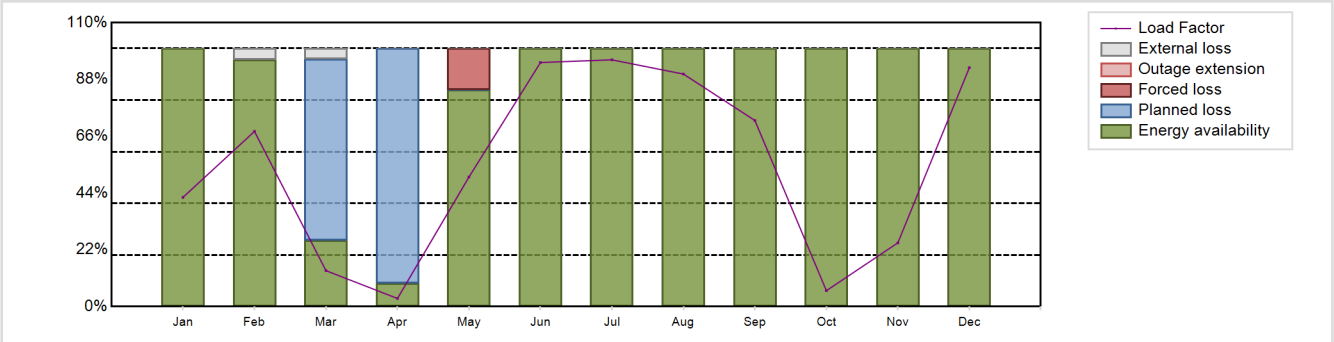
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 1958.53 GW(e).h
 Energy Availability Factor (EAF) : 84.54 %
 Unit Capability Factor (UCF) : 85.22 %
 Load Factor (LF) : 54.4 %
 Operating Factor (OF) : 75.01 %
 Equivalent non-electrical energy generated (NEG) : 0 GW(e).h

Forced Loss Rate (FLR) : 1.56 %
 Unplanned Capability Loss Factor (UCL) : 1.35 %
 Planned Unavailability Factor (PUF) : 13.43 %
 Externally cause unavailability (XUF) : 0.67 %
 Total off-line time : 2189 hours

Annual Summary

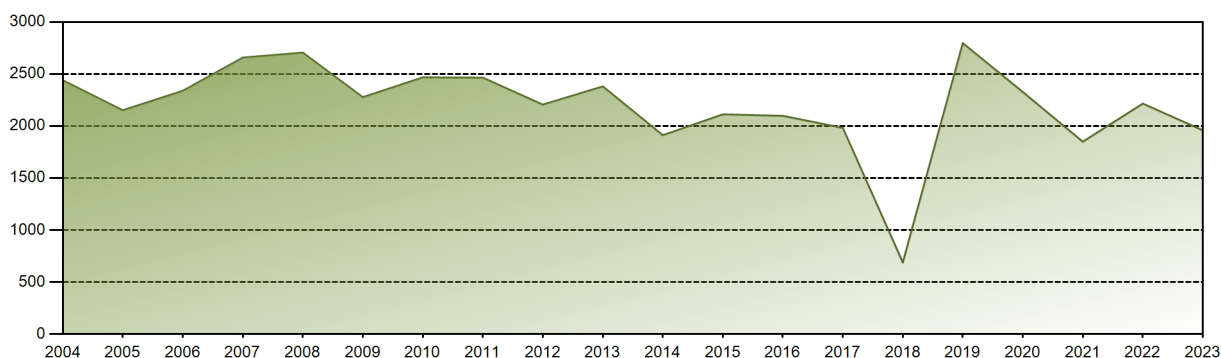


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 129.48 | 187.44 | 42.64 | 9.39 | 153.49 | 279.79 | 292.32 | 275.46 | 213.40 | 18.91 | 73.16 | 283.04 | 1958.53 |
| EAF [%] | 100.00 | 95.71 | 25.74 | 9.15 | 84.07 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 84.54 |
| UCF [%] | 100.00 | 100.00 | 29.79 | 9.15 | 84.07 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.22 |
| LF [%] | 42.34 | 67.87 | 13.95 | 3.17 | 50.20 | 94.55 | 95.60 | 90.08 | 72.11 | 6.19 | 24.72 | 92.56 | 54.40 |
| OF [%] | 100.00 | 100.00 | 30.51 | 11.67 | 86.96 | 100.00 | 100.00 | 100.00 | 100.00 | 17.47 | 54.86 | 100.00 | 75.01 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 15.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.56 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 15.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.35 |
| PUF [%] | 0.00 | 0.00 | 70.21 | 90.85 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.43 |
| XUF [%] | 0.00 | 4.29 | 4.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.67 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 115303.16 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.56 % |
| Cumulative Energy Availability Factor (EAF) | : 72.74 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.09 % |
| Cumulative Unit Capability Factor (UCF) | : 77.68 % | Cumulative Planned Unavailability Factor (PUF) | : 20.23 % |
| Cumulative Load Factor (LF) | : 63.51 % | Cumulative Externally cause unavailability (XUF) | : 4.94 % |
| Cumulative Operating Factor (OF) | : 79.14 % | | |

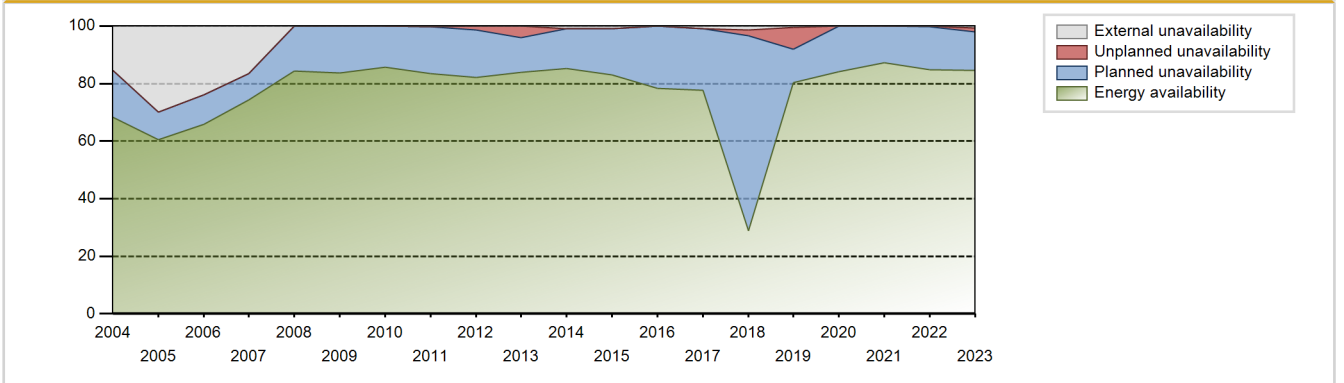
Electricity Production (net) [GWh]



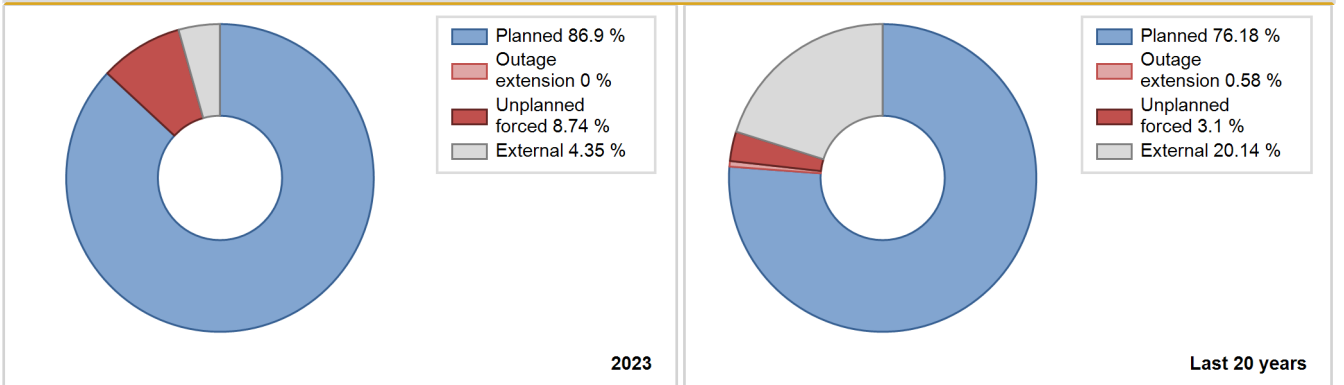
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1973 | 918.20 | 4180 | 411 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1974 | 1990.06 | 8463 | 411 | 79.22 | 79.22 | 55.27 | 96.61 | 0.90 | 0.72 | 20.06 | 0.01 |
| 1975 | 1015.76 | 5426 | 411 | 50.91 | 50.94 | 28.21 | 61.94 | 1.27 | 0.66 | 48.40 | 0.03 |
| 1976 | 2421.71 | 8247 | 411 | 74.05 | 74.17 | 67.08 | 93.89 | 0.97 | 0.73 | 25.10 | 0.12 |
| 1977 | 2101.05 | 7462 | 411 | 76.38 | 76.40 | 58.36 | 85.18 | 6.73 | 5.52 | 18.09 | 0.01 |
| 1978 | 2978.78 | 8074 | 411 | 82.58 | 82.60 | 82.74 | 92.17 | 1.55 | 1.30 | 16.10 | 0.02 |
| 1979 | 2435.60 | 6232 | 411 | 64.63 | 64.65 | 67.65 | 71.14 | 2.14 | 1.41 | 33.94 | 0.02 |
| 1980 | 3466.37 | 8072 | 411 | 90.90 | 91.05 | 96.02 | 91.89 | 0.33 | 0.30 | 8.65 | 0.15 |
| 1981 | 2870.79 | 7448 | 411 | 80.94 | 80.95 | 79.74 | 85.02 | 2.81 | 2.34 | 16.71 | 0.01 |
| 1982 | 2848.07 | 7875 | 411 | 85.52 | 85.52 | 79.11 | 89.90 | 1.80 | 1.56 | 12.91 | 0.01 |
| 1983 | 3217.37 | 7884 | 411 | 88.25 | 88.27 | 89.36 | 90.00 | 0.19 | 0.17 | 11.57 | 0.02 |
| 1984 | 3112.02 | 8060 | 411 | 84.90 | 84.92 | 86.20 | 91.76 | 1.41 | 1.22 | 13.87 | 0.01 |
| 1985 | 2388.76 | 6001 | 411 | 67.02 | 67.05 | 66.35 | 68.50 | 0.61 | 0.41 | 32.54 | 0.03 |
| 1986 | 2805.84 | 8074 | 411 | 85.08 | 85.08 | 77.93 | 92.17 | 5.88 | 5.32 | 9.60 | 0.00 |
| 1987 | 3268.23 | 7972 | 440 | 86.00 | 86.00 | 84.79 | 91.00 | 0.96 | 0.83 | 13.17 | 0.00 |
| 1988 | 2925.01 | 7482 | 411 | 82.67 | 82.73 | 81.02 | 85.18 | 6.53 | 5.78 | 11.49 | 0.06 |
| 1989 | 2675.48 | 6731 | 411 | 75.44 | 76.23 | 74.31 | 76.84 | 1.18 | 0.91 | 22.86 | 0.79 |
| 1990 | 2735.50 | 6838 | 411 | 75.95 | 75.95 | 75.98 | 78.06 | 2.00 | 1.55 | 22.50 | 0.00 |
| 1991 | 2773.12 | 6965 | 411 | 77.27 | 77.27 | 77.02 | 79.51 | 7.17 | 5.97 | 16.76 | 0.00 |
| 1992 | 2271.37 | 6651 | 411 | 63.44 | 63.70 | 62.92 | 75.73 | 17.65 | 13.65 | 22.65 | 0.26 |
| 1993 | 1992.62 | 5663 | 411 | 56.14 | 59.56 | 55.35 | 64.65 | 14.77 | 10.32 | 30.11 | 3.42 |
| 1994 | 1971.62 | 5359 | 411 | 56.50 | 58.63 | 54.76 | 61.18 | 7.34 | 4.65 | 36.72 | 2.13 |
| 1995 | 1581.37 | 5398 | 411 | 62.24 | 62.24 | 43.92 | 61.62 | 5.06 | 3.32 | 34.44 | 0.00 |
| 1996 | 1409.96 | 4466 | 411 | 46.43 | 47.44 | 39.05 | 50.84 | 6.51 | 3.30 | 49.26 | 1.00 |
| 1997 | 2404.12 | 7942 | 411 | 88.48 | 88.48 | 66.77 | 90.66 | 5.02 | 4.68 | 6.84 | 0.00 |
| 1998 | 1291.73 | 5658 | 411 | 37.66 | 59.27 | 35.88 | 64.59 | 12.77 | 8.68 | 32.05 | 21.61 |
| 1999 | 2028.49 | 7355 | 411 | 58.01 | 86.57 | 56.34 | 83.96 | 0.97 | 0.85 | 12.58 | 28.56 |
| 2000 | 1298.85 | 4643 | 411 | 37.17 | 84.13 | 35.98 | 52.86 | 0.80 | 0.68 | 15.19 | 46.96 |
| 2001 | 2243.22 | 7098 | 411 | 63.27 | 81.60 | 62.31 | 81.03 | 0.91 | 0.75 | 17.65 | 18.33 |
| 2002 | 1841.48 | 5660 | 411 | 51.65 | 68.90 | 51.15 | 64.61 | 0.00 | 0.00 | 31.10 | 17.25 |
| 2003 | 2164.00 | 6444 | 411 | 60.41 | 75.51 | 60.11 | 73.56 | 0.73 | 0.55 | 23.94 | 15.10 |
| 2004 | 2440.48 | 7326 | 411 | 68.21 | 83.64 | 67.60 | 83.40 | 0.00 | 0.00 | 16.36 | 15.43 |
| 2005 | 2151.67 | 6901 | 411 | 60.60 | 90.57 | 59.76 | 78.78 | 0.01 | 0.01 | 9.43 | 29.97 |
| 2006 | 2338.66 | 7661 | 411 | 65.95 | 89.94 | 64.96 | 87.45 | 0.00 | 0.00 | 10.06 | 23.98 |
| 2007 | 2658.02 | 7740 | 411 | 74.43 | 90.96 | 73.83 | 88.36 | 0.00 | 0.00 | 9.04 | 16.53 |
| 2008 | 2705.75 | 7397 | 411 | 84.34 | 84.34 | 74.95 | 84.21 | 0.00 | 0.00 | 15.66 | 0.00 |
| 2009 | 2277.43 | 7333 | 411 | 83.76 | 83.77 | 63.26 | 83.71 | 0.00 | 0.00 | 16.23 | 0.01 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2010 | 2467.97 | 7912 | 411 | 85.79 | 85.82 | 68.55 | 90.32 | 0.00 | 0.00 | 14.18 | 0.03 |
| 2011 | 2465.32 | 7870 | 411 | 83.47 | 83.62 | 68.48 | 89.85 | 0.00 | 0.00 | 16.38 | 0.15 |
| 2012 | 2205.74 | 7021 | 411 | 82.24 | 82.24 | 61.10 | 79.93 | 1.67 | 1.39 | 16.37 | 0.00 |
| 2013 | 2380.88 | 7811 | 411 | 83.98 | 83.98 | 66.13 | 89.17 | 4.60 | 4.05 | 11.97 | 0.00 |
| 2014 | 1911.66 | 7536 | 411 | 85.18 | 86.19 | 53.09 | 86.02 | 0.00 | 0.00 | 13.81 | 1.01 |
| 2015 | 2112.22 | 7373 | 411 | 83.10 | 84.00 | 58.67 | 84.17 | 0.01 | 0.01 | 15.99 | 0.91 |
| 2016 | 2097.80 | 6386 | 411 | 78.45 | 78.45 | 58.11 | 72.70 | 0.00 | 0.00 | 21.55 | 0.00 |
| 2017 | 1982.33 | 7025 | 411 | 77.78 | 78.62 | 55.06 | 80.19 | 0.00 | 0.00 | 21.38 | 0.84 |
| 2018 | 688.02 | 2652 | 411 | 28.92 | 30.25 | 19.11 | 30.27 | 5.22 | 1.97 | 67.78 | 1.33 |
| 2019 | 2796.96 | 7740 | 411 | 80.24 | 80.62 | 77.69 | 88.36 | 6.14 | 7.61 | 11.77 | 0.38 |
| 2020 | 2327.08 | 7193 | 411 | 84.03 | 84.03 | 64.46 | 81.89 | 0.07 | 0.05 | 15.92 | 0.00 |
| 2021 | 1849.44 | 6406 | 411 | 87.16 | 87.16 | 51.37 | 73.13 | 0.00 | 0.00 | 12.84 | 0.00 |
| 2022 | 2215.25 | 7356 | 411 | 84.90 | 84.90 | 61.53 | 83.97 | 0.26 | 0.22 | 14.88 | 0.00 |
| 2023 | 1958.53 | 6571 | 411 | 84.54 | 85.22 | 54.40 | 75.01 | 1.56 | 1.35 | 13.43 | 0.67 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1973 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 97 | | | 48 | |
| C. Inspection, maintenance or repair combined with refuelling | 1153 | | | 1473 | 3 | |
| D. Inspection, maintenance or repair without refuelling | | | | 72 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 52 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 38 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 939 | | | 157 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 4 |
| Z. Other | | | | | 8 | |
| Subtotal | 1153 | 97 | 939 | 1597 | 60 | 201 |
| Total | | 2189 | | | 1858 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1973 to 2023 | |
|--|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 6 |
| 13. Reactor Auxiliary Systems | | | | 3 |
| 15. Reactor Cooling Systems | | | 97 | 14 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 1 |
| 31. Turbine and auxiliaries | | | | 2 |
| 32. Feedwater and Main Steam System | | | | 6 |
| 34. Miscellaneous Systems | | | | 13 |
| 35. All other I&C Systems | | | | 1 |
| 41. Main Generator Systems | | | | 1 |
| 42. Electrical Power Supply Systems | | | | 3 |
| Total | | | 97 | 50 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in June, December. Additional electricity generation amounted to 1071 MWh. The unit was in the intermediate maintenance outage from 2023.03.10 to 2023.04.27. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-13

KOLA-2

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

Reactor Unit Details

Reactor type and model : PWR / VVER V-230
 Thermal power : 1375 MWth
 Gross electrical power : 440 MWe
 Reference unit power (net) : 411 MWe

Key Dates

Construction Date : 1970-05-01
 Grid Date : 1974-12-09
 Commercial Date : 1975-02-21
 Age at end of year : 49 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 28600
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.5
 Reactor outlet temperature [°C] : 300
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 4.4
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

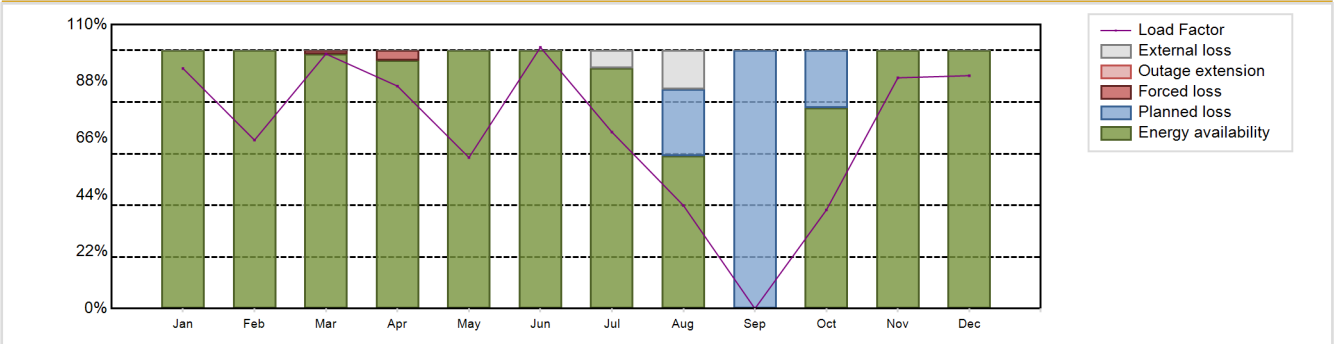
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 2488.57 GW(e).h
 Energy Availability Factor (EAF) : 85.42 %
 Unit Capability Factor (UCF) : 87.27 %
 Load Factor (LF) : 69.12 %
 Operating Factor (OF) : 86.24 %
 Equivalent non-electrical energy generated (NEG) : 0 GW(e).h

Forced Loss Rate (FLR) : 0.5 %
 Unplanned Capability Loss Factor (UCL) : 0.44 %
 Planned Unavailability Factor (PUF) : 12.29 %
 Externally cause unavailability (XUF) : 1.84 %
 Total off-line time : 1205 hours

Annual Summary

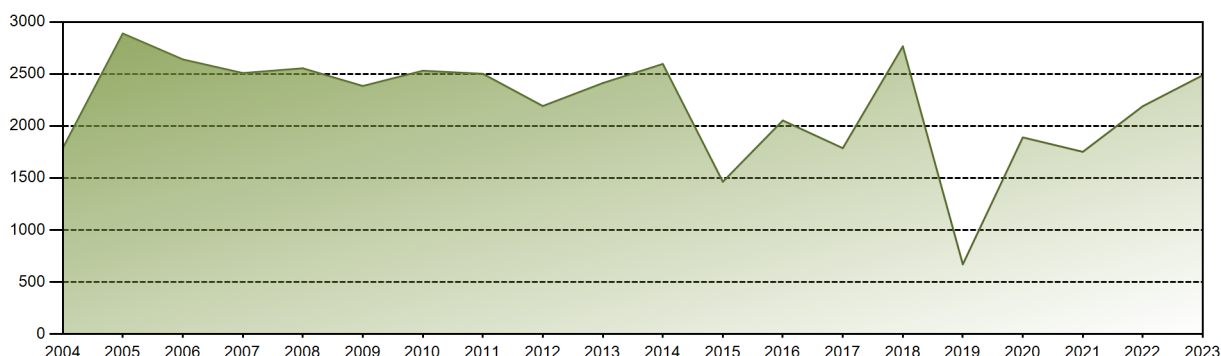


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|---------|
| GW(e)-h | 284.47 | 180.27 | 301.65 | 255.09 | 178.98 | 299.49 | 209.13 | 122.23 | 0.00 | 116.80 | 264.55 | 275.91 | 2488.57 |
| EAF [%] | 100.00 | 100.00 | 98.55 | 96.16 | 100.00 | 100.00 | 93.25 | 59.23 | 0.01 | 77.81 | 100.00 | 100.00 | 85.42 |
| UCF [%] | 100.00 | 100.00 | 98.55 | 96.16 | 100.00 | 100.00 | 100.00 | 74.20 | 0.01 | 77.81 | 100.00 | 100.00 | 87.27 |
| LF [%] | 93.03 | 65.27 | 98.65 | 86.20 | 58.53 | 101.21 | 68.39 | 39.97 | 0.00 | 38.20 | 89.40 | 90.23 | 69.12 |
| OF [%] | 100.00 | 100.00 | 98.52 | 97.22 | 92.74 | 100.00 | 100.00 | 57.93 | 0.00 | 88.31 | 100.00 | 100.00 | 86.24 |
| FLR [%] | 0.00 | 0.00 | 1.45 | 3.84 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 |
| UCL [%] | 0.00 | 0.00 | 1.45 | 3.84 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.44 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.80 | 99.99 | 22.19 | 0.00 | 0.00 | 12.29 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.75 | 14.96 | 0.00 | 0.00 | 0.00 | 0.00 | 1.84 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 112612.62 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.55 % |
| Cumulative Energy Availability Factor (EAF) | : 73.45 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.04 % |
| Cumulative Unit Capability Factor (UCF) | : 77.8 % | Cumulative Planned Unavailability Factor (PUF) | : 20.17 % |
| Cumulative Load Factor (LF) | : 63.9 % | Cumulative Externally cause unavailability (XUF) | : 4.34 % |
| Cumulative Operating Factor (OF) | : 76.95 % | | |

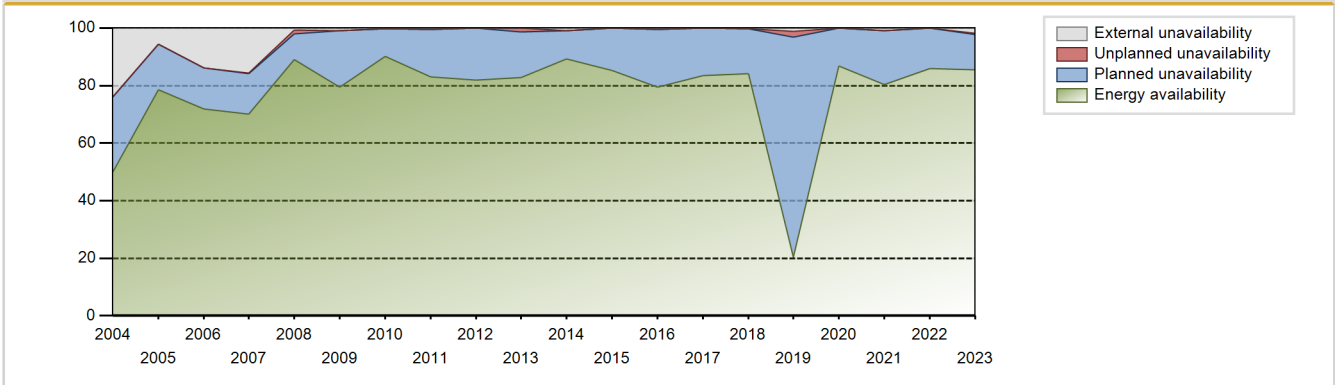
Electricity Production (net) [GWh]



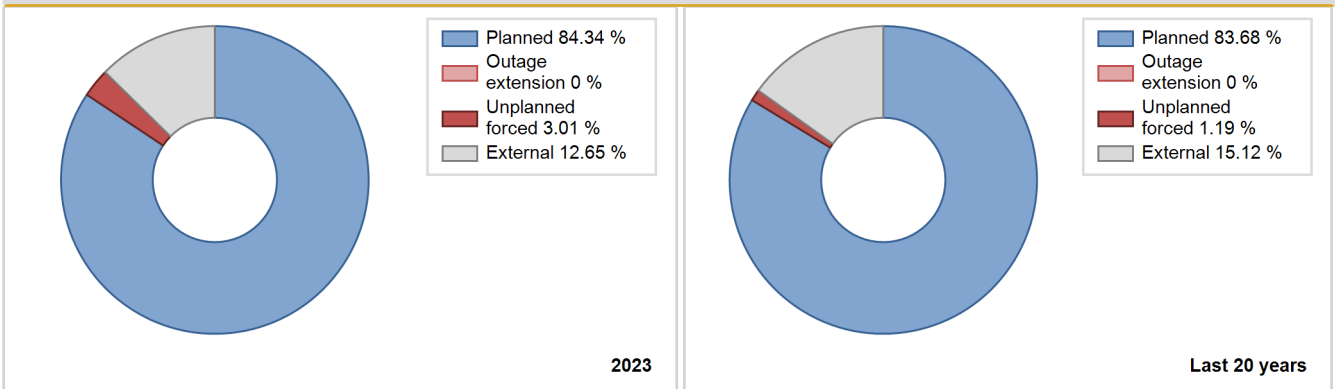
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 1383.07 | 6449 | 411 | 88.23 | 88.23 | 37.48 | 73.97 | 3.66 | 3.35 | 8.41 | 0.00 |
| 1976 | 1943.15 | 7083 | 411 | 70.82 | 70.82 | 53.82 | 80.64 | 0.74 | 0.53 | 28.65 | 0.00 |
| 1977 | 2627.24 | 7038 | 411 | 76.90 | 77.05 | 72.97 | 80.34 | 1.10 | 0.85 | 22.09 | 0.15 |
| 1978 | 2982.47 | 7576 | 411 | 82.71 | 82.71 | 82.84 | 86.48 | 0.67 | 0.56 | 16.73 | 0.00 |
| 1979 | 3057.59 | 7663 | 411 | 82.40 | 83.51 | 84.92 | 87.48 | 3.13 | 2.70 | 13.79 | 1.11 |
| 1980 | 3266.85 | 7966 | 411 | 85.80 | 85.99 | 90.49 | 90.69 | 0.71 | 0.62 | 13.40 | 0.19 |
| 1981 | 3146.68 | 8225 | 411 | 87.78 | 87.78 | 87.40 | 93.89 | 2.81 | 2.54 | 9.68 | 0.00 |
| 1982 | 2462.96 | 6742 | 411 | 71.24 | 71.24 | 68.41 | 76.96 | 3.13 | 2.30 | 26.46 | 0.00 |
| 1983 | 3072.64 | 7963 | 411 | 85.27 | 85.30 | 85.34 | 90.90 | 3.18 | 2.80 | 11.90 | 0.03 |
| 1984 | 3034.45 | 8079 | 411 | 86.75 | 86.76 | 84.05 | 91.97 | 1.97 | 1.74 | 11.50 | 0.00 |
| 1985 | 3055.56 | 7872 | 411 | 84.90 | 84.94 | 84.87 | 89.86 | 3.18 | 2.79 | 12.27 | 0.04 |
| 1986 | 2844.15 | 7405 | 411 | 79.74 | 79.78 | 79.00 | 84.53 | 4.19 | 3.49 | 16.73 | 0.04 |
| 1987 | 3345.38 | 7900 | 440 | 89.59 | 89.59 | 86.79 | 90.18 | 0.58 | 0.52 | 9.89 | 0.00 |
| 1988 | 2873.27 | 7451 | 411 | 80.46 | 80.49 | 79.59 | 84.82 | 5.60 | 4.78 | 14.73 | 0.03 |
| 1989 | 2707.27 | 6859 | 411 | 74.79 | 78.05 | 75.19 | 78.30 | 0.67 | 0.52 | 21.43 | 3.26 |
| 1990 | 2610.91 | 6751 | 411 | 72.72 | 72.86 | 72.52 | 77.07 | 6.09 | 4.73 | 22.42 | 0.14 |
| 1991 | 2701.86 | 6983 | 411 | 75.33 | 75.41 | 75.04 | 79.71 | 11.29 | 9.60 | 14.99 | 0.08 |
| 1992 | 2133.04 | 5871 | 411 | 61.85 | 61.85 | 59.09 | 66.85 | 16.94 | 12.61 | 25.54 | 0.00 |
| 1993 | 2138.83 | 6377 | 411 | 60.68 | 65.73 | 59.41 | 72.80 | 7.71 | 5.49 | 28.77 | 5.05 |
| 1994 | 398.60 | 1466 | 411 | 16.68 | 16.68 | 11.07 | 16.74 | 18.79 | 3.86 | 79.46 | 0.00 |
| 1995 | 2205.78 | 6846 | 411 | 93.58 | 93.58 | 61.27 | 78.15 | 2.08 | 1.99 | 4.43 | 0.00 |
| 1996 | 1946.17 | 6243 | 411 | 65.47 | 66.30 | 53.91 | 71.07 | 3.53 | 2.43 | 31.27 | 0.84 |
| 1997 | 1157.94 | 3955 | 411 | 40.64 | 53.44 | 32.16 | 45.15 | 3.35 | 1.85 | 44.70 | 12.80 |
| 1998 | 2655.63 | 8029 | 411 | 74.46 | 83.64 | 73.76 | 91.66 | 8.88 | 8.15 | 8.22 | 9.18 |
| 1999 | 1272.59 | 4423 | 411 | 36.30 | 48.99 | 35.35 | 50.49 | 17.19 | 10.17 | 40.84 | 12.69 |
| 2000 | 2430.51 | 7626 | 411 | 68.16 | 83.38 | 67.32 | 86.82 | 2.56 | 2.19 | 14.43 | 15.22 |
| 2001 | 1722.31 | 6574 | 411 | 49.08 | 84.74 | 47.84 | 75.05 | 1.21 | 1.03 | 14.22 | 35.67 |
| 2002 | 1738.75 | 5564 | 411 | 48.66 | 83.24 | 48.29 | 63.52 | 0.30 | 0.25 | 16.51 | 34.58 |
| 2003 | 1866.10 | 5459 | 411 | 52.04 | 66.40 | 51.83 | 62.32 | 0.54 | 0.36 | 33.24 | 14.37 |
| 2004 | 1787.07 | 5731 | 411 | 49.92 | 73.84 | 49.50 | 65.24 | 0.04 | 0.03 | 26.12 | 23.93 |
| 2005 | 2889.18 | 7379 | 411 | 78.59 | 84.24 | 80.25 | 84.24 | 0.00 | 0.00 | 15.76 | 5.65 |
| 2006 | 2640.13 | 7597 | 411 | 71.98 | 85.73 | 73.33 | 86.72 | 0.00 | 0.00 | 14.27 | 13.75 |
| 2007 | 2508.92 | 7474 | 411 | 70.10 | 85.69 | 69.69 | 85.32 | 0.19 | 0.16 | 14.14 | 15.59 |
| 2008 | 2554.70 | 7762 | 411 | 89.13 | 89.92 | 70.76 | 88.37 | 1.32 | 1.20 | 8.88 | 0.79 |
| 2009 | 2384.55 | 6872 | 411 | 79.44 | 80.28 | 66.23 | 78.45 | 0.00 | 0.00 | 19.72 | 0.84 |
| 2010 | 2531.18 | 7619 | 411 | 90.18 | 90.41 | 70.30 | 86.97 | 0.00 | 0.00 | 9.59 | 0.24 |
| 2011 | 2501.98 | 7752 | 411 | 83.07 | 83.63 | 69.50 | 88.50 | 0.00 | 0.00 | 16.37 | 0.56 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2012 | 2192.07 | 7775 | 411 | 81.85 | 81.85 | 60.72 | 88.51 | 0.00 | 0.00 | 18.14 | 0.00 |
| 2013 | 2412.70 | 7233 | 411 | 82.80 | 82.80 | 67.01 | 82.57 | 1.51 | 1.27 | 15.93 | 0.00 |
| 2014 | 2596.45 | 7823 | 411 | 89.32 | 90.15 | 72.11 | 89.29 | 0.03 | 0.03 | 9.82 | 0.83 |
| 2015 | 1463.78 | 5450 | 411 | 85.32 | 85.32 | 40.66 | 62.21 | 0.00 | 0.00 | 14.68 | 0.00 |
| 2016 | 2053.14 | 6416 | 411 | 79.35 | 79.79 | 56.87 | 73.04 | 0.00 | 0.00 | 20.21 | 0.43 |
| 2017 | 1787.16 | 5615 | 411 | 83.48 | 83.48 | 49.64 | 64.10 | 0.08 | 0.07 | 16.45 | 0.00 |
| 2018 | 2765.53 | 7437 | 411 | 84.10 | 84.42 | 76.81 | 84.90 | 0.00 | 0.00 | 15.58 | 0.32 |
| 2019 | 670.53 | 1904 | 411 | 20.38 | 21.54 | 18.62 | 21.74 | 8.76 | 2.07 | 76.39 | 1.17 |
| 2020 | 1890.68 | 7188 | 411 | 86.71 | 86.71 | 52.37 | 81.83 | 0.00 | 0.00 | 13.29 | 0.01 |
| 2021 | 1752.15 | 6931 | 411 | 80.43 | 81.40 | 48.67 | 79.12 | 0.00 | 0.00 | 18.60 | 0.97 |
| 2022 | 2190.58 | 6498 | 411 | 85.85 | 85.85 | 60.84 | 74.18 | 0.00 | 0.00 | 14.15 | 0.00 |
| 2023 | 2488.57 | 7555 | 411 | 85.42 | 87.27 | 69.12 | 86.24 | 0.50 | 0.44 | 12.29 | 1.84 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|---|------------|-------------|------------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 32 | | | 64 | |
| C. Inspection, maintenance or repair combined with refuelling | 999 | | | 1469 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 51 | | |
| E. Testing of plant systems or components | | | | 7 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 101 | | |
| H. Nuclear regulatory requirements | | | | | 4 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 27 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 175 | | | 258 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| Z. Other | | | | | 0 | |
| Subtotal | 999 | 32 | 175 | 1628 | 69 | 287 |
| Total | | 1206 | | | 1984 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 37 |
| 12. Reactor I&C Systems | | 1 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 15 |
| 16. Steam generation systems | | 3 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 1 |
| 32. Feedwater and Main Steam System | | 0 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 0 |
| 42. Electrical Power Supply Systems | 32 | 2 |
| Total | 32 | 65 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in March-July, November-December. Additional electricity generation amounted to 18602 MWh. The unit was in the intermediate maintenance outage from 2023.08.24 to 2023.10.04. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-32

KOLA-3

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KALUGA (JSC "Kaluga turbine plant" 32, Glagoleva Street, Kaluga, 248021, Russia)

Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1375 MWth
 Gross electrical power : 440 MWe
 Reference unit power (net) : 411 MWe

Key Dates

Construction Date : 1977-04-01
 Grid Date : 1981-03-24
 Commercial Date : 1982-12-03
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 28600
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.5
 Reactor outlet temperature [°C] : 300
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 4.4
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

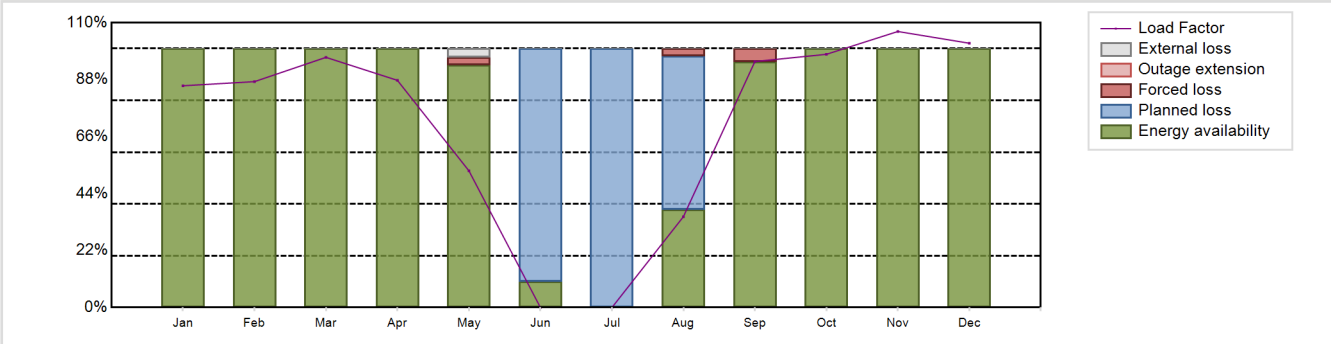
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 2534.41 GW(e).h
 Energy Availability Factor (EAF) : 77.88 %
 Unit Capability Factor (UCF) : 78.16 %
 Load Factor (LF) : 70.39 %
 Operating Factor (OF) : 75.39 %
 Equivalent non-electrical energy generated (NEG) : 0 GW(e).h

Forced Loss Rate (FLR) : 1.16 %
 Unplanned Capability Loss Factor (UCL) : 0.92 %
 Planned Unavailability Factor (PUF) : 20.92 %
 Externally cause unavailability (XUF) : 0.28 %
 Total off-line time : 2156 hours

Annual Summary

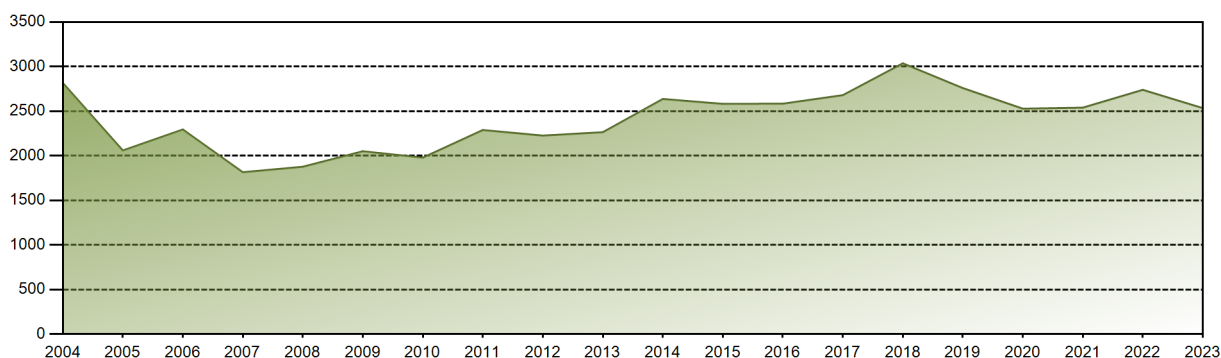


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|-------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 261.91 | 240.95 | 295.45 | 259.62 | 161.41 | 0.00 | 0.00 | 107.28 | 281.16 | 299.02 | 315.48 | 312.13 | 2534.41 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 93.68 | 10.01 | 0.01 | 37.83 | 94.99 | 100.00 | 100.00 | 100.00 | 77.88 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 96.94 | 10.01 | 0.01 | 37.83 | 94.99 | 100.00 | 100.00 | 100.00 | 78.16 |
| LF [%] | 85.65 | 87.24 | 96.62 | 87.73 | 52.79 | 0.00 | 0.00 | 35.08 | 95.01 | 97.79 | 106.61 | 102.08 | 70.39 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 65.99 | 0.00 | 0.00 | 45.83 | 95.00 | 100.00 | 100.00 | 100.00 | 75.39 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 3.06 | 0.00 | 0.00 | 7.08 | 5.01 | 0.00 | 0.00 | 0.00 | 1.16 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 3.06 | 0.00 | 0.00 | 2.88 | 5.01 | 0.00 | 0.00 | 0.00 | 0.92 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 89.99 | 99.99 | 59.29 | 0.00 | 0.00 | 0.00 | 0.00 | 20.92 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 3.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.28 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 106306.02 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.26 % |
| Cumulative Energy Availability Factor (EAF) | : 76.81 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.93 % |
| Cumulative Unit Capability Factor (UCF) | : 82.33 % | Cumulative Planned Unavailability Factor (PUF) | : 15.75 % |
| Cumulative Load Factor (LF) | : 70.18 % | Cumulative Externally cause unavailability (XUF) | : 5.52 % |
| Cumulative Operating Factor (OF) | : 82.17 % | | |

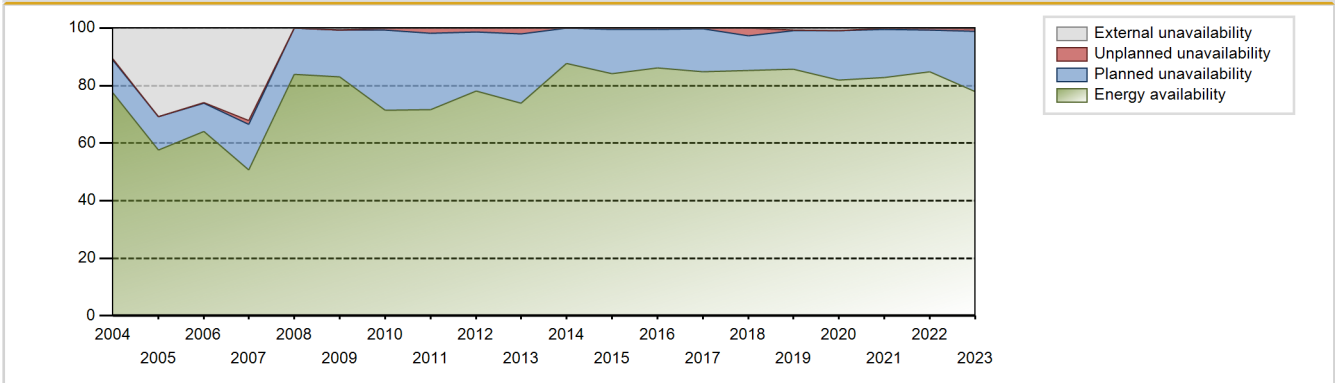
Electricity Production (net) [GWh]



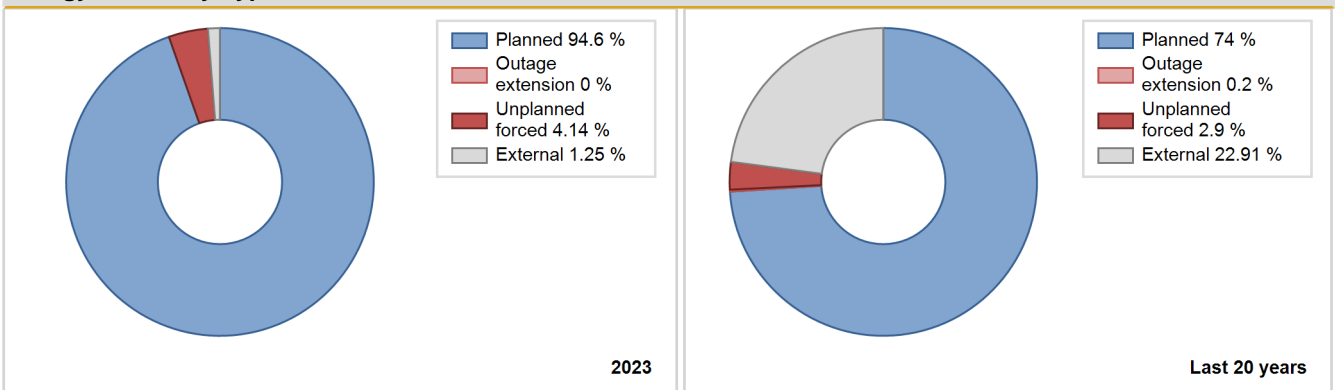
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1982 | 1891.17 | 7252 | 411 | 99.35 | 99.38 | 98.74 | 100.00 | 0.08 | 0.08 | 0.54 | 0.03 |
| 1983 | 2459.86 | 6818 | 411 | 71.98 | 71.99 | 68.32 | 77.83 | 3.90 | 2.92 | 25.09 | 0.01 |
| 1984 | 2830.67 | 7610 | 411 | 82.71 | 82.71 | 78.41 | 86.63 | 1.76 | 1.48 | 15.80 | 0.01 |
| 1985 | 2972.56 | 7814 | 411 | 86.68 | 86.77 | 82.56 | 89.20 | 2.25 | 2.00 | 11.23 | 0.09 |
| 1986 | 2627.25 | 7244 | 411 | 74.11 | 74.11 | 72.97 | 82.69 | 16.48 | 14.62 | 11.27 | 0.00 |
| 1987 | 2837.81 | 7024 | 440 | 74.79 | 74.79 | 73.63 | 80.18 | 6.83 | 5.49 | 19.73 | 0.00 |
| 1988 | 2933.19 | 7913 | 411 | 81.43 | 81.52 | 81.25 | 90.08 | 4.73 | 4.05 | 14.44 | 0.08 |
| 1989 | 3186.68 | 8047 | 411 | 87.85 | 90.50 | 88.51 | 91.86 | 0.81 | 0.74 | 8.76 | 2.65 |
| 1990 | 3256.91 | 8022 | 411 | 89.72 | 89.77 | 90.46 | 91.58 | 0.95 | 0.87 | 9.37 | 0.05 |
| 1991 | 2935.21 | 7188 | 411 | 79.78 | 79.78 | 81.53 | 82.05 | 2.74 | 2.25 | 17.97 | 0.00 |
| 1992 | 2806.37 | 7396 | 411 | 87.75 | 87.95 | 77.74 | 84.21 | 2.36 | 2.13 | 9.93 | 0.20 |
| 1993 | 2548.00 | 6833 | 411 | 70.46 | 81.91 | 70.77 | 78.00 | 1.41 | 1.17 | 16.93 | 11.45 |
| 1994 | 2466.01 | 6373 | 411 | 70.82 | 70.90 | 68.49 | 72.75 | 10.76 | 8.55 | 20.55 | 0.08 |
| 1995 | 2526.12 | 7083 | 411 | 80.64 | 81.00 | 70.16 | 80.86 | 0.82 | 0.67 | 18.33 | 0.36 |
| 1996 | 2327.31 | 6928 | 411 | 79.77 | 79.77 | 64.46 | 78.87 | 5.33 | 4.49 | 15.74 | 0.00 |
| 1997 | 2340.50 | 7114 | 411 | 74.96 | 78.46 | 65.01 | 81.21 | 0.56 | 0.44 | 21.11 | 3.49 |
| 1998 | 2006.34 | 6705 | 411 | 56.35 | 86.29 | 55.73 | 76.54 | 4.27 | 3.85 | 9.86 | 29.94 |
| 1999 | 2140.57 | 7040 | 411 | 59.90 | 72.59 | 59.45 | 80.37 | 9.77 | 7.86 | 19.55 | 12.69 |
| 2000 | 2244.74 | 7731 | 411 | 62.46 | 87.91 | 62.18 | 88.01 | 0.08 | 0.07 | 12.02 | 25.46 |
| 2001 | 2543.29 | 7057 | 411 | 70.64 | 85.28 | 70.64 | 80.56 | 1.10 | 0.95 | 13.77 | 14.64 |
| 2002 | 2742.35 | 7909 | 411 | 75.89 | 91.39 | 76.17 | 90.29 | 0.43 | 0.40 | 8.21 | 15.51 |
| 2003 | 2740.72 | 7335 | 411 | 75.61 | 83.69 | 76.12 | 83.73 | 0.06 | 0.05 | 16.26 | 8.08 |
| 2004 | 2816.85 | 7688 | 411 | 77.37 | 88.10 | 78.02 | 87.52 | 0.57 | 0.51 | 11.39 | 10.73 |
| 2005 | 2059.39 | 7672 | 411 | 57.64 | 88.49 | 57.19 | 87.57 | 0.00 | 0.00 | 11.51 | 30.85 |
| 2006 | 2294.60 | 7436 | 411 | 64.00 | 89.99 | 63.73 | 84.89 | 0.05 | 0.04 | 9.97 | 25.99 |
| 2007 | 1815.27 | 6506 | 411 | 50.72 | 82.86 | 50.42 | 74.27 | 1.49 | 1.25 | 15.89 | 32.14 |
| 2008 | 1876.73 | 7405 | 411 | 83.82 | 83.82 | 51.98 | 84.30 | 0.04 | 0.03 | 16.15 | 0.00 |
| 2009 | 2050.45 | 7340 | 411 | 83.13 | 83.85 | 56.95 | 83.79 | 0.10 | 0.08 | 16.07 | 0.71 |
| 2010 | 1979.23 | 6009 | 411 | 71.48 | 71.48 | 54.97 | 68.60 | 1.03 | 0.75 | 27.78 | 0.00 |
| 2011 | 2288.62 | 6405 | 411 | 71.67 | 71.67 | 63.57 | 73.12 | 2.56 | 1.89 | 26.45 | 0.00 |
| 2012 | 2226.17 | 6701 | 411 | 78.13 | 78.13 | 61.66 | 76.29 | 1.74 | 1.38 | 20.49 | 0.00 |
| 2013 | 2264.33 | 6396 | 411 | 73.80 | 73.80 | 62.89 | 73.01 | 2.75 | 2.09 | 24.11 | 0.00 |
| 2014 | 2636.67 | 7712 | 411 | 87.60 | 87.60 | 73.23 | 88.03 | 0.02 | 0.02 | 12.38 | 0.00 |
| 2015 | 2581.99 | 7364 | 411 | 84.12 | 84.12 | 71.71 | 84.06 | 0.45 | 0.38 | 15.50 | 0.00 |
| 2016 | 2583.96 | 6573 | 411 | 86.16 | 86.29 | 71.57 | 74.83 | 0.41 | 0.36 | 13.36 | 0.13 |
| 2017 | 2679.44 | 7494 | 411 | 84.70 | 84.70 | 74.42 | 85.55 | 0.31 | 0.27 | 15.03 | 0.00 |
| 2018 | 3036.60 | 7433 | 411 | 85.34 | 85.34 | 84.34 | 84.85 | 2.24 | 2.62 | 12.04 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2019 | 2759.12 | 7606 | 411 | 85.71 | 86.49 | 76.63 | 86.83 | 0.04 | 0.04 | 13.47 | 0.78 |
| 2020 | 2527.89 | 7116 | 411 | 81.99 | 82.81 | 70.02 | 81.01 | 0.00 | 0.00 | 17.19 | 0.82 |
| 2021 | 2539.74 | 7038 | 411 | 82.91 | 82.91 | 70.54 | 80.34 | 0.53 | 0.44 | 16.65 | 0.00 |
| 2022 | 2739.16 | 7514 | 411 | 84.71 | 84.71 | 76.08 | 85.78 | 0.68 | 0.79 | 14.50 | 0.00 |
| 2023 | 2534.41 | 6604 | 411 | 77.88 | 78.16 | 70.39 | 75.39 | 1.16 | 0.92 | 20.92 | 0.28 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1982 to 2023 | | |
|---|-------------|-------------|------------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 80 | | | 66 | |
| C. Inspection, maintenance or repair combined with refuelling | 1774 | | | 1270 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 60 | | |
| E. Testing of plant systems or components | | | | 10 | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 47 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 302 | | | 114 |
| L. Human factor related | | | | | 2 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 3 | |
| Subtotal | 1774 | 80 | 302 | 1340 | 72 | 162 |
| Total | | 2156 | | | 1574 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1982 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 6 |
| 12. Reactor I&C Systems | | 22 |
| 15. Reactor Cooling Systems | | 11 |
| 16. Steam generation systems | | 8 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 31. Turbine and auxiliaries | 23 | 4 |
| 32. Feedwater and Main Steam System | 57 | 8 |
| 34. Miscellaneous Systems | | 0 |
| 41. Main Generator Systems | | 1 |
| 42. Electrical Power Supply Systems | | 8 |
| Total | 80 | 68 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in August-December. Additional electricity generation amounted to 40285 MWh. The unit was in the overhaul outage from 2023.06.04 to 2023.08.21. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-33

KOLA-4

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KALUGA (JSC "Kaluga turbine plant" 32, Glagoleva Street, Kaluga, 248021, Russia)

Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1375 MWth
 Gross electrical power : 440 MWe
 Reference unit power (net) : 411 MWe

Key Dates

Construction Date : 1976-08-01
 Grid Date : 1984-10-11
 Commercial Date : 1984-12-06
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 28600
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.1
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.5
 Reactor outlet temperature [°C] : 300
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 4.4
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

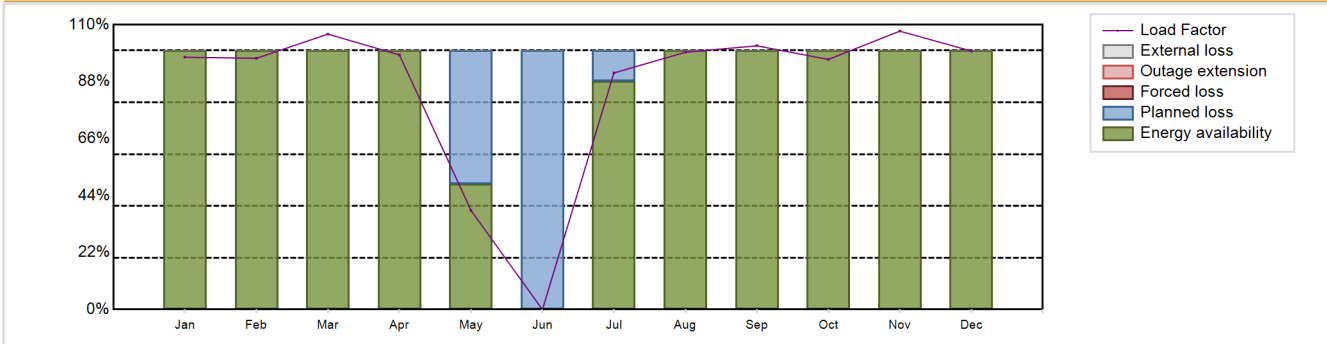
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 3102.73 GW(e).h
 Energy Availability Factor (EAF) : 86.39 %
 Unit Capability Factor (UCF) : 86.39 %
 Load Factor (LF) : 86.18 %
 Operating Factor (OF) : 86.37 %
 Equivalent non-electrical energy generated (NEG) : 0 GW(e).h

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 13.61 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1194 hours

Annual Summary

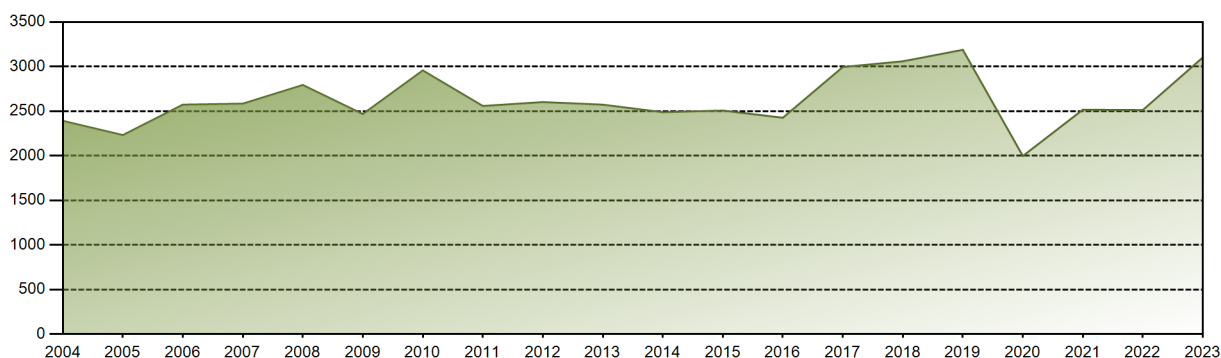


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 297.98 | 267.95 | 325.23 | 290.99 | 117.15 | 0.00 | 279.38 | 303.86 | 301.39 | 295.36 | 318.16 | 305.28 | 3102.73 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 48.39 | 0.01 | 88.12 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.39 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 48.39 | 0.01 | 88.12 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.39 |
| LF [%] | 97.45 | 97.02 | 106.36 | 98.33 | 38.31 | 0.00 | 91.37 | 99.37 | 101.85 | 96.59 | 107.52 | 99.83 | 86.18 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 44.49 | 0.00 | 91.80 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.37 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 51.61 | 99.99 | 11.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.61 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 101890.34 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.48 % |
| Cumulative Energy Availability Factor (EAF) | : 76.94 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.09 % |
| Cumulative Unit Capability Factor (UCF) | : 82.32 % | Cumulative Planned Unavailability Factor (PUF) | : 15.58 % |
| Cumulative Load Factor (LF) | : 72.38 % | Cumulative Externally cause unavailability (XUF) | : 5.38 % |
| Cumulative Operating Factor (OF) | : 82.39 % | | |

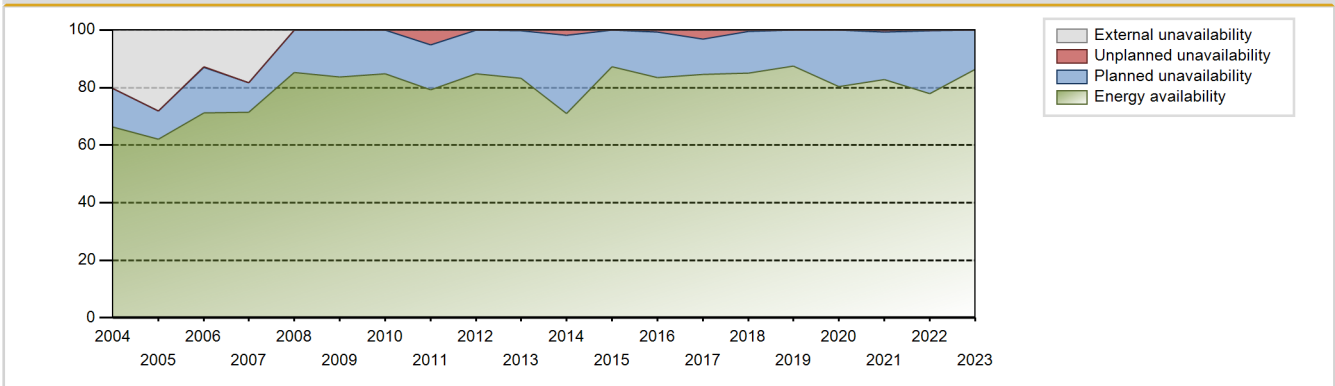
Electricity Production (net) [GWh]



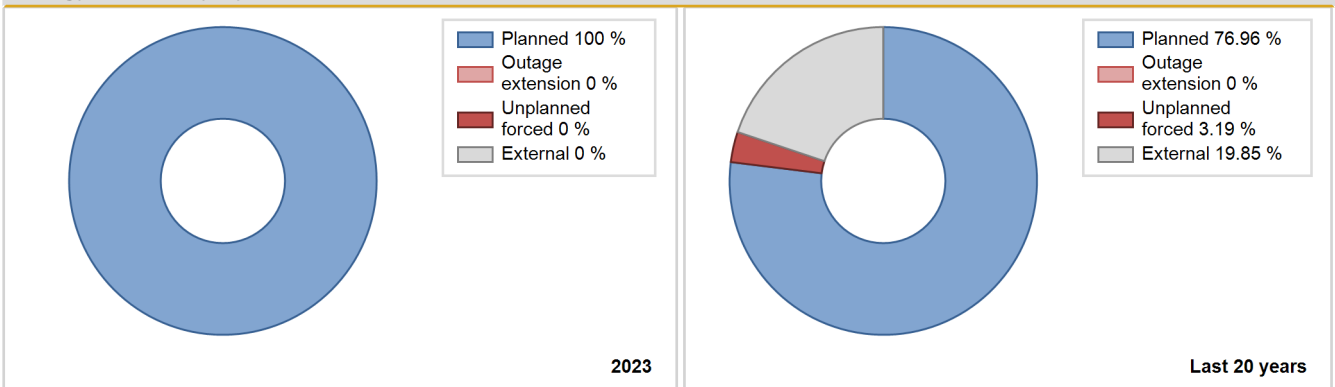
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|--------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 249.38 | 1605 | 411 | 100.00 | 100.00 | 55.09 | 98.12 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1985 | 2585.77 | 7751 | 411 | 78.18 | 78.19 | 71.82 | 88.48 | 3.31 | 2.68 | 19.14 | 0.01 |
| 1986 | 2690.18 | 7230 | 411 | 72.36 | 72.36 | 74.72 | 82.53 | 6.11 | 4.71 | 22.93 | 0.00 |
| 1987 | 3341.17 | 7861 | 440 | 85.50 | 85.50 | 86.68 | 89.74 | 0.91 | 0.79 | 13.72 | 0.00 |
| 1988 | 3124.21 | 7762 | 411 | 84.95 | 84.96 | 86.54 | 88.37 | 4.04 | 3.58 | 11.47 | 0.01 |
| 1989 | 3111.51 | 7793 | 411 | 85.77 | 87.57 | 86.42 | 88.96 | 1.33 | 1.18 | 11.25 | 1.80 |
| 1990 | 2930.40 | 7142 | 411 | 80.24 | 80.28 | 81.39 | 81.53 | 0.76 | 0.62 | 19.10 | 0.05 |
| 1991 | 2790.49 | 7429 | 411 | 76.70 | 76.70 | 77.51 | 84.81 | 8.47 | 7.09 | 16.21 | 0.00 |
| 1992 | 2764.94 | 7253 | 411 | 79.99 | 80.51 | 76.60 | 82.58 | 2.77 | 2.29 | 17.19 | 0.52 |
| 1993 | 2826.99 | 8247 | 411 | 79.00 | 92.43 | 78.52 | 94.14 | 5.98 | 5.88 | 1.69 | 13.43 |
| 1994 | 1939.77 | 5915 | 411 | 55.77 | 62.72 | 53.88 | 67.52 | 20.29 | 15.97 | 21.31 | 6.95 |
| 1995 | 2288.81 | 7022 | 411 | 73.83 | 73.83 | 63.57 | 80.16 | 7.04 | 5.59 | 20.57 | 0.00 |
| 1996 | 2537.72 | 7792 | 411 | 84.09 | 84.09 | 70.29 | 88.71 | 4.39 | 3.86 | 12.05 | 0.00 |
| 1997 | 2271.67 | 6848 | 411 | 74.56 | 76.16 | 63.10 | 78.17 | 6.93 | 5.67 | 18.18 | 1.59 |
| 1998 | 1927.55 | 6336 | 411 | 49.19 | 69.38 | 53.54 | 72.33 | 8.64 | 6.56 | 24.05 | 20.20 |
| 1999 | 2567.48 | 7193 | 411 | 71.16 | 82.00 | 71.31 | 82.11 | 1.51 | 1.26 | 16.75 | 10.84 |
| 2000 | 2177.50 | 7096 | 411 | 60.44 | 86.31 | 60.31 | 80.78 | 0.07 | 0.06 | 13.63 | 25.86 |
| 2001 | 2447.14 | 7149 | 411 | 67.98 | 87.38 | 67.97 | 81.61 | 0.00 | 0.00 | 12.62 | 19.40 |
| 2002 | 2601.71 | 7281 | 411 | 71.52 | 79.71 | 72.26 | 83.12 | 0.00 | 0.00 | 20.29 | 8.19 |
| 2003 | 2480.80 | 6663 | 411 | 68.69 | 90.88 | 68.90 | 76.06 | 1.45 | 1.34 | 7.78 | 22.20 |
| 2004 | 2391.59 | 7863 | 411 | 66.38 | 86.78 | 66.24 | 89.52 | 0.00 | 0.00 | 13.22 | 20.40 |
| 2005 | 2231.75 | 7879 | 411 | 62.10 | 90.21 | 61.98 | 89.93 | 0.00 | 0.00 | 9.79 | 28.11 |
| 2006 | 2573.11 | 7217 | 411 | 71.26 | 84.11 | 71.47 | 82.39 | 0.13 | 0.11 | 15.79 | 12.85 |
| 2007 | 2584.08 | 7640 | 411 | 71.52 | 89.77 | 71.77 | 87.21 | 0.00 | 0.00 | 10.23 | 18.25 |
| 2008 | 2793.49 | 7794 | 411 | 85.15 | 85.20 | 77.38 | 88.73 | 0.05 | 0.04 | 14.76 | 0.04 |
| 2009 | 2468.01 | 7538 | 411 | 83.73 | 83.74 | 68.55 | 86.05 | 0.01 | 0.01 | 16.25 | 0.02 |
| 2010 | 2956.73 | 7332 | 411 | 84.73 | 84.73 | 82.12 | 83.70 | 0.00 | 0.00 | 15.27 | 0.00 |
| 2011 | 2558.01 | 6803 | 411 | 79.30 | 79.33 | 71.06 | 77.67 | 5.98 | 5.05 | 15.62 | 0.03 |
| 2012 | 2601.69 | 7459 | 411 | 84.75 | 84.75 | 72.06 | 84.92 | 0.11 | 0.09 | 15.16 | 0.00 |
| 2013 | 2572.70 | 7084 | 411 | 83.22 | 83.22 | 71.46 | 80.87 | 0.26 | 0.22 | 16.56 | 0.00 |
| 2014 | 2488.19 | 6241 | 411 | 70.91 | 70.91 | 69.10 | 71.24 | 2.61 | 1.90 | 27.18 | 0.00 |
| 2015 | 2506.63 | 6870 | 411 | 87.25 | 87.25 | 69.62 | 78.42 | 0.00 | 0.00 | 12.75 | 0.00 |
| 2016 | 2425.95 | 6422 | 411 | 83.44 | 83.44 | 67.20 | 73.11 | 0.86 | 0.73 | 15.83 | 0.00 |
| 2017 | 2994.93 | 7633 | 411 | 84.56 | 84.56 | 83.18 | 87.13 | 3.60 | 3.16 | 12.28 | 0.00 |
| 2018 | 3058.96 | 7464 | 411 | 84.97 | 84.97 | 84.96 | 85.21 | 0.57 | 0.49 | 14.54 | 0.00 |
| 2019 | 3188.15 | 7831 | 411 | 87.41 | 87.48 | 88.55 | 89.39 | 0.00 | 0.00 | 12.52 | 0.07 |
| 2020 | 1996.91 | 5992 | 411 | 80.37 | 80.37 | 55.31 | 68.21 | 0.00 | 0.00 | 19.63 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 2516.21 | 6801 | 411 | 82.77 | 82.77 | 69.89 | 77.64 | 0.85 | 0.71 | 16.52 | 0.00 |
| 2022 | 2512.64 | 6357 | 411 | 77.84 | 77.84 | 69.79 | 72.57 | 0.41 | 0.32 | 21.84 | 0.00 |
| 2023 | 3102.73 | 7566 | 411 | 86.39 | 86.39 | 86.18 | 86.37 | 0.00 | 0.00 | 13.61 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|-------------|-------------|-----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 50 | |
| C. Inspection, maintenance or repair combined with refuelling | 1165 | | | 1172 | 15 | |
| D. Inspection, maintenance or repair without refuelling | | | | 66 | | |
| E. Testing of plant systems or components | | | | 4 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 39 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | 29 | | | 178 |
| L. Human factor related | | | | | 3 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| Z. Other | | | | | 0 | |
| Subtotal | 1165 | | 29 | 1242 | 68 | 217 |
| Total | | 1194 | | | 1527 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 12 |
| 14. Safety Systems | | 6 |
| 15. Reactor Cooling Systems | | 4 |
| 16. Steam generation systems | | 9 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 32. Feedwater and Main Steam System | | 5 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 13 |
| Total | | 54 |

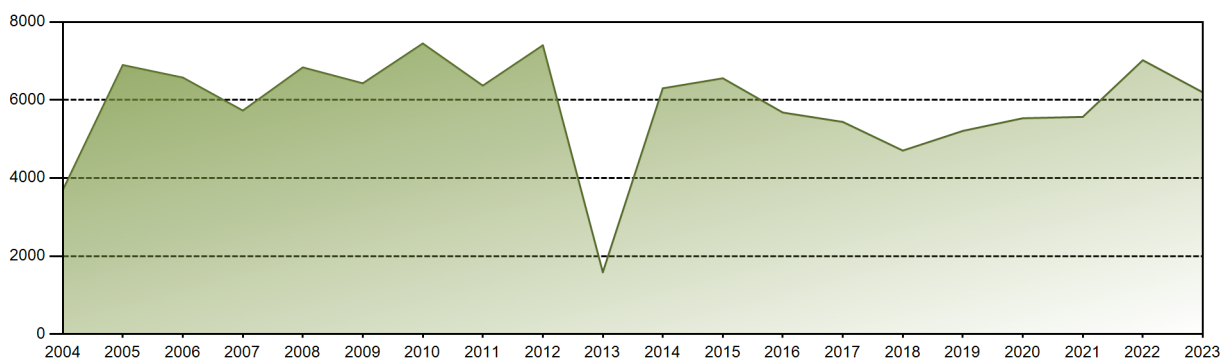
Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-May, July-December. Additional electricity generation amounted to 97736 MWh. The unit was in the overhaul outage from 2023.05.16 to 2023.07.03. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 236137.58 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.83 % |
| Cumulative Energy Availability Factor (EAF) | : 64.81 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.33 % |
| Cumulative Unit Capability Factor (UCF) | : 66.65 % | Cumulative Planned Unavailability Factor (PUF) | : 29.02 % |
| Cumulative Load Factor (LF) | : 65.14 % | Cumulative Externally cause unavailability (XUF) | : 1.84 % |
| Cumulative Operating Factor (OF) | : 74.65 % | | |

Electricity Production (net) [GWh]

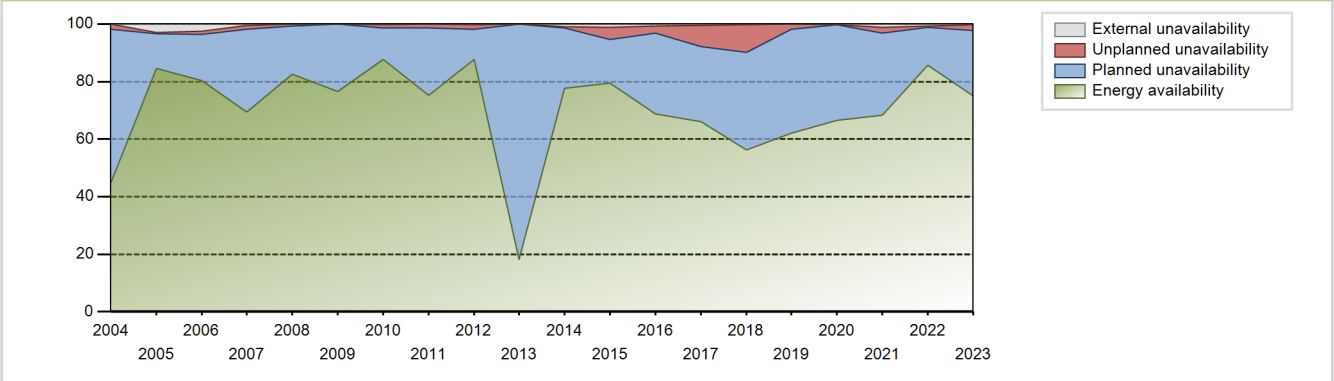


Performance for Years of Commercial Operation

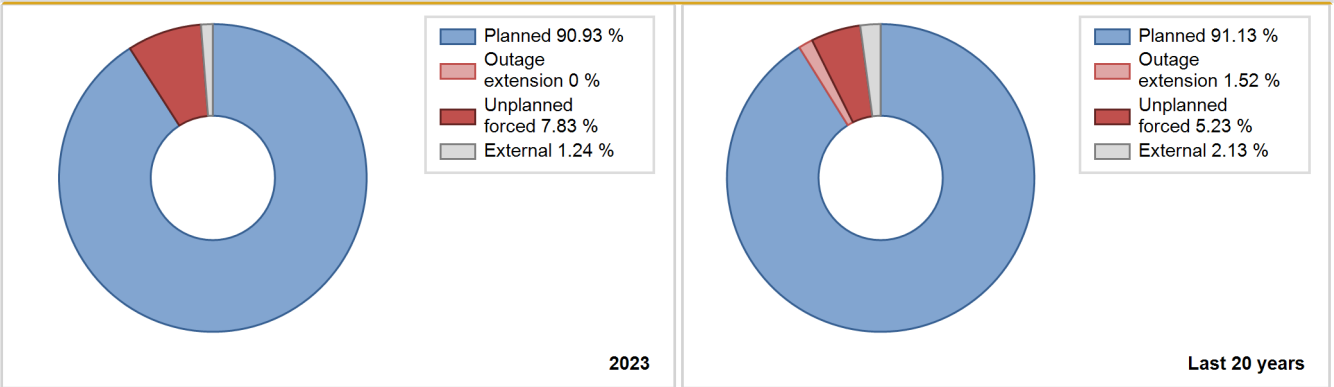
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1979 | 3613.90 | 6734 | 925 | 62.36 | 62.36 | 62.31 | 80.40 | 27.83 | 24.04 | 13.59 | 0.00 |
| 1980 | 6404.32 | 7658 | 925 | 78.45 | 79.02 | 78.82 | 87.18 | 10.04 | 8.82 | 12.15 | 0.58 |
| 1981 | 6385.88 | 7874 | 925 | 78.71 | 78.71 | 78.81 | 89.89 | 8.73 | 7.53 | 13.77 | 0.00 |
| 1982 | 5875.79 | 6443 | 925 | 71.11 | 71.11 | 72.51 | 73.55 | 6.25 | 4.74 | 24.14 | 0.00 |
| 1983 | 5707.64 | 7104 | 925 | 70.07 | 70.07 | 70.44 | 81.10 | 10.00 | 7.78 | 22.15 | 0.00 |
| 1984 | 6326.50 | 7219 | 925 | 77.06 | 77.10 | 77.86 | 82.18 | 5.31 | 4.33 | 18.57 | 0.05 |
| 1985 | 6459.94 | 7598 | 925 | 79.41 | 79.41 | 79.72 | 86.74 | 6.09 | 5.15 | 15.43 | 0.00 |
| 1986 | 5617.31 | 6575 | 925 | 69.08 | 69.08 | 69.32 | 75.06 | 15.66 | 12.82 | 18.10 | 0.00 |
| 1987 | 7196.69 | 7539 | 1000 | 83.29 | 83.29 | 82.15 | 86.06 | 3.73 | 3.23 | 13.48 | 0.00 |
| 1988 | 5725.66 | 6609 | 925 | 73.88 | 73.88 | 70.47 | 75.24 | 3.50 | 2.68 | 23.44 | 0.00 |
| 1989 | 6164.20 | 6797 | 925 | 74.90 | 74.91 | 76.07 | 77.59 | 14.58 | 12.79 | 12.30 | 0.02 |
| 1990 | 4789.70 | 6874 | 925 | 62.20 | 62.20 | 59.11 | 78.47 | 26.17 | 22.05 | 15.75 | 0.00 |
| 1991 | 4375.96 | 7361 | 925 | 55.26 | 56.28 | 54.00 | 84.03 | 0.70 | 0.40 | 43.32 | 1.02 |
| 1992 | 2158.37 | 3552 | 925 | 27.24 | 27.24 | 26.57 | 40.44 | 3.87 | 1.10 | 71.67 | 0.00 |
| 1993 | 4438.15 | 7432 | 925 | 57.09 | 85.00 | 54.77 | 84.84 | 2.25 | 1.95 | 13.04 | 27.91 |
| 1994 | 4212.17 | 7385 | 925 | 53.46 | 55.29 | 51.98 | 84.30 | 37.66 | 33.40 | 11.31 | 1.82 |
| 1995 | 4745.36 | 7708 | 925 | 59.79 | 90.79 | 58.56 | 87.99 | 0.91 | 0.83 | 8.38 | 31.00 |
| 1996 | 4196.12 | 7099 | 925 | 52.69 | 52.84 | 51.64 | 80.82 | 7.80 | 4.47 | 42.69 | 0.15 |
| 1997 | 4354.28 | 7076 | 925 | 54.94 | 55.26 | 53.74 | 80.78 | 7.36 | 4.39 | 40.36 | 0.32 |
| 1998 | 1685.05 | 2805 | 925 | 21.30 | 21.71 | 20.80 | 32.02 | 5.62 | 1.29 | 77.00 | 0.41 |
| 1999 | 3708.09 | 6066 | 925 | 46.84 | 48.03 | 45.76 | 69.25 | 4.72 | 2.38 | 49.59 | 1.19 |
| 2000 | 3668.06 | 6211 | 925 | 46.19 | 48.87 | 45.14 | 70.71 | 3.97 | 2.02 | 49.11 | 2.68 |
| 2001 | 4768.15 | 7667 | 925 | 60.09 | 61.11 | 58.84 | 87.52 | 0.33 | 0.20 | 38.69 | 1.02 |
| 2002 | 3027.77 | 4770 | 925 | 38.07 | 38.25 | 37.37 | 54.45 | 0.00 | 0.00 | 61.75 | 0.19 |
| 2003 | 3756.24 | 5834 | 925 | 46.36 | 47.10 | 46.36 | 66.60 | 0.00 | 0.00 | 52.90 | 0.74 |
| 2004 | 3692.07 | 4318 | 925 | 44.97 | 45.06 | 45.44 | 49.16 | 3.87 | 1.82 | 53.13 | 0.09 |
| 2005 | 6896.62 | 7782 | 925 | 84.68 | 87.51 | 85.10 | 88.83 | 0.58 | 0.51 | 11.98 | 2.83 |
| 2006 | 6574.42 | 7320 | 925 | 80.34 | 82.92 | 81.14 | 83.56 | 1.28 | 1.07 | 16.01 | 2.58 |
| 2007 | 5728.65 | 6207 | 925 | 69.48 | 69.99 | 70.70 | 70.86 | 1.70 | 1.21 | 28.80 | 0.51 |
| 2008 | 6835.74 | 7351 | 925 | 82.61 | 82.63 | 84.13 | 83.69 | 0.80 | 0.66 | 16.70 | 0.03 |
| 2009 | 6428.15 | 6778 | 925 | 76.64 | 76.67 | 79.33 | 77.37 | 0.00 | 0.00 | 23.33 | 0.03 |
| 2010 | 7448.67 | 8076 | 925 | 87.81 | 88.09 | 91.92 | 92.19 | 1.15 | 1.03 | 10.88 | 0.28 |
| 2011 | 6368.67 | 6539 | 925 | 75.31 | 75.39 | 78.61 | 74.65 | 1.56 | 1.20 | 23.41 | 0.09 |
| 2012 | 7401.98 | 7802 | 925 | 87.76 | 88.01 | 91.10 | 88.82 | 1.85 | 1.66 | 10.33 | 0.25 |
| 2013 | 1584.36 | 1606 | 925 | 18.25 | 18.25 | 19.55 | 18.33 | 0.44 | 0.08 | 81.67 | 0.00 |
| 2014 | 6299.77 | 7011 | 925 | 77.67 | 78.52 | 77.74 | 80.03 | 0.54 | 0.43 | 21.05 | 0.86 |
| 2015 | 6556.20 | 7160 | 925 | 79.38 | 80.44 | 80.91 | 81.74 | 2.96 | 4.25 | 15.31 | 1.06 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|------|-------|------|
| 2016 | 5678.19 | 6425 | 925 | 68.85 | 69.57 | 69.88 | 73.14 | 3.29 | 2.37 | 28.06 | 0.72 |
| 2017 | 5437.61 | 6209 | 925 | 66.14 | 66.59 | 67.11 | 70.88 | 3.75 | 7.38 | 26.03 | 0.45 |
| 2018 | 4702.96 | 5689 | 925 | 56.25 | 56.48 | 58.04 | 64.94 | 11.38 | 9.58 | 33.94 | 0.22 |
| 2019 | 5207.62 | 5656 | 925 | 62.03 | 62.17 | 64.27 | 64.57 | 2.74 | 1.75 | 36.08 | 0.13 |
| 2020 | 5532.83 | 5945 | 925 | 66.59 | 66.89 | 68.09 | 67.68 | 0.00 | 0.00 | 33.10 | 0.30 |
| 2021 | 5567.70 | 6162 | 925 | 68.28 | 69.35 | 68.71 | 70.34 | 2.85 | 2.04 | 28.61 | 1.07 |
| 2022 | 7019.38 | 7651 | 925 | 85.77 | 86.45 | 86.63 | 87.34 | 0.65 | 0.56 | 12.99 | 0.68 |
| 2023 | 6196.09 | 6818 | 925 | 74.92 | 75.23 | 76.47 | 77.83 | 2.54 | 1.96 | 22.81 | 0.31 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1979 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 107 | |
| C. Inspection, maintenance or repair combined with refuelling | 1941 | | | 1397 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 582 | | |
| E. Testing of plant systems or components | | | | 12 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 93 | | |
| H. Nuclear regulatory requirements | | | | | 4 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 5 |
| L. Human factor related | | | | | 3 | |
| Z. Other | | | | | 27 | |
| Subtotal | 1941 | | | 2084 | 141 | 5 |
| Total | | 1941 | | | 2230 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1979 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 41 |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 4 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 16 |
| 16. Steam generation systems | | 3 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 6 |
| 32. Feedwater and Main Steam System | | 7 |
| 34. Miscellaneous Systems | | 13 |
| 41. Main Generator Systems | | 3 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 106 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-March, June-December. Additional electricity generation amounted to 120580 MWh. The unit was in the unit overhaul from 2023.03.02 to 2023.05.22. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-38

KURSK-3

RUSSIA

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : REA (Joint Stock Company 'Concern Rosenergoatom') |
| Owner | : REA (Joint Stock Company 'Concern Rosenergoatom') |
| Reactor Supplier | : AEM (Atomenergomash) |
| Turbine Supplier | : KTF (Kharkiv Turbine Factory) |

Reactor Unit Details

| | |
|----------------------------|--------------------|
| Reactor type and model | : LWGR / RBMK-1000 |
| Thermal power | : 3200 MWth |
| Gross electrical power | : 1000 MWe |
| Reference unit power (net) | : 925 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 1978-04-01 |
| Grid Date | : 1983-10-17 |
| Commercial Date | : 1984-03-30 |
| Age at end of year | : 40 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : ON-line |
| Moderator material | : GRAPHITE |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : - |
| Part of the core refuelled [%] | : - |
| Average discharge burnup [MWd/t] | : 10000 |
| Active core diameter [m] | : 11.8 |
| Active core height/length [m] | : 7 |
| Number of fissile fuel assemblies/bundles | : 1661 |
| Fuel linear heat generation rate [kW/m] | : 16 |
| Number of control rod assemblies | : 170 |
| Number of external reactor coolant loops | : 2 |
| Coolant type | : H2O |

| | |
|-----------------------------------|---------------|
| Operating coolant pressure [MPa] | : 7 |
| Reactor outlet temperature [°C] | : 284 |
| Number of SG | : NA |
| Containment type | : Confinement |
| Containment design pressure [MPa] | : - |

Secondary systems

| | |
|--|------------------------|
| Number of turbine-generators per unit/reactor | : 2 |
| Turbine speed [rpm] | : 3000 |
| Number of LP cylinders per turbine | : - |
| HP cylinder inlet steam pressure [MPa] | : 6.59 |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : River (once-through) |
| Number of main condensate pumps | : - |
| Number of FW pumps for full power operation | : - |
| Number of on-site safety related diesel generators | : - |

Non-electrical applications

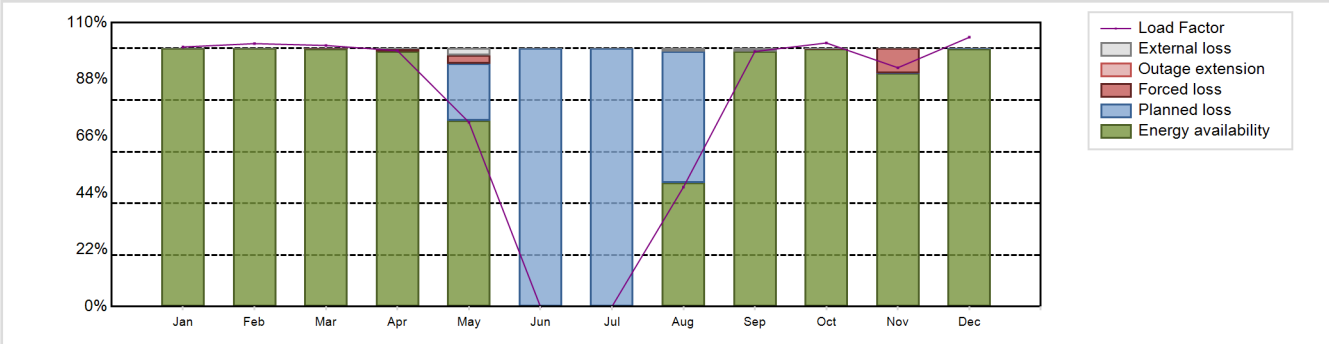
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|--|-----------|
| | : DH / PH |
|--|-----------|

Annual Production Results (2023)

| | |
|--|-------------------|
| Net Energy Production | : 6186.94 GW(e).h |
| Energy Availability Factor (EAF) | : 75.52 % |
| Unit Capability Factor (UCF) | : 75.96 % |
| Load Factor (LF) | : 76.35 % |
| Operating Factor (OF) | : 77.77 % |
| Equivalent non-electrical energy generated (NEG) | : 38.74 GW(e).h |

| | |
|--|--------------|
| Forced Loss Rate (FLR) | : 1.48 % |
| Unplanned Capability Loss Factor (UCL) | : 1.14 % |
| Planned Unavailability Factor (PUF) | : 22.9 % |
| Externally cause unavailability (XUF) | : 0.44 % |
| Total off-line time | : 1947 hours |

Annual Summary

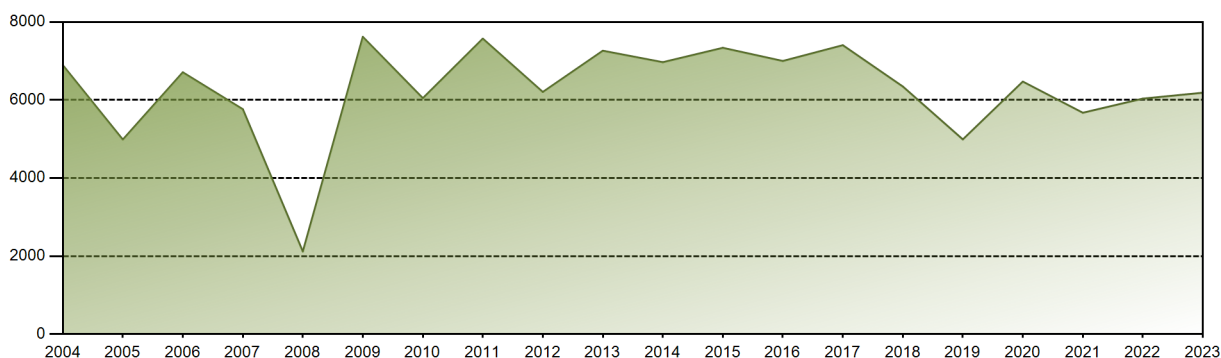


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 692.07 | 633.18 | 696.17 | 660.22 | 491.54 | 0.00 | 0.00 | 318.50 | 658.13 | 702.83 | 616.27 | 718.02 | 6186.94 |
| EAF [%] | 100.00 | 100.00 | 99.97 | 98.82 | 72.15 | 0.00 | 0.00 | 47.96 | 98.99 | 99.90 | 90.38 | 99.94 | 75.52 |
| UCF [%] | 100.00 | 100.00 | 99.97 | 99.08 | 74.84 | 0.00 | 0.00 | 49.19 | 100.00 | 99.96 | 90.38 | 99.94 | 75.96 |
| LF [%] | 100.56 | 101.86 | 101.16 | 99.13 | 71.42 | 0.00 | 0.00 | 46.28 | 98.82 | 102.13 | 92.53 | 104.33 | 76.35 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 78.09 | 0.00 | 0.00 | 63.04 | 100.00 | 100.00 | 93.75 | 100.00 | 77.77 |
| FLR [%] | 0.00 | 0.00 | 0.03 | 0.92 | 4.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 9.57 | 0.00 | 1.48 |
| UCL [%] | 0.00 | 0.00 | 0.03 | 0.92 | 3.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 9.57 | 0.00 | 1.14 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 21.96 | 100.00 | 100.00 | 50.81 | 0.00 | 0.00 | 0.06 | 0.06 | 22.90 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.25 | 2.70 | 0.00 | 0.00 | 1.23 | 1.01 | 0.06 | 0.00 | 0.00 | 0.44 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 240876.17 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.69 % |
| Cumulative Energy Availability Factor (EAF) | : 73.99 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.25 % |
| Cumulative Unit Capability Factor (UCF) | : 75.23 % | Cumulative Planned Unavailability Factor (PUF) | : 21.52 % |
| Cumulative Load Factor (LF) | : 74.09 % | Cumulative Externally cause unavailability (XUF) | : 1.24 % |
| Cumulative Operating Factor (OF) | : 77.77 % | | |

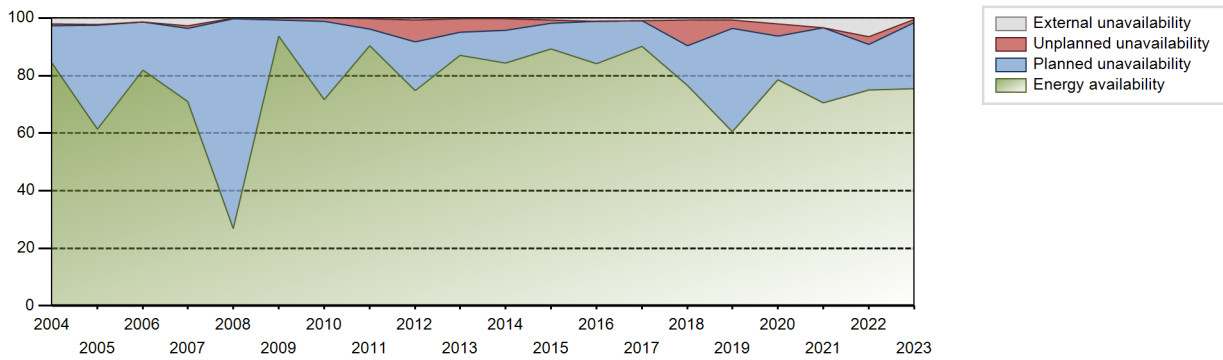
Electricity Production (net) [GWh]



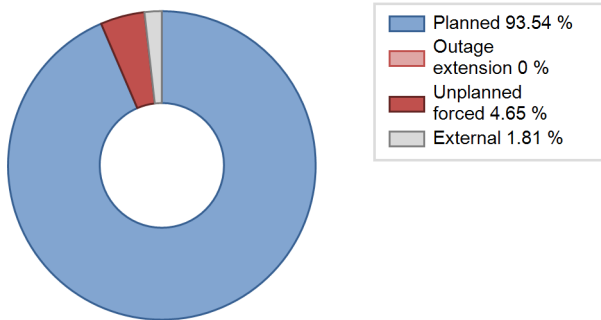
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 5479.24 | 6830 | 925 | 72.49 | 72.49 | 72.15 | 76.71 | 9.02 | 7.18 | 20.33 | 0.00 |
| 1985 | 6260.75 | 7250 | 925 | 77.59 | 77.93 | 77.26 | 82.76 | 7.60 | 6.41 | 15.66 | 0.34 |
| 1986 | 4810.84 | 6269 | 925 | 60.00 | 60.42 | 59.37 | 71.56 | 15.08 | 10.73 | 28.85 | 0.42 |
| 1987 | 5458.95 | 6185 | 1000 | 66.40 | 69.01 | 62.32 | 70.61 | 5.11 | 3.71 | 27.28 | 2.61 |
| 1988 | 6693.64 | 7471 | 925 | 83.64 | 83.64 | 82.38 | 85.05 | 3.44 | 2.98 | 13.38 | 0.00 |
| 1989 | 5900.50 | 7200 | 925 | 74.29 | 74.32 | 72.82 | 82.19 | 8.84 | 7.21 | 18.48 | 0.03 |
| 1990 | 6889.42 | 8096 | 925 | 86.52 | 86.52 | 85.02 | 92.42 | 7.78 | 7.30 | 6.18 | 0.00 |
| 1991 | 5138.96 | 5704 | 925 | 63.17 | 63.42 | 63.42 | 65.11 | 1.30 | 0.83 | 35.74 | 0.25 |
| 1992 | 6630.50 | 8126 | 925 | 82.13 | 82.13 | 81.61 | 92.52 | 5.97 | 5.22 | 12.66 | 0.00 |
| 1993 | 5562.30 | 6438 | 925 | 70.34 | 71.22 | 68.64 | 73.49 | 8.24 | 6.39 | 22.39 | 0.88 |
| 1994 | 5077.86 | 6495 | 925 | 66.69 | 73.60 | 62.67 | 74.14 | 0.74 | 0.55 | 25.84 | 6.92 |
| 1995 | 5318.13 | 5974 | 925 | 65.40 | 65.70 | 65.63 | 68.20 | 2.80 | 1.90 | 32.41 | 0.30 |
| 1996 | 6739.27 | 7383 | 925 | 82.67 | 82.89 | 82.94 | 84.05 | 2.36 | 2.00 | 15.11 | 0.22 |
| 1997 | 6548.72 | 7325 | 925 | 81.56 | 82.46 | 80.82 | 83.62 | 0.21 | 0.17 | 17.37 | 0.89 |
| 1998 | 4528.32 | 5405 | 925 | 56.53 | 60.26 | 55.88 | 61.70 | 17.21 | 12.53 | 27.20 | 3.74 |
| 1999 | 6006.85 | 6749 | 925 | 74.33 | 75.32 | 74.13 | 77.04 | 4.80 | 3.80 | 20.87 | 0.99 |
| 2000 | 6382.33 | 7415 | 925 | 78.26 | 78.85 | 78.55 | 84.41 | 7.98 | 6.83 | 14.32 | 0.59 |
| 2001 | 3535.20 | 3948 | 925 | 43.53 | 44.65 | 43.63 | 45.07 | 0.15 | 0.07 | 55.28 | 1.12 |
| 2002 | 6699.77 | 7788 | 925 | 85.07 | 88.23 | 82.68 | 88.90 | 0.29 | 0.26 | 11.51 | 3.16 |
| 2003 | 5100.59 | 5469 | 925 | 61.84 | 62.23 | 62.95 | 62.43 | 0.00 | 0.00 | 37.77 | 0.39 |
| 2004 | 6894.20 | 7660 | 925 | 84.35 | 86.33 | 84.85 | 87.20 | 0.82 | 0.71 | 12.96 | 1.98 |
| 2005 | 4987.10 | 5598 | 925 | 61.31 | 63.49 | 61.55 | 63.90 | 0.59 | 0.37 | 36.14 | 2.17 |
| 2006 | 6711.22 | 7353 | 925 | 81.93 | 83.37 | 82.82 | 83.94 | 0.00 | 0.00 | 16.63 | 1.44 |
| 2007 | 5765.28 | 6535 | 925 | 71.07 | 73.75 | 71.15 | 74.60 | 1.12 | 0.84 | 25.41 | 2.68 |
| 2008 | 2117.39 | 2374 | 925 | 26.82 | 26.82 | 26.06 | 27.03 | 1.30 | 0.35 | 72.83 | 0.00 |
| 2009 | 7620.95 | 8216 | 925 | 93.77 | 93.87 | 94.05 | 93.79 | 0.58 | 0.55 | 5.58 | 0.10 |
| 2010 | 6048.61 | 6352 | 925 | 71.67 | 71.78 | 74.65 | 72.51 | 1.44 | 1.05 | 27.17 | 0.11 |
| 2011 | 7574.35 | 8228 | 925 | 90.44 | 90.80 | 93.49 | 93.94 | 3.77 | 3.56 | 5.64 | 0.36 |
| 2012 | 6207.22 | 6900 | 925 | 74.78 | 75.44 | 76.39 | 78.55 | 5.35 | 7.58 | 16.98 | 0.66 |
| 2013 | 7264.06 | 8022 | 925 | 87.02 | 87.23 | 89.65 | 91.58 | 5.04 | 4.63 | 8.14 | 0.21 |
| 2014 | 6969.97 | 7506 | 925 | 84.29 | 84.49 | 86.01 | 85.68 | 0.85 | 4.03 | 11.48 | 0.21 |
| 2015 | 7338.33 | 8075 | 925 | 89.24 | 89.93 | 90.56 | 92.18 | 1.22 | 1.11 | 8.97 | 0.68 |
| 2016 | 7001.08 | 7556 | 925 | 84.05 | 85.12 | 86.17 | 86.02 | 0.00 | 0.00 | 14.88 | 1.07 |
| 2017 | 7405.52 | 8018 | 925 | 90.09 | 90.92 | 91.39 | 91.53 | 0.10 | 0.09 | 9.00 | 0.83 |
| 2018 | 6346.60 | 7060 | 925 | 76.64 | 77.41 | 78.32 | 80.59 | 4.10 | 8.89 | 13.70 | 0.77 |
| 2019 | 4990.43 | 5623 | 925 | 60.49 | 61.19 | 61.59 | 64.19 | 2.25 | 2.92 | 35.90 | 0.70 |
| 2020 | 6473.17 | 7464 | 925 | 78.62 | 80.58 | 79.67 | 84.97 | 4.13 | 4.32 | 15.11 | 1.96 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 5674.03 | 6517 | 925 | 70.44 | 73.85 | 70.02 | 74.39 | 0.03 | 0.02 | 26.12 | 3.41 |
| 2022 | 6036.60 | 7369 | 925 | 74.89 | 81.43 | 74.50 | 84.12 | 3.05 | 2.57 | 16.01 | 6.53 |
| 2023 | 6186.94 | 6813 | 925 | 75.52 | 75.96 | 76.35 | 77.77 | 1.48 | 1.14 | 22.90 | 0.44 |

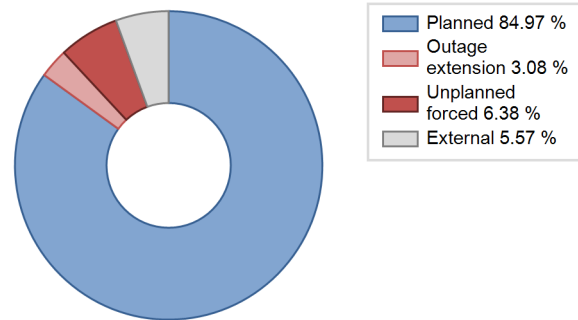
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 45 | | | 133 | |
| C. Inspection, maintenance or repair combined with refuelling | 1900 | | | 1166 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 642 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 8 |
| L. Human factor related | | | | | 1 | |
| Subtotal | 1900 | 45 | | 1809 | 134 | 8 |
| Total | | 1945 | | | 1951 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 45 | 22 |
| 12. Reactor I&C Systems | | 15 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 10 |
| 15. Reactor Cooling Systems | | 49 |
| 16. Steam generation systems | | 2 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 21. Fuel Handling and Storage Facilities | | 4 |
| 31. Turbine and auxiliaries | | 4 |
| 32. Feedwater and Main Steam System | | 9 |
| 41. Main Generator Systems | | 9 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | 45 | 133 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-April, October-December. Additional electricity generation amounted to 95702 MWh. The unit was in the routine maintenance from 2023.05.25 to 2023.08.12. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-39

KURSK-4

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

Reactor Unit Details

Reactor type and model : LWGR / RBMK-1000
 Thermal power : 3200 MWth
 Gross electrical power : 1000 MWe
 Reference unit power (net) : 925 MWe

Key Dates

Construction Date : 1981-05-01
 Grid Date : 1985-12-02
 Commercial Date : 1986-02-05
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : ON-line
 Moderator material : GRAPHITE
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 10000
 Active core diameter [m] : 11.8
 Active core height/length [m] : 7
 Number of fissile fuel assemblies/bundles : 1661
 Fuel linear heat generation rate [kW/m] : 16
 Number of control rod assemblies : 167
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 7
 Reactor outlet temperature [°C] : 284
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : -

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.59
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

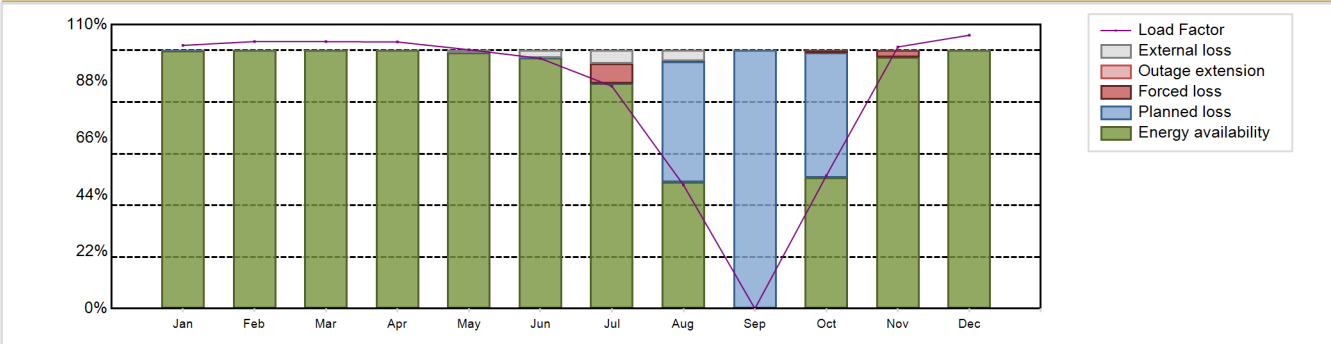
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 6760.71 GW(e).h
 Energy Availability Factor (EAF) : 81.64 %
 Unit Capability Factor (UCF) : 82.74 %
 Load Factor (LF) : 83.43 %
 Operating Factor (OF) : 84.67 %
 Equivalent non-electrical energy generated (NEG) : 63.62 GW(e).h

Forced Loss Rate (FLR) : 1.14 %
 Unplanned Capability Loss Factor (UCL) : 0.95 %
 Planned Unavailability Factor (PUF) : 16.3 %
 Externally cause unavailability (XUF) : 1.1 %
 Total off-line time : 1343 hours

Annual Summary

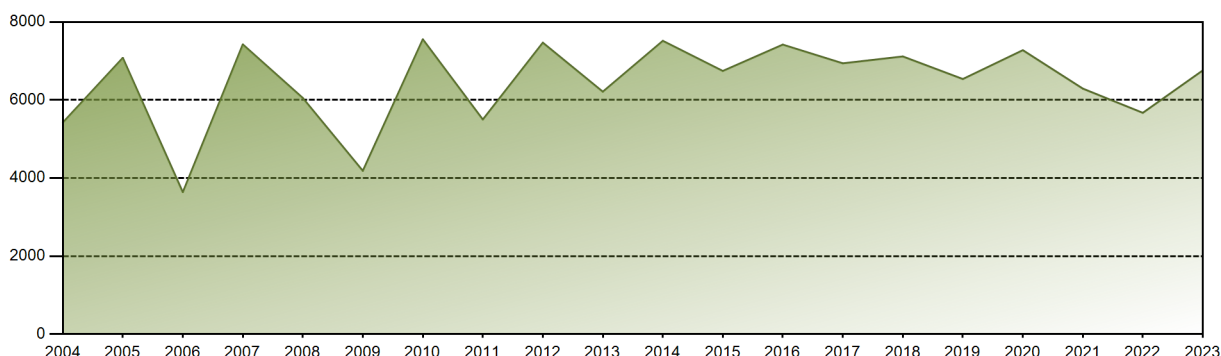


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 701.66 | 642.99 | 711.60 | 687.90 | 690.16 | 645.43 | 592.80 | 329.81 | 0.00 | 354.57 | 674.99 | 728.79 | 6760.71 |
| EAF [%] | 99.93 | 100.00 | 100.00 | 100.00 | 99.05 | 97.09 | 87.09 | 48.99 | 0.00 | 50.85 | 97.48 | 100.00 | 81.64 |
| UCF [%] | 99.93 | 100.00 | 100.00 | 100.00 | 100.00 | 99.88 | 92.23 | 53.12 | 0.00 | 50.85 | 97.48 | 100.00 | 82.74 |
| LF [%] | 101.96 | 103.44 | 103.40 | 103.29 | 100.28 | 96.91 | 86.14 | 47.92 | 0.00 | 51.52 | 101.35 | 105.90 | 83.43 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.35 | 57.80 | 0.00 | 64.11 | 100.00 | 100.00 | 84.67 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.71 | 0.28 | 0.00 | 1.82 | 2.52 | 0.00 | 1.14 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.71 | 0.15 | 0.00 | 0.94 | 2.52 | 0.00 | 0.95 |
| PUF [%] | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.05 | 46.73 | 100.00 | 48.21 | 0.00 | 0.00 | 16.30 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.95 | 2.79 | 5.15 | 4.13 | 0.00 | 0.00 | 0.00 | 0.00 | 1.10 |

Historical Summary

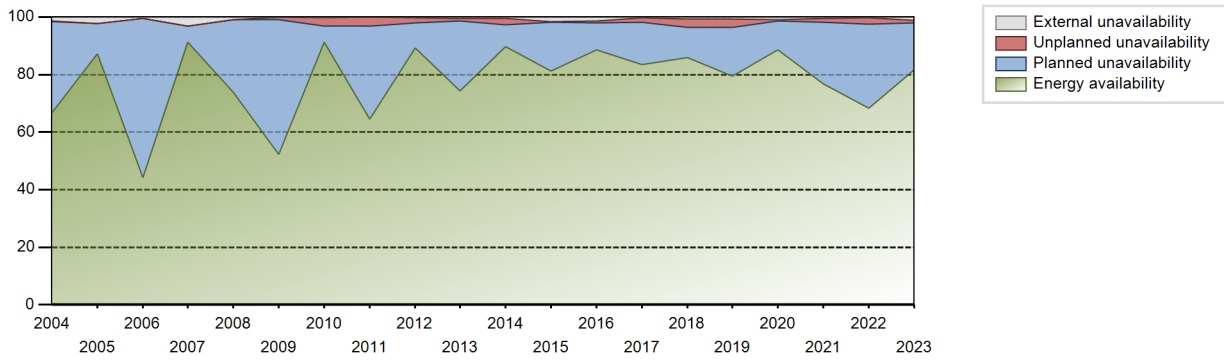
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 240918.76 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.45 % |
| Cumulative Energy Availability Factor (EAF) | : 77.34 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.04 % |
| Cumulative Unit Capability Factor (UCF) | : 78.34 % | Cumulative Planned Unavailability Factor (PUF) | : 19.62 % |
| Cumulative Load Factor (LF) | : 78.16 % | Cumulative Externally cause unavailability (XUF) | : 1 % |
| Cumulative Operating Factor (OF) | : 80.53 % | | |

Electricity Production (net) [GWh]

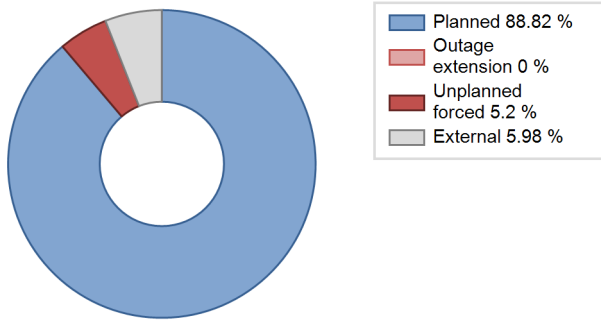


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 6328.54 | 7574 | 925 | 80.35 | 80.81 | 80.28 | 88.06 | 12.66 | 11.71 | 7.47 | 0.46 |
| 1987 | 6167.68 | 6704 | 1000 | 72.29 | 72.43 | 70.41 | 76.53 | 6.80 | 5.28 | 22.29 | 0.14 |
| 1988 | 6653.03 | 7390 | 925 | 81.73 | 81.73 | 81.88 | 84.13 | 5.02 | 4.32 | 13.95 | 0.01 |
| 1989 | 6131.81 | 6954 | 925 | 75.98 | 76.02 | 75.67 | 79.38 | 4.04 | 3.20 | 20.78 | 0.05 |
| 1990 | 6050.02 | 6922 | 925 | 73.62 | 73.71 | 74.66 | 79.02 | 7.62 | 6.08 | 20.21 | 0.09 |
| 1991 | 7356.07 | 8469 | 925 | 90.30 | 92.54 | 90.78 | 96.68 | 4.21 | 4.06 | 3.40 | 2.24 |
| 1992 | 6117.37 | 7324 | 925 | 75.44 | 75.44 | 75.30 | 83.39 | 2.41 | 1.87 | 22.69 | 0.00 |
| 1993 | 5638.27 | 6439 | 925 | 70.98 | 71.72 | 69.58 | 73.50 | 4.54 | 3.41 | 24.87 | 0.74 |
| 1994 | 5369.44 | 6255 | 925 | 66.98 | 71.55 | 66.26 | 71.40 | 1.27 | 0.92 | 27.53 | 4.57 |
| 1995 | 6207.48 | 7001 | 925 | 77.02 | 78.61 | 76.61 | 79.92 | 3.36 | 2.74 | 18.66 | 1.58 |
| 1996 | 6590.19 | 7373 | 925 | 80.16 | 81.40 | 81.11 | 83.94 | 3.23 | 2.71 | 15.89 | 1.23 |
| 1997 | 5971.68 | 6664 | 925 | 73.05 | 73.87 | 73.70 | 76.07 | 2.70 | 2.05 | 24.08 | 0.82 |
| 1998 | 6641.43 | 7751 | 925 | 82.33 | 86.66 | 81.96 | 88.48 | 1.46 | 1.29 | 12.05 | 4.34 |
| 1999 | 5895.38 | 6595 | 925 | 72.77 | 74.17 | 72.76 | 75.29 | 1.02 | 0.77 | 25.06 | 1.40 |
| 2000 | 6778.77 | 7423 | 925 | 82.81 | 83.47 | 83.43 | 84.51 | 0.59 | 0.50 | 16.03 | 0.66 |
| 2001 | 6671.63 | 7281 | 925 | 81.52 | 82.20 | 82.34 | 83.12 | 0.81 | 0.67 | 17.13 | 0.68 |
| 2002 | 5530.98 | 6094 | 925 | 67.61 | 68.31 | 68.26 | 69.57 | 1.54 | 1.07 | 30.62 | 0.71 |
| 2003 | 6233.39 | 6802 | 925 | 75.84 | 77.26 | 76.93 | 77.65 | 0.27 | 0.21 | 22.54 | 1.42 |
| 2004 | 5422.93 | 6005 | 925 | 66.70 | 68.02 | 66.74 | 68.36 | 0.27 | 0.18 | 31.80 | 1.32 |
| 2005 | 7081.14 | 7858 | 925 | 87.15 | 89.43 | 87.38 | 89.69 | 0.00 | 0.00 | 10.57 | 2.28 |
| 2006 | 3636.44 | 4115 | 925 | 44.24 | 44.77 | 44.88 | 46.97 | 0.00 | 0.00 | 55.23 | 0.53 |
| 2007 | 7426.50 | 8298 | 925 | 91.23 | 94.27 | 91.65 | 94.73 | 0.19 | 0.18 | 5.54 | 3.04 |
| 2008 | 6052.40 | 6580 | 925 | 73.94 | 74.87 | 74.49 | 74.91 | 0.00 | 0.00 | 25.13 | 0.93 |
| 2009 | 4184.28 | 4786 | 925 | 52.34 | 52.46 | 51.64 | 54.63 | 1.38 | 0.73 | 46.81 | 0.12 |
| 2010 | 7557.08 | 8109 | 925 | 91.31 | 91.65 | 93.26 | 92.57 | 2.88 | 2.72 | 5.62 | 0.35 |
| 2011 | 5500.69 | 5729 | 925 | 64.46 | 64.51 | 67.89 | 65.41 | 4.61 | 3.12 | 32.37 | 0.05 |
| 2012 | 7470.41 | 8144 | 925 | 89.18 | 89.36 | 91.94 | 92.71 | 2.11 | 1.93 | 8.72 | 0.18 |
| 2013 | 6213.89 | 6807 | 925 | 74.33 | 74.78 | 76.69 | 77.71 | 1.12 | 0.85 | 24.37 | 0.46 |
| 2014 | 7517.80 | 8201 | 925 | 89.67 | 90.11 | 92.78 | 93.62 | 2.44 | 2.26 | 7.64 | 0.44 |
| 2015 | 6745.34 | 7348 | 925 | 81.17 | 82.83 | 83.24 | 83.88 | 0.07 | 0.06 | 17.11 | 1.67 |
| 2016 | 7420.59 | 8055 | 925 | 88.67 | 90.08 | 91.33 | 91.70 | 0.76 | 0.69 | 9.23 | 1.40 |
| 2017 | 6940.86 | 7471 | 925 | 83.55 | 83.71 | 85.66 | 85.29 | 2.08 | 1.78 | 14.52 | 0.15 |
| 2018 | 7117.30 | 7645 | 925 | 85.95 | 86.70 | 87.84 | 87.27 | 3.14 | 2.81 | 10.49 | 0.75 |
| 2019 | 6538.38 | 7095 | 925 | 79.38 | 80.03 | 80.69 | 80.99 | 2.71 | 2.99 | 16.98 | 0.65 |
| 2020 | 7277.83 | 7991 | 925 | 88.64 | 89.46 | 89.57 | 90.97 | 0.62 | 0.56 | 9.98 | 0.81 |
| 2021 | 6292.87 | 6865 | 925 | 76.86 | 77.33 | 77.66 | 78.37 | 1.79 | 1.41 | 21.26 | 0.47 |
| 2022 | 5672.23 | 6628 | 925 | 68.23 | 68.49 | 70.00 | 75.66 | 0.11 | 2.17 | 29.34 | 0.26 |

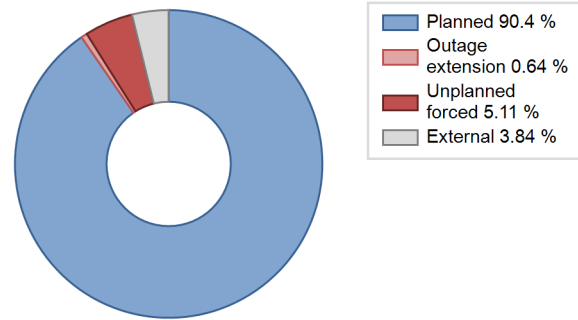
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 42 | | | 69 | |
| C. Inspection, maintenance or repair combined with refuelling | 1301 | | | 1182 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 372 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 72 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 5 | |
| Z. Other | | | | | 5 | |
| Subtotal | 1301 | 42 | | 1626 | 79 | 1 |
| Total | | 1343 | | | 1706 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1986 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 8 |
| 12. Reactor I&C Systems | | | | 13 |
| 15. Reactor Cooling Systems | | | | 13 |
| 16. Steam generation systems | | | | 0 |
| 31. Turbine and auxiliaries | | | | 3 |
| 32. Feedwater and Main Steam System | | | 42 | 7 |
| 33. Circulating Water System | | | | 3 |
| 42. Electrical Power Supply Systems | | | | 22 |
| Total | | | 42 | 69 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-May, October-December. Additional electricity generation amounted to 148610 MWh. The unit was in the intermediate maintenance outage from 2023.08.18 to 2023.10.12. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-163

LENINGRAD 2-1

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : AEM (Atomenergomash)

Reactor Unit Details

Reactor type and model : PWR / VVER V-491
 Thermal power : 3200 MWth
 Gross electrical power : 1188 MWe
 Reference unit power (net) : 1101 MWe

Key Dates

Construction Date : 2008-10-25
 Grid Date : 2018-03-09
 Commercial Date : 2018-10-29
 Age at end of year : 5 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : -
 Fuel material : -
 Refuelling type : -
 Moderator material : -
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : -
 Active core diameter [m] : -
 Active core height/length [m] : -
 Number of fissile fuel assemblies/bundles : -
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : -
 Number of external reactor coolant loops : -
 Coolant type : -

Operating coolant pressure [MPa] : -
 Reactor outlet temperature [°C] : -
 Number of SG : -
 Containment type : -
 Containment design pressure [MPa] : -

Secondary systems

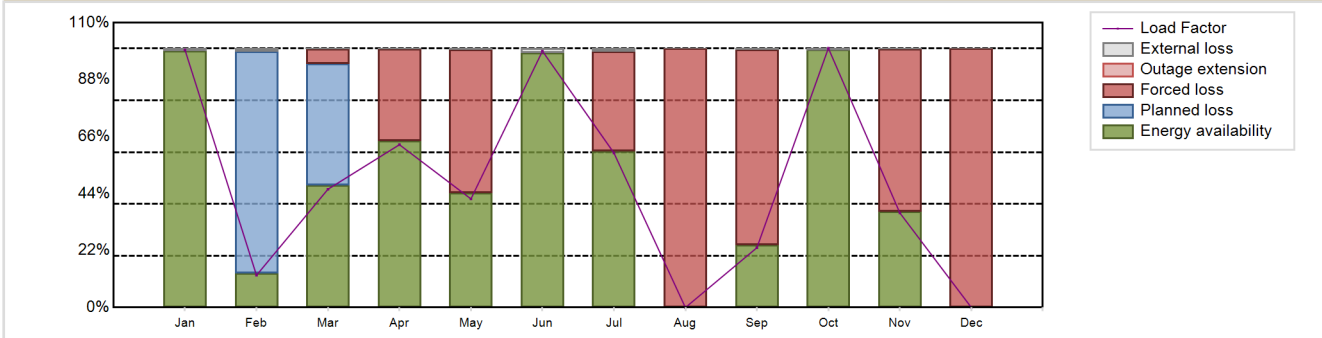
Number of turbine-generators per unit/reactor : -
 Turbine speed [rpm] : -
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : -
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 4690.9 GW(e).h
 Energy Availability Factor (EAF) : 49.18 %
 Unit Capability Factor (UCF) : 49.71 %
 Load Factor (LF) : 48.64 %
 Operating Factor (OF) : 50.19 %
 Forced Loss Rate (FLR) : 44.41 %
 Unplanned Capability Loss Factor (UCL) : 39.72 %
 Planned Unavailability Factor (PUF) : 10.57 %
 Externally cause unavailability (XUF) : 0.53 %
 Total off-line time : 4363 hours

Annual Summary

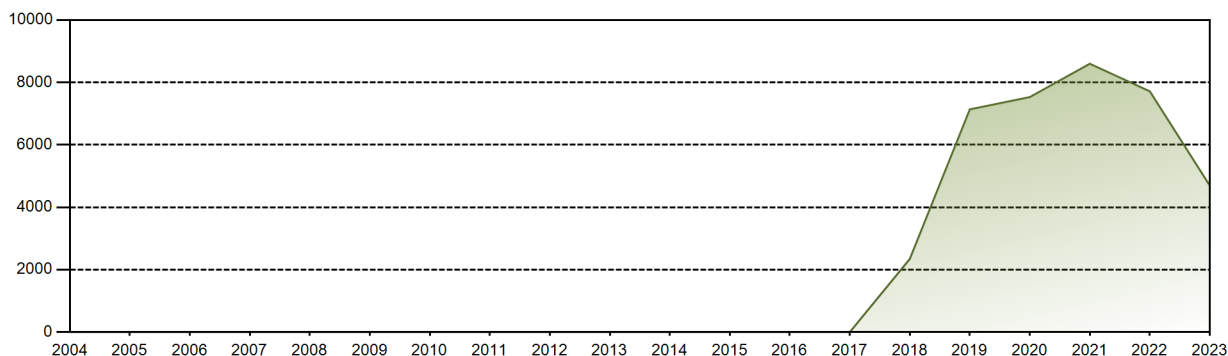


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|-------|--------|--------|--------|--------|--------|-------|--------|--------|--------|-------|---------|
| GW(e)-h | 814.96 | 92.13 | 374.30 | 498.52 | 343.67 | 785.06 | 489.10 | 0.00 | 183.12 | 820.42 | 289.61 | 0.00 | 4690.90 |
| EAF [%] | 99.05 | 13.23 | 47.26 | 64.33 | 44.21 | 98.47 | 60.32 | 0.01 | 24.26 | 99.49 | 36.95 | 0.01 | 49.18 |
| UCF [%] | 100.00 | 14.31 | 47.33 | 64.53 | 44.64 | 100.00 | 61.41 | 0.01 | 24.72 | 100.00 | 37.09 | 0.01 | 49.71 |
| LF [%] | 99.49 | 12.45 | 45.69 | 62.89 | 41.95 | 99.03 | 59.71 | 0.00 | 23.10 | 100.16 | 36.53 | 0.00 | 48.64 |
| OF [%] | 100.00 | 14.43 | 54.03 | 64.58 | 42.61 | 100.00 | 61.42 | 0.00 | 25.56 | 100.00 | 37.08 | 0.00 | 50.19 |
| FLR [%] | 0.00 | 0.00 | 10.68 | 35.47 | 55.36 | 0.00 | 38.59 | 99.99 | 75.28 | 0.00 | 62.91 | 99.99 | 44.41 |
| UCL [%] | 0.00 | 0.00 | 5.66 | 35.47 | 55.36 | 0.00 | 38.59 | 99.99 | 75.28 | 0.00 | 62.91 | 99.99 | 39.72 |
| PUF [%] | 0.00 | 85.69 | 47.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.57 |
| XUF [%] | 0.95 | 1.07 | 0.07 | 0.20 | 0.43 | 1.53 | 1.10 | 0.00 | 0.46 | 0.51 | 0.13 | 0.00 | 0.53 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 38016.72 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 14.77 % |
| Cumulative Energy Availability Factor (EAF) | : 73.74 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 13.51 % |
| Cumulative Unit Capability Factor (UCF) | : 74.75 % | Cumulative Planned Unavailability Factor (PUF) | : 11.74 % |
| Cumulative Load Factor (LF) | : 72.22 % | Cumulative Externally cause unavailability (XUF) | : 1.01 % |
| Cumulative Operating Factor (OF) | : 75.15 % | | |

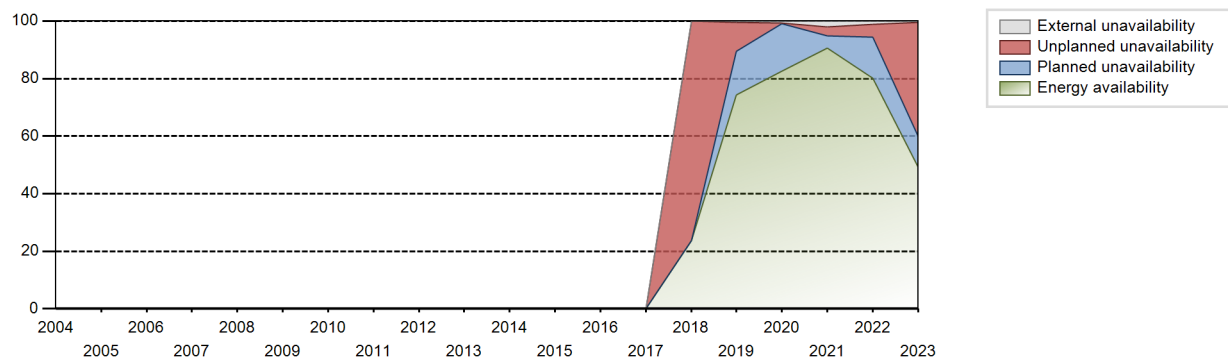
Electricity Production (net) [GWh]



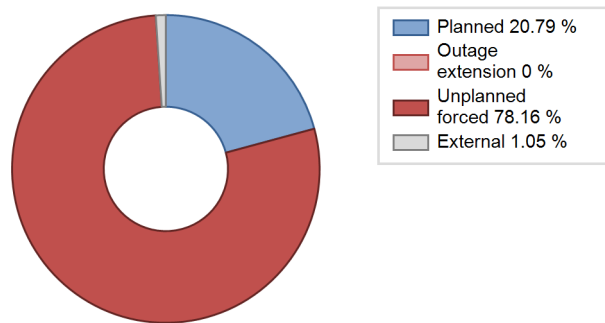
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2018 | 2344.91 | 3078 | 1085 | 23.75 | 23.75 | 20.26 | 25.14 | 76.25 | 76.25 | 0.00 | 0.00 |
| 2019 | 7137.13 | 6666 | 1101 | 74.35 | 74.93 | 74.00 | 76.10 | 8.67 | 9.99 | 15.09 | 0.57 |
| 2020 | 7530.82 | 7037 | 1101 | 82.64 | 83.44 | 77.87 | 80.11 | 0.18 | 0.15 | 16.41 | 0.80 |
| 2021 | 8598.45 | 8324 | 1101 | 90.52 | 92.65 | 89.15 | 95.02 | 3.11 | 2.98 | 4.38 | 2.12 |
| 2022 | 7714.52 | 7241 | 1101 | 80.22 | 81.40 | 79.99 | 82.66 | 5.16 | 4.42 | 14.17 | 1.18 |
| 2023 | 4690.90 | 4397 | 1101 | 49.18 | 49.71 | 48.64 | 50.19 | 44.41 | 39.72 | 10.57 | 0.53 |

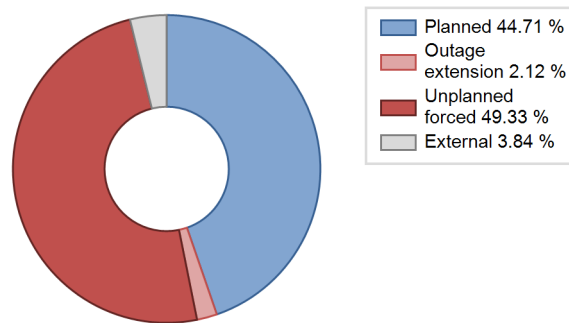
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2018 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 3450 | | | 1203 | |
| C. Inspection, maintenance or repair combined with refuelling | 918 | | | 948 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 47 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 62 |
| Subtotal | 918 | 3450 | | 995 | 1203 | 62 |
| Total | | 4368 | | | 2260 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2018 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|-------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 16. Steam generation systems | | | 196 | 72 |
| 31. Turbine and auxiliaries | | | 1569 | 393 |
| 32. Feedwater and Main Steam System | | | | 95 |
| 33. Circulating Water System | | | | 5 |
| 41. Main Generator Systems | | | 1685 | 498 |
| 42. Electrical Power Supply Systems | | | | 1 |
| Total | | | 3450 | 1064 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. The unit was in the intermediate maintenance outage from 2023.02.05 to 2023.03.15. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-164

LENINGRAD 2-2

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : AEM (Atomenergomash)

Reactor Unit Details

Reactor type and model : PWR / VVER V-491
 Thermal power : 3200 MWth
 Gross electrical power : 1188 MWe
 Reference unit power (net) : 1101 MWe

Key Dates

Construction Date : 2010-04-15
 Grid Date : 2020-10-22
 Commercial Date : 2021-03-18
 Age at end of year : 3 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : -
 Fuel material : -
 Refuelling type : -
 Moderator material : -
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : -
 Active core diameter [m] : -
 Active core height/length [m] : -
 Number of fissile fuel assemblies/bundles : -
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : -
 Number of external reactor coolant loops : -
 Coolant type : -

Operating coolant pressure [MPa] : -
 Reactor outlet temperature [°C] : -
 Number of SG : -
 Containment type : -
 Containment design pressure [MPa] : -

Secondary systems

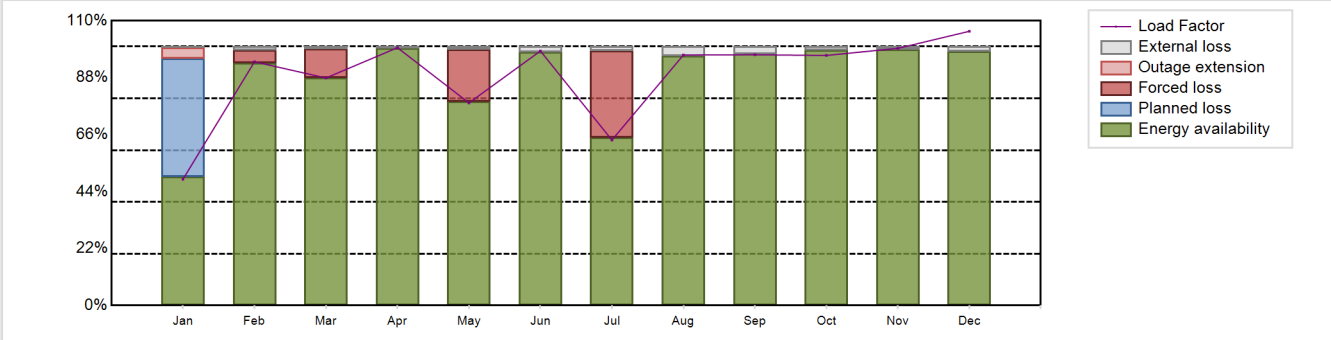
Number of turbine-generators per unit/reactor : -
 Turbine speed [rpm] : -
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : -
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8555.51 GW(e).h
 Energy Availability Factor (EAF) : 88.29 %
 Unit Capability Factor (UCF) : 89.89 %
 Load Factor (LF) : 88.71 %
 Operating Factor (OF) : 90.24 %
 Forced Loss Rate (FLR) : 6.13 %
 Unplanned Capability Loss Factor (UCL) : 6.22 %
 Planned Unavailability Factor (PUF) : 3.89 %
 Externally cause unavailability (XUF) : 1.59 %
 Total off-line time : 855 hours

Annual Summary

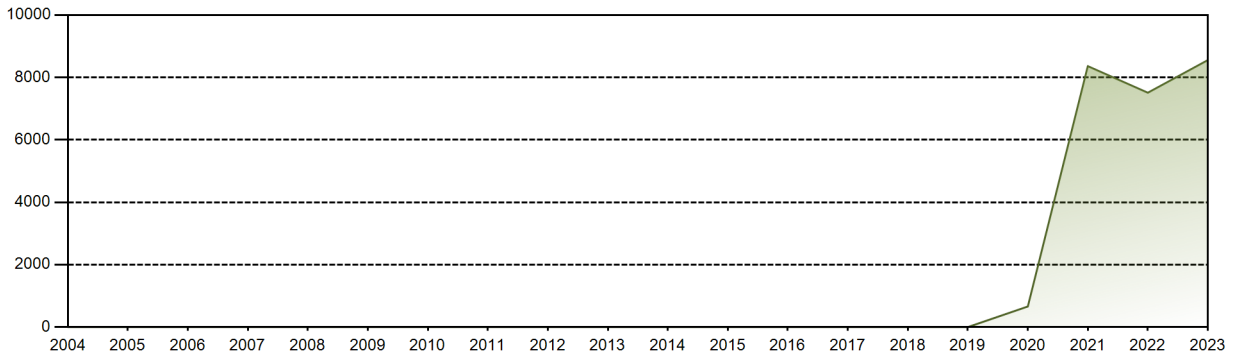


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 399.75 | 696.38 | 719.92 | 789.38 | 641.02 | 779.31 | 523.41 | 792.55 | 767.77 | 791.12 | 787.35 | 867.57 | 8555.51 |
| EAF [%] | 49.65 | 93.73 | 87.86 | 99.29 | 78.80 | 97.75 | 64.89 | 96.47 | 97.22 | 98.69 | 98.85 | 98.14 | 88.29 |
| UCF [%] | 50.11 | 95.05 | 88.78 | 100.00 | 79.90 | 100.00 | 66.64 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 89.89 |
| LF [%] | 48.80 | 94.12 | 87.89 | 99.58 | 78.26 | 98.31 | 63.90 | 96.75 | 96.85 | 96.58 | 99.32 | 105.91 | 88.71 |
| OF [%] | 50.81 | 96.13 | 89.52 | 100.00 | 81.05 | 100.00 | 67.20 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.24 |
| FLR [%] | 0.00 | 4.95 | 11.22 | 0.00 | 20.10 | 0.00 | 33.36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.13 |
| UCL [%] | 4.09 | 4.95 | 11.22 | 0.00 | 20.10 | 0.00 | 33.36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.22 |
| PUF [%] | 45.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.89 |
| XUF [%] | 0.46 | 1.31 | 0.92 | 0.71 | 1.10 | 2.25 | 1.74 | 3.53 | 2.78 | 1.31 | 1.15 | 1.86 | 1.59 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 25087.26 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.53 % |
| Cumulative Energy Availability Factor (EAF) | : 84.46 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.28 % |
| Cumulative Unit Capability Factor (UCF) | : 86.1 % | Cumulative Planned Unavailability Factor (PUF) | : 10.62 % |
| Cumulative Load Factor (LF) | : 84.82 % | Cumulative Externally cause unavailability (XUF) | : 1.65 % |
| Cumulative Operating Factor (OF) | : 86.54 % | | |

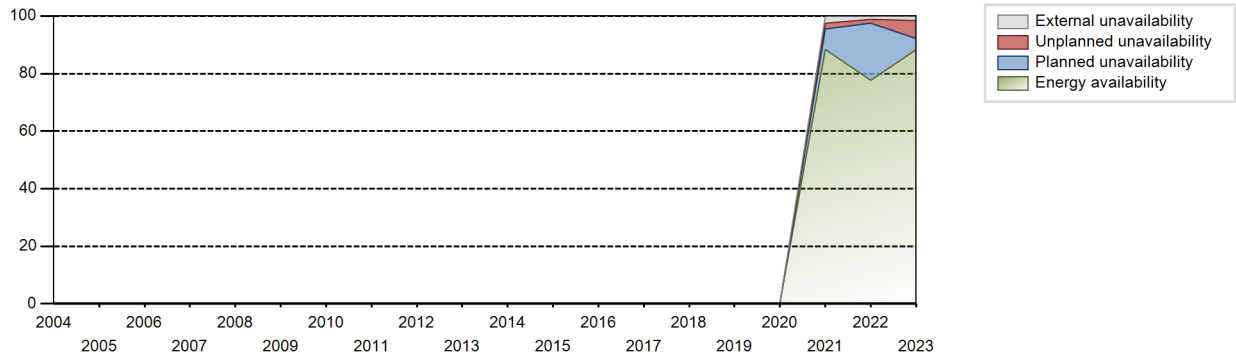
Electricity Production (net) [GWh]



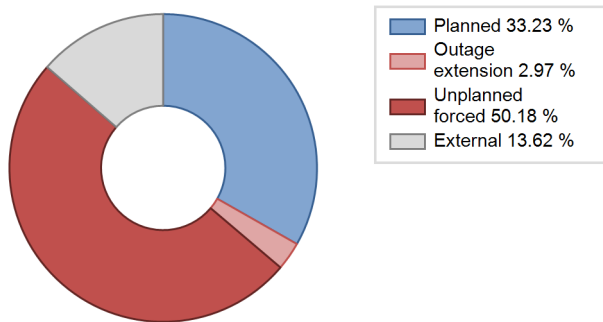
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2021 | 8361.90 | 7935 | 1101 | 88.43 | 90.96 | 88.87 | 91.67 | 2.03 | 1.88 | 7.16 | 2.53 |
| 2022 | 7510.31 | 6919 | 1101 | 77.62 | 78.66 | 77.87 | 78.98 | 1.74 | 1.39 | 19.95 | 1.04 |
| 2023 | 8555.51 | 7905 | 1101 | 88.29 | 89.89 | 88.71 | 90.24 | 6.13 | 6.22 | 3.89 | 1.59 |

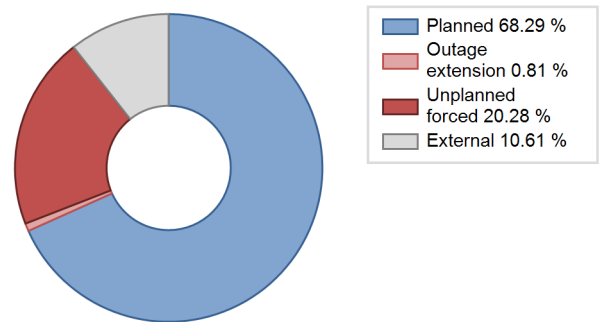
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2021 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 505 | | | 267 | |
| C. Inspection, maintenance or repair combined with refuelling | 336 | | | 816 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 104 | | |
| Z. Other | | 30 | | | 11 | |
| Subtotal | 336 | 535 | | 920 | 278 | |
| Total | | 871 | | | 1198 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2021 to 2023 | |
|-------------------------------------|------------|------------|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 13. Reactor Auxiliary Systems | | 127 | | 42 |
| 15. Reactor Cooling Systems | | | | 40 |
| 16. Steam generation systems | | 37 | | 12 |
| 31. Turbine and auxiliaries | | 41 | | 26 |
| 41. Main Generator Systems | | 301 | | 122 |
| 42. Electrical Power Supply Systems | | | | 2 |
| Total | | 506 | | 244 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. The unit was in the intermediate maintenance outage from 2023.01.01 to 2023.01.15. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-34 **LENINGRAD-3** **RUSSIA**

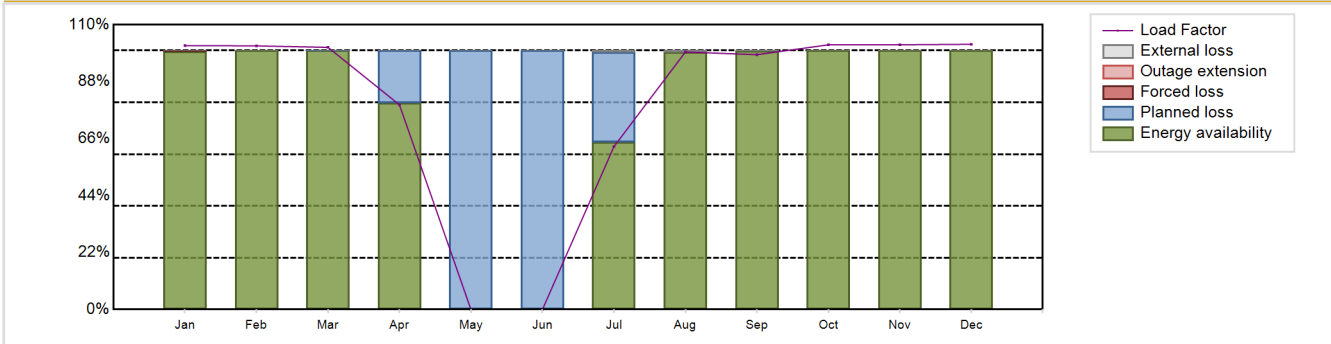
Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : LWGR / RBMK-1000 | Construction Date | : 1973-12-01 |
| Thermal power | : 3200 MWth | Grid Date | : 1979-12-07 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1980-06-29 |
| Reference unit power (net) | : 925 MWe | Age at end of year | : 44 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 284 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : ON-line | Containment type | : Confinement |
| Moderator material | : GRAPHITE | Containment design pressure [MPa] | : - |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : - | Number of turbine-generators per unit/reactor | : 2 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 22000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 11.8 | HP cylinder inlet steam pressure [MPa] | : 6.59 |
| Active core height/length [m] | : 7 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 1661 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 14.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 211 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : DH / PH |

| Annual Production Results (2023) | | | |
|--|-------------------|--|--------------|
| Net Energy Production | : 6419.76 GW(e).h | Forced Loss Rate (FLR) | : 0.04 % |
| Energy Availability Factor (EAF) | : 78.53 % | Unplanned Capability Loss Factor (UCL) | : 0.03 % |
| Unit Capability Factor (UCF) | : 78.64 % | Planned Unavailability Factor (PUF) | : 21.33 % |
| Load Factor (LF) | : 79.23 % | Externally cause unavailability (XUF) | : 0.11 % |
| Operating Factor (OF) | : 79.63 % | Total off-line time | : 1784 hours |
| Equivalent non-electrical energy generated (NEG) | : 69.19 GW(e).h | | |

Annual Summary

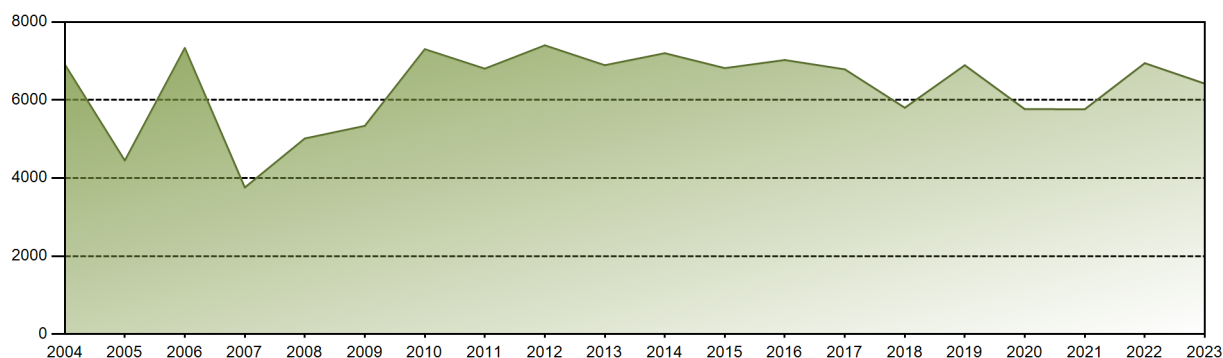


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 701.41 | 632.93 | 696.82 | 526.41 | 0.00 | 0.00 | 432.85 | 684.48 | 655.46 | 703.50 | 680.90 | 705.00 | 6419.76 |
| EAF [%] | 99.67 | 100.00 | 99.99 | 79.67 | 0.00 | 0.00 | 64.60 | 99.38 | 99.96 | 100.00 | 100.00 | 100.00 | 78.53 |
| UCF [%] | 99.67 | 100.00 | 99.99 | 79.67 | 0.00 | 0.00 | 65.25 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 78.64 |
| LF [%] | 101.92 | 101.82 | 101.25 | 79.04 | 0.00 | 0.00 | 62.90 | 99.46 | 98.42 | 102.22 | 102.24 | 102.44 | 79.23 |
| OF [%] | 100.00 | 100.00 | 100.00 | 83.33 | 0.00 | 0.00 | 73.12 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 79.63 |
| FLR [%] | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| UCL [%] | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| PUF [%] | 0.00 | 0.00 | 0.01 | 20.33 | 100.00 | 100.00 | 34.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.33 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.65 | 0.62 | 0.04 | 0.00 | 0.00 | 0.00 | 0.11 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 259763.95 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.59 % |
| Cumulative Energy Availability Factor (EAF) | : 73.78 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.76 % |
| Cumulative Unit Capability Factor (UCF) | : 74.6 % | Cumulative Planned Unavailability Factor (PUF) | : 22.64 % |
| Cumulative Load Factor (LF) | : 72.82 % | Cumulative Externally cause unavailability (XUF) | : 0.82 % |
| Cumulative Operating Factor (OF) | : 76.51 % | | |

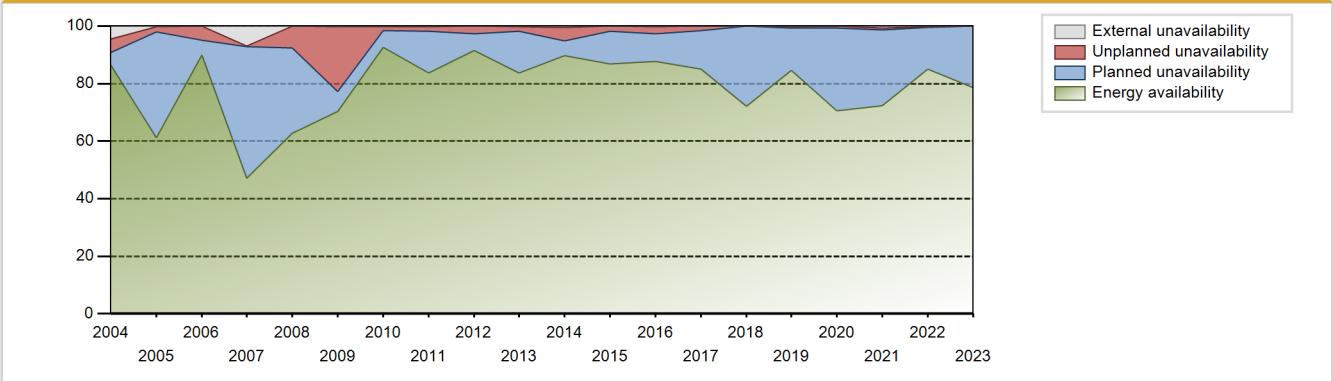
Electricity Production (net) [GWh]



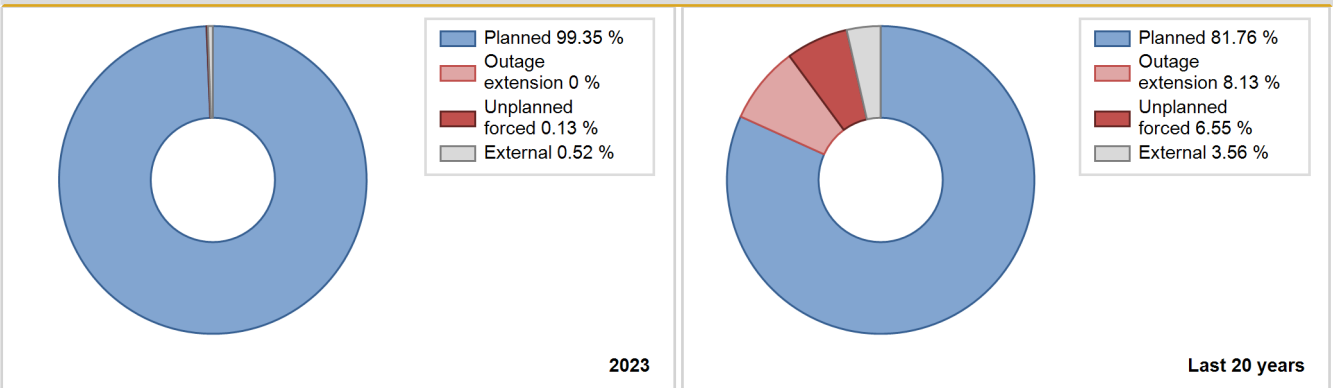
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | 5345.39 | 7504 | 925 | 81.59 | 81.61 | 80.55 | 90.94 | 10.86 | 9.95 | 8.45 | 0.02 |
| 1981 | 6553.56 | 7528 | 925 | 81.35 | 81.66 | 80.88 | 85.94 | 9.31 | 8.38 | 9.96 | 0.32 |
| 1982 | 6413.26 | 7448 | 925 | 80.27 | 80.80 | 79.15 | 85.02 | 7.18 | 6.25 | 12.95 | 0.53 |
| 1983 | 5708.44 | 6809 | 925 | 70.90 | 71.30 | 70.45 | 77.73 | 7.88 | 6.10 | 22.61 | 0.39 |
| 1984 | 7214.95 | 8060 | 925 | 89.22 | 89.76 | 88.80 | 91.76 | 1.88 | 1.72 | 8.52 | 0.55 |
| 1985 | 6831.90 | 7835 | 925 | 84.94 | 85.42 | 84.31 | 89.44 | 5.45 | 4.92 | 9.67 | 0.47 |
| 1986 | 6890.93 | 7935 | 925 | 85.89 | 86.44 | 85.04 | 90.58 | 3.36 | 3.01 | 10.55 | 0.55 |
| 1987 | 6010.31 | 6362 | 1000 | 69.36 | 70.37 | 68.61 | 72.63 | 1.12 | 0.79 | 28.83 | 1.01 |
| 1988 | 6951.74 | 7885 | 925 | 86.53 | 86.53 | 85.56 | 89.77 | 1.44 | 1.26 | 12.21 | 0.00 |
| 1989 | 6938.14 | 7455 | 925 | 85.86 | 86.23 | 85.62 | 85.10 | 0.97 | 0.84 | 12.93 | 0.37 |
| 1990 | 7531.93 | 8280 | 925 | 92.35 | 92.96 | 92.95 | 94.52 | 1.36 | 1.28 | 5.76 | 0.61 |
| 1991 | 6506.60 | 7197 | 925 | 80.59 | 80.59 | 80.30 | 82.16 | 1.25 | 1.02 | 18.39 | 0.00 |
| 1992 | 5516.63 | 6122 | 925 | 68.39 | 68.49 | 67.90 | 69.70 | 2.92 | 2.06 | 29.45 | 0.09 |
| 1993 | 7143.82 | 7966 | 925 | 88.90 | 90.14 | 88.16 | 90.94 | 0.56 | 0.51 | 9.35 | 1.24 |
| 1994 | 6631.82 | 8135 | 925 | 91.04 | 92.42 | 81.84 | 92.87 | 0.26 | 0.24 | 7.34 | 1.39 |
| 1995 | 3585.96 | 4332 | 925 | 46.53 | 49.40 | 44.25 | 49.45 | 0.44 | 0.22 | 50.38 | 2.87 |
| 1996 | 0.00 | 0 | 925 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1997 | 0.00 | 0 | 925 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1998 | 1386.50 | 1610 | 925 | 17.41 | 17.49 | 17.11 | 18.38 | 4.00 | 0.73 | 81.78 | 0.08 |
| 1999 | 7853.14 | 8701 | 925 | 97.08 | 99.66 | 96.92 | 99.33 | 0.34 | 0.34 | 0.00 | 2.58 |
| 2000 | 6352.80 | 7169 | 925 | 78.25 | 79.64 | 78.19 | 81.61 | 1.83 | 1.49 | 18.87 | 1.39 |
| 2001 | 6173.49 | 7007 | 925 | 76.58 | 78.92 | 76.19 | 79.99 | 0.19 | 0.15 | 20.93 | 2.34 |
| 2002 | 2514.75 | 3332 | 925 | 31.88 | 33.60 | 31.03 | 38.04 | 17.29 | 7.02 | 59.38 | 1.72 |
| 2003 | 6729.17 | 8100 | 925 | 84.54 | 86.65 | 83.05 | 92.47 | 6.00 | 5.53 | 7.82 | 2.11 |
| 2004 | 6909.08 | 8426 | 925 | 86.47 | 90.86 | 85.03 | 95.92 | 5.04 | 4.82 | 4.31 | 4.40 |
| 2005 | 4447.28 | 5397 | 925 | 61.10 | 61.46 | 54.88 | 61.60 | 2.72 | 1.72 | 36.83 | 0.36 |
| 2006 | 7332.11 | 8274 | 925 | 89.86 | 89.86 | 90.49 | 94.45 | 2.22 | 4.89 | 5.25 | 0.00 |
| 2007 | 3755.96 | 4820 | 925 | 47.04 | 54.08 | 46.35 | 55.02 | 0.24 | 0.13 | 45.78 | 7.04 |
| 2008 | 5013.64 | 5632 | 925 | 62.68 | 62.71 | 61.70 | 64.12 | 1.64 | 7.69 | 29.60 | 0.03 |
| 2009 | 5336.12 | 6209 | 925 | 70.38 | 70.65 | 65.85 | 70.88 | 3.40 | 22.58 | 6.78 | 0.26 |
| 2010 | 7303.22 | 8261 | 925 | 92.58 | 92.88 | 90.13 | 94.30 | 1.27 | 1.19 | 5.93 | 0.29 |
| 2011 | 6803.29 | 7548 | 925 | 83.65 | 83.81 | 83.97 | 86.17 | 0.47 | 1.73 | 14.46 | 0.15 |
| 2012 | 7401.44 | 8115 | 925 | 91.56 | 91.65 | 91.09 | 92.38 | 2.66 | 2.51 | 5.84 | 0.10 |
| 2013 | 6892.27 | 7446 | 925 | 83.65 | 83.95 | 85.06 | 85.00 | 1.79 | 1.55 | 14.50 | 0.30 |
| 2014 | 7199.40 | 8229 | 925 | 89.69 | 90.10 | 88.84 | 93.93 | 1.79 | 4.75 | 5.15 | 0.41 |
| 2015 | 6817.12 | 7628 | 925 | 86.76 | 86.85 | 84.13 | 87.08 | 2.01 | 1.78 | 11.37 | 0.09 |
| 2016 | 7024.91 | 7879 | 925 | 87.77 | 87.94 | 86.46 | 89.70 | 2.71 | 2.45 | 9.62 | 0.16 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2017 | 6786.43 | 7460 | 925 | 84.94 | 84.96 | 83.75 | 85.16 | 1.87 | 1.62 | 13.42 | 0.03 |
| 2018 | 5801.48 | 6257 | 925 | 72.16 | 72.21 | 71.60 | 71.43 | 0.02 | 0.02 | 27.77 | 0.05 |
| 2019 | 6890.81 | 7642 | 925 | 84.69 | 84.85 | 85.04 | 87.24 | 0.65 | 0.56 | 14.59 | 0.16 |
| 2020 | 5765.23 | 6269 | 925 | 70.51 | 70.53 | 70.95 | 71.37 | 1.02 | 0.72 | 28.75 | 0.01 |
| 2021 | 5763.58 | 6496 | 925 | 72.24 | 72.94 | 71.13 | 74.16 | 0.80 | 0.59 | 26.47 | 0.70 |
| 2022 | 6944.66 | 7526 | 925 | 84.93 | 85.20 | 85.70 | 85.91 | 0.14 | 0.12 | 14.68 | 0.26 |
| 2023 | 6419.76 | 6976 | 925 | 78.53 | 78.64 | 79.23 | 79.63 | 0.04 | 0.03 | 21.33 | 0.11 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 97 | |
| C. Inspection, maintenance or repair combined with refuelling | 1785 | | | 849 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 877 | | |
| E. Testing of plant systems or components | | | | 1 | 16 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 121 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 74 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 12 |
| L. Human factor related | | | | | 3 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 1 | |
| Subtotal | 1785 | | | 1922 | 117 | 16 |
| Total | | 1785 | | | 2055 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1980 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 9 |
| 12. Reactor I&C Systems | | 4 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 6 |
| 16. Steam generation systems | | 2 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 6 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 51 |
| 32. Feedwater and Main Steam System | | 6 |
| 33. Circulating Water System | | 1 |
| 35. All other I&C Systems | | 15 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 12 |
| Total | | 116 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-April, July-December. Additional electricity generation amounted to 107503 MWh. The unit was in the intermediate maintenance outage from 2023.04.25 to 2023.07.09. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-35

LENINGRAD-4

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : LWGR / RBMK-1000 | Construction Date | : 1975-02-01 |
| Thermal power | : 3200 MWth | Grid Date | : 1981-02-09 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1981-08-29 |
| Reference unit power (net) | : 925 MWe | Age at end of year | : 42 years |

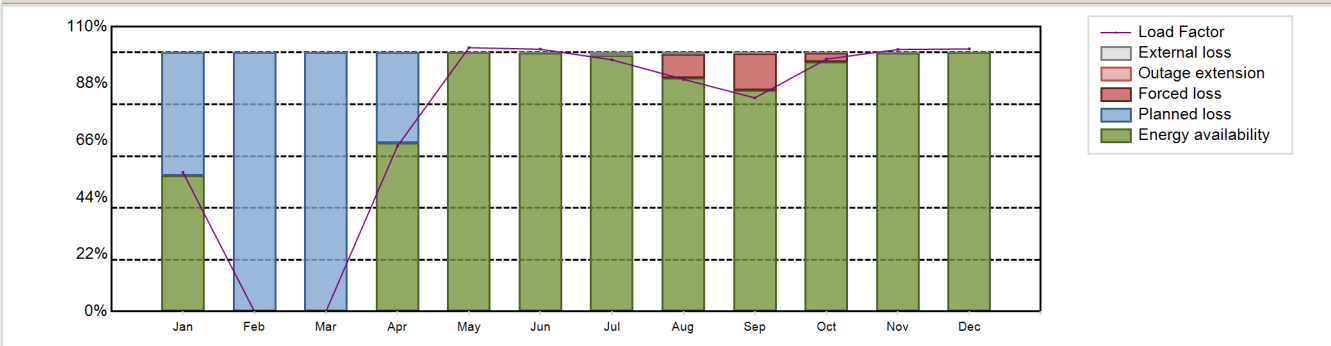
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 284 |
| Refuelling type | : ON-line | Number of SG | : NA |
| Moderator material | : GRAPHITE | Containment type | : Confinement |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : - |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 2 |
| Average discharge burnup [MWd/t] | : 22000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 11.8 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 7 | HP cylinder inlet steam pressure [MPa] | : 6.59 |
| Number of fissile fuel assemblies/bundles | : 1661 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 14.5 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 211 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : DH / PH |

Annual Production Results (2023)

| | | | |
|--|-------------------|--|--------------|
| Net Energy Production | : 6049.67 GW(e).h | Forced Loss Rate (FLR) | : 2.88 % |
| Energy Availability Factor (EAF) | : 74.49 % | Unplanned Capability Loss Factor (UCL) | : 2.22 % |
| Unit Capability Factor (UCF) | : 74.7 % | Planned Unavailability Factor (PUF) | : 23.08 % |
| Load Factor (LF) | : 74.66 % | Externally cause unavailability (XUF) | : 0.21 % |
| Operating Factor (OF) | : 75.92 % | Total off-line time | : 2109 hours |
| Equivalent non-electrical energy generated (NEG) | : 60.52 GW(e).h | | |

Annual Summary

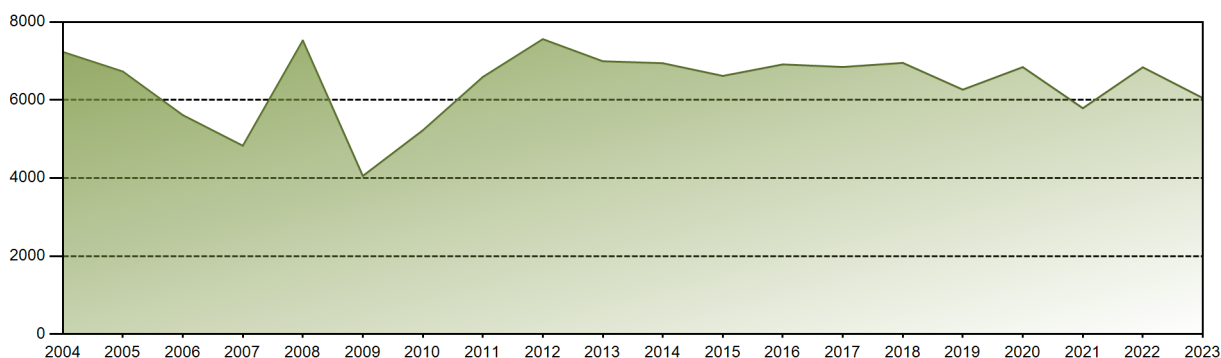


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 369.68 | 0.00 | 0.00 | 425.65 | 701.22 | 674.61 | 668.94 | 617.21 | 549.50 | 670.91 | 673.98 | 697.97 | 6049.67 |
| EAF [%] | 52.35 | 0.00 | 0.00 | 65.08 | 100.00 | 99.82 | 98.86 | 90.29 | 85.54 | 96.47 | 99.98 | 100.00 | 74.49 |
| UCF [%] | 52.35 | 0.00 | 0.00 | 65.08 | 100.00 | 100.00 | 100.00 | 90.97 | 85.92 | 96.56 | 100.00 | 100.00 | 74.70 |
| LF [%] | 53.72 | 0.00 | 0.00 | 63.91 | 101.89 | 101.29 | 97.20 | 89.68 | 82.51 | 97.49 | 101.20 | 101.42 | 74.66 |
| OF [%] | 54.84 | 0.00 | 0.00 | 71.81 | 100.00 | 100.00 | 100.00 | 90.99 | 87.92 | 100.00 | 100.00 | 100.00 | 75.92 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.03 | 14.08 | 3.44 | 0.00 | 0.00 | 2.88 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.03 | 14.08 | 3.44 | 0.00 | 0.00 | 2.22 |
| PUF [%] | 47.65 | 100.00 | 100.00 | 34.92 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 23.08 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 | 1.14 | 0.67 | 0.38 | 0.09 | 0.02 | 0.00 | 0.21 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 250407.22 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.94 % |
| Cumulative Energy Availability Factor (EAF) | : 75.02 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.94 % |
| Cumulative Unit Capability Factor (UCF) | : 75.9 % | Cumulative Planned Unavailability Factor (PUF) | : 21.15 % |
| Cumulative Load Factor (LF) | : 74.25 % | Cumulative Externally cause unavailability (XUF) | : 0.88 % |
| Cumulative Operating Factor (OF) | : 77.61 % | | |

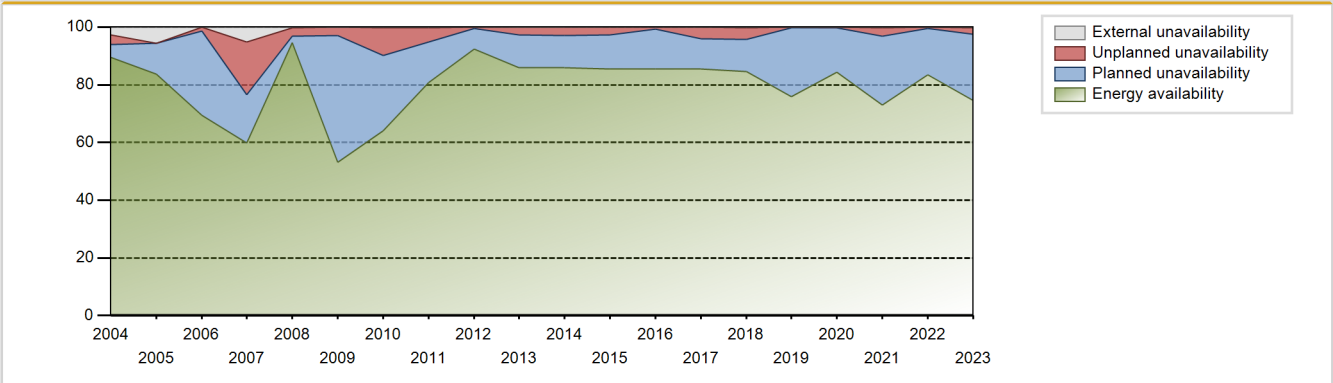
Electricity Production (net) [GWh]



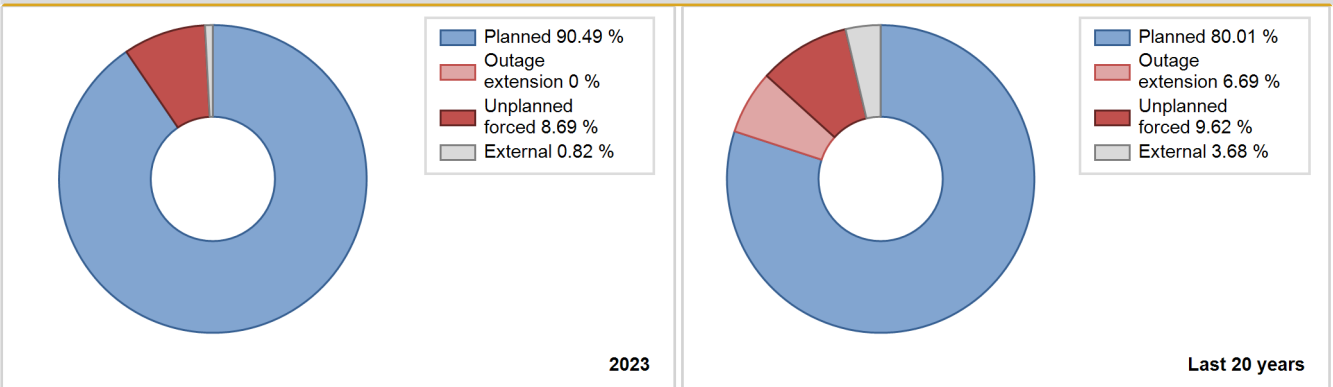
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 3931.27 | 6151 | 925 | 76.82 | 76.83 | 76.06 | 83.41 | 12.21 | 10.69 | 12.48 | 0.01 |
| 1982 | 6715.19 | 7609 | 925 | 83.59 | 83.72 | 82.87 | 86.86 | 4.43 | 3.88 | 12.40 | 0.13 |
| 1983 | 6844.23 | 8159 | 925 | 85.33 | 86.12 | 84.47 | 93.14 | 6.80 | 6.29 | 7.59 | 0.79 |
| 1984 | 6126.32 | 6803 | 925 | 74.43 | 74.94 | 75.40 | 77.45 | 3.19 | 2.47 | 22.59 | 0.52 |
| 1985 | 7335.31 | 8309 | 925 | 90.92 | 91.18 | 90.53 | 94.85 | 3.29 | 3.10 | 5.72 | 0.26 |
| 1986 | 7060.95 | 7826 | 925 | 87.65 | 88.69 | 87.14 | 89.34 | 0.49 | 0.44 | 10.87 | 1.04 |
| 1987 | 7319.23 | 7530 | 1000 | 84.15 | 85.01 | 83.55 | 85.96 | 2.18 | 1.90 | 13.09 | 0.86 |
| 1988 | 6050.44 | 6667 | 925 | 74.82 | 74.82 | 74.47 | 75.90 | 0.72 | 0.54 | 24.64 | 0.00 |
| 1989 | 7409.69 | 8185 | 925 | 91.46 | 91.89 | 91.44 | 93.44 | 2.23 | 2.10 | 6.01 | 0.43 |
| 1990 | 7762.56 | 8588 | 925 | 95.38 | 96.06 | 95.80 | 98.04 | 2.33 | 2.29 | 1.65 | 0.68 |
| 1991 | 6130.70 | 6870 | 925 | 76.14 | 76.77 | 75.66 | 78.42 | 1.77 | 1.38 | 21.85 | 0.62 |
| 1992 | 5618.11 | 6617 | 925 | 70.29 | 70.79 | 69.15 | 75.34 | 4.30 | 3.18 | 26.02 | 0.51 |
| 1993 | 6735.70 | 7762 | 925 | 85.27 | 87.61 | 83.13 | 88.61 | 1.54 | 1.37 | 11.02 | 2.34 |
| 1994 | 6167.07 | 7340 | 925 | 82.08 | 83.16 | 76.11 | 83.79 | 1.33 | 1.12 | 15.72 | 1.07 |
| 1995 | 6140.97 | 7270 | 925 | 82.96 | 86.06 | 75.79 | 82.99 | 0.29 | 0.25 | 13.69 | 3.11 |
| 1996 | 7079.69 | 8048 | 925 | 88.30 | 88.78 | 87.13 | 91.62 | 4.63 | 4.31 | 6.91 | 0.47 |
| 1997 | 7644.68 | 8760 | 925 | 95.95 | 98.19 | 94.34 | 100.00 | 1.81 | 1.81 | 0.00 | 2.24 |
| 1998 | 3681.98 | 4341 | 925 | 45.98 | 47.31 | 45.44 | 49.55 | 2.11 | 1.02 | 51.68 | 1.32 |
| 1999 | 0.00 | 0 | 925 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2000 | 0.00 | 0 | 925 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2001 | 3585.73 | 4387 | 925 | 44.56 | 45.54 | 44.25 | 50.08 | 23.52 | 14.00 | 40.46 | 0.98 |
| 2002 | 7528.53 | 8760 | 925 | 93.93 | 97.55 | 92.91 | 100.00 | 2.45 | 2.45 | 0.00 | 3.62 |
| 2003 | 1957.16 | 2399 | 925 | 24.69 | 26.03 | 24.15 | 27.39 | 2.58 | 0.69 | 73.28 | 1.35 |
| 2004 | 7232.18 | 8243 | 925 | 89.58 | 92.27 | 89.01 | 93.84 | 3.43 | 3.28 | 4.45 | 2.70 |
| 2005 | 6730.12 | 7838 | 925 | 83.76 | 89.33 | 83.05 | 89.46 | 0.11 | 0.10 | 10.57 | 5.57 |
| 2006 | 5611.94 | 6197 | 925 | 69.36 | 69.36 | 69.26 | 70.74 | 0.80 | 1.36 | 29.29 | 0.00 |
| 2007 | 4827.43 | 5713 | 925 | 59.73 | 64.85 | 59.58 | 65.22 | 3.84 | 18.24 | 16.91 | 5.11 |
| 2008 | 7526.25 | 8714 | 925 | 94.69 | 94.90 | 92.63 | 99.20 | 2.93 | 2.86 | 2.24 | 0.22 |
| 2009 | 4052.83 | 4695 | 925 | 53.23 | 53.37 | 50.02 | 53.60 | 4.90 | 2.75 | 43.88 | 0.14 |
| 2010 | 5222.37 | 5798 | 925 | 64.04 | 64.18 | 64.45 | 66.19 | 3.64 | 9.60 | 26.21 | 0.14 |
| 2011 | 6589.79 | 7177 | 925 | 80.76 | 81.01 | 81.33 | 81.94 | 3.53 | 4.93 | 14.06 | 0.25 |
| 2012 | 7559.92 | 8254 | 925 | 92.28 | 92.30 | 93.04 | 93.97 | 0.23 | 0.52 | 7.18 | 0.02 |
| 2013 | 6992.92 | 7739 | 925 | 85.84 | 85.93 | 86.30 | 88.34 | 2.97 | 2.63 | 11.43 | 0.09 |
| 2014 | 6942.49 | 7665 | 925 | 85.92 | 86.00 | 85.67 | 87.49 | 2.03 | 2.77 | 11.23 | 0.08 |
| 2015 | 6617.16 | 7414 | 925 | 85.58 | 85.60 | 81.66 | 84.63 | 2.97 | 2.62 | 11.78 | 0.02 |
| 2016 | 6912.04 | 7660 | 925 | 85.43 | 85.45 | 85.07 | 87.20 | 0.85 | 0.73 | 13.82 | 0.01 |
| 2017 | 6846.75 | 7873 | 925 | 85.57 | 85.58 | 84.50 | 89.87 | 4.04 | 4.04 | 10.39 | 0.01 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2018 | 6951.25 | 7499 | 925 | 84.68 | 84.83 | 85.79 | 85.61 | 4.62 | 4.11 | 11.06 | 0.15 |
| 2019 | 6265.79 | 6730 | 925 | 75.83 | 75.83 | 77.33 | 76.83 | 0.31 | 0.24 | 23.94 | 0.00 |
| 2020 | 6842.29 | 7486 | 925 | 84.44 | 84.44 | 84.21 | 85.22 | 0.42 | 0.35 | 15.20 | 0.01 |
| 2021 | 5789.70 | 6585 | 925 | 72.99 | 73.22 | 71.45 | 75.17 | 3.83 | 2.91 | 23.87 | 0.23 |
| 2022 | 6839.10 | 7399 | 925 | 83.47 | 83.51 | 84.40 | 84.46 | 0.41 | 0.34 | 16.15 | 0.05 |
| 2023 | 6049.67 | 6651 | 925 | 74.49 | 74.70 | 74.66 | 75.92 | 2.88 | 2.22 | 23.08 | 0.21 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|--|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 155 | | | 87 | |
| C. Inspection, maintenance or repair combined with refuelling | 1958 | | | 1350 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 199 | | |
| E. Testing of plant systems or components | | | | | 0 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 150 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 95 | 33 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 10 |
| L. Human factor related | | | | | 1 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 0 | |
| Z. Other | | | | | 18 | 1 |
| Subtotal | 1958 | 155 | | 1794 | 139 | 12 |
| Total | | 2113 | | | 1945 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 7 |
| 12. Reactor I&C Systems | 155 | 24 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 18 |
| 16. Steam generation systems | | 10 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 31. Turbine and auxiliaries | | 11 |
| 32. Feedwater and Main Steam System | | 4 |
| 33. Circulating Water System | | 1 |
| 41. Main Generator Systems | | 3 |
| 42. Electrical Power Supply Systems | | 9 |
| Total | 155 | 88 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January, April-December. Additional electricity generation amounted to 74711 MWh. The unit was in the unit overhaul from 2023.01.17 to 2023.04.09. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

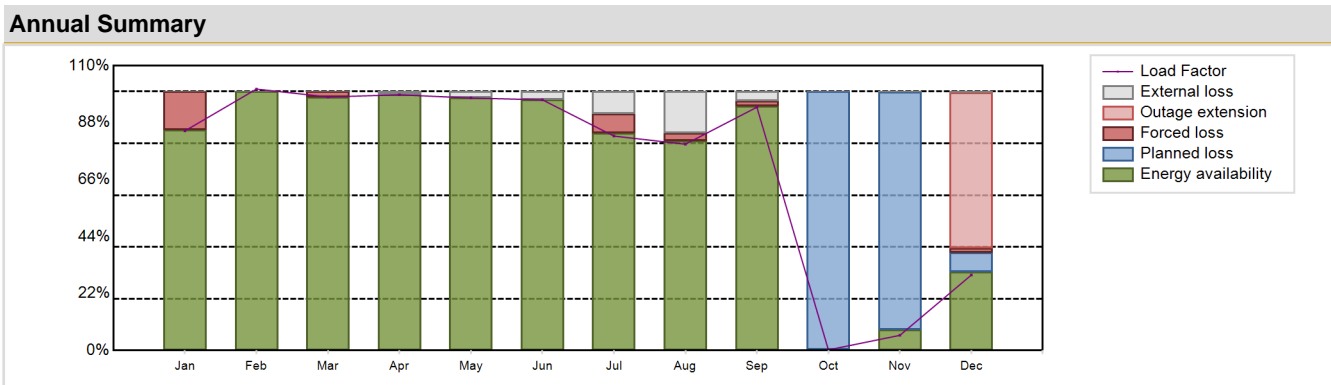
RU-161 **NOVOVORONEZH 2-1** **RUSSIA**

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : AEM (Atomenergomash)

| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-392M | Construction Date | : 2008-06-24 |
| Thermal power | : 3200 MWth | Grid Date | : 2016-08-05 |
| Gross electrical power | : 1180 MWe | Commercial Date | : 2017-02-27 |
| Reference unit power (net) | : 1100 MWe | Age at end of year | : 7 years |

| Design Characteristics | |
|--|--------|
| Primary Systems | |
| Reactor vessel centreline orientation | : - |
| Fuel material | : - |
| Refuelling type | : - |
| Moderator material | : - |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : - |
| Part of the core refuelled [%] | : - |
| Average discharge burnup [MWd/t] | : - |
| Active core diameter [m] | : - |
| Active core height/length [m] | : - |
| Number of fissile fuel assemblies/bundles | : - |
| Fuel linear heat generation rate [kW/m] | : - |
| Number of control rod assemblies | : - |
| Number of external reactor coolant loops | : - |
| Coolant type | : - |
| Operating coolant pressure [MPa] | : - |
| Reactor outlet temperature [°C] | : - |
| Number of SG | : - |
| Containment type | : - |
| Containment design pressure [MPa] | : - |
| Secondary systems | |
| Number of turbine-generators per unit/reactor | : - |
| Turbine speed [rpm] | : - |
| Number of LP cylinders per turbine | : - |
| HP cylinder inlet steam pressure [MPa] | : - |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : - |
| Number of main condensate pumps | : - |
| Number of FW pumps for full power operation | : - |
| Number of on-site safety related diesel generators | : - |
| Non-electrical applications | |
| | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 6950.52 GW(e).h | Forced Loss Rate (FLR) | : 3.35 % |
| Energy Availability Factor (EAF) | : 72.63 % | Unplanned Capability Loss Factor (UCL) | : 7.71 % |
| Unit Capability Factor (UCF) | : 75.62 % | Planned Unavailability Factor (PUF) | : 16.66 % |
| Load Factor (LF) | : 72.13 % | Externally cause unavailability (XUF) | : 2.99 % |
| Operating Factor (OF) | : 76.22 % | Total off-line time | : 2083 hours |

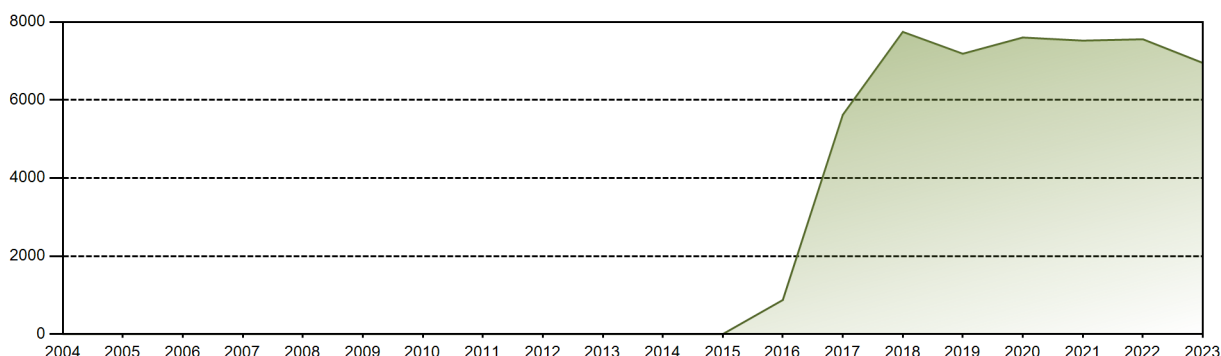


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|--------|---------|
| GW(e)-h | 694.30 | 746.36 | 801.40 | 782.09 | 798.20 | 766.82 | 677.83 | 652.11 | 744.22 | 2.04 | 46.52 | 238.63 | 6950.51 |
| EAF [%] | 85.30 | 100.00 | 97.96 | 98.89 | 97.56 | 96.77 | 83.92 | 81.09 | 94.44 | 0.25 | 7.92 | 30.39 | 72.63 |
| UCF [%] | 85.30 | 100.00 | 97.96 | 100.00 | 100.00 | 100.00 | 92.46 | 97.06 | 98.06 | 0.25 | 8.00 | 30.88 | 75.62 |
| LF [%] | 84.84 | 100.97 | 97.92 | 98.75 | 97.53 | 96.82 | 82.82 | 79.68 | 93.97 | 0.25 | 5.87 | 29.16 | 72.13 |
| OF [%] | 86.56 | 100.00 | 98.52 | 100.00 | 100.00 | 100.00 | 92.74 | 97.58 | 98.61 | 0.54 | 8.89 | 33.60 | 76.22 |
| FLR [%] | 14.70 | 0.00 | 2.04 | 0.00 | 0.00 | 0.00 | 7.54 | 2.94 | 1.94 | 0.00 | 0.00 | 5.52 | 3.35 |
| UCL [%] | 14.70 | 0.00 | 2.04 | 0.00 | 0.00 | 0.00 | 7.54 | 2.94 | 1.94 | 0.00 | 0.00 | 61.72 | 7.71 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 99.75 | 92.00 | 7.40 | 16.66 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 1.11 | 2.44 | 3.23 | 8.54 | 15.97 | 3.63 | 0.00 | 0.08 | 0.49 | 2.99 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 51061.15 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.2 % |
| Cumulative Energy Availability Factor (EAF) | : 76.21 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.25 % |
| Cumulative Unit Capability Factor (UCF) | : 78.39 % | Cumulative Planned Unavailability Factor (PUF) | : 14.35 % |
| Cumulative Load Factor (LF) | : 74.9 % | Cumulative Externally cause unavailability (XUF) | : 2.18 % |
| Cumulative Operating Factor (OF) | : 80.35 % | | |

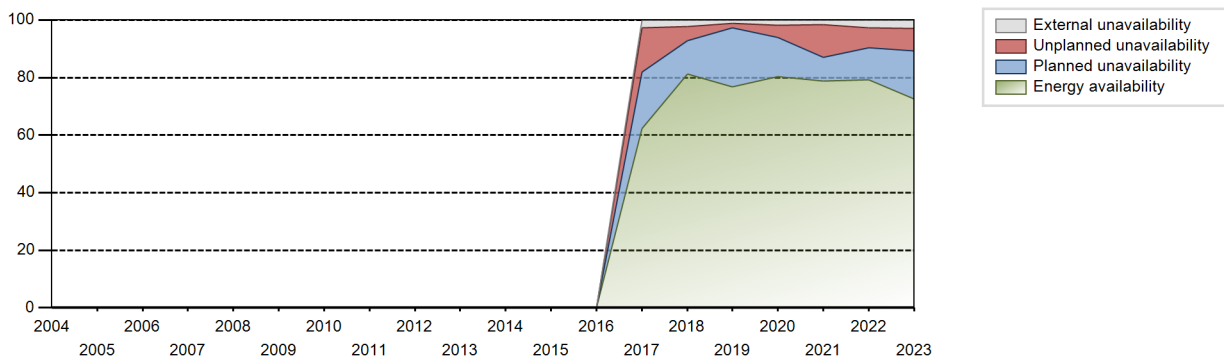
Electricity Production (net) [GWh]



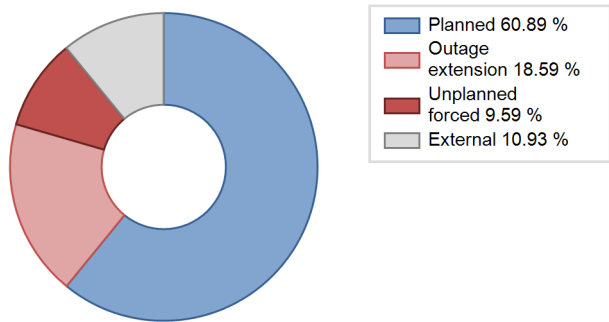
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2017 | 5620.47 | 6226 | 1114 | 62.35 | 65.08 | 60.87 | 75.08 | 19.08 | 15.34 | 19.58 | 2.73 |
| 2018 | 7746.87 | 7378 | 1114 | 81.34 | 83.60 | 79.38 | 84.22 | 5.56 | 4.92 | 11.47 | 2.27 |
| 2019 | 7186.30 | 6885 | 1100 | 76.74 | 77.97 | 74.58 | 78.60 | 1.81 | 1.44 | 20.59 | 1.22 |
| 2020 | 7602.46 | 7465 | 1100 | 80.29 | 82.00 | 78.68 | 84.98 | 3.44 | 4.32 | 13.67 | 1.71 |
| 2021 | 7523.13 | 6953 | 1100 | 78.81 | 80.41 | 78.07 | 79.37 | 4.37 | 11.39 | 8.19 | 1.60 |
| 2022 | 7558.04 | 7279 | 1100 | 79.16 | 81.98 | 78.44 | 83.09 | 7.76 | 6.89 | 11.13 | 2.81 |
| 2023 | 6950.52 | 6677 | 1100 | 72.63 | 75.62 | 72.13 | 76.22 | 3.35 | 7.71 | 16.66 | 2.99 |

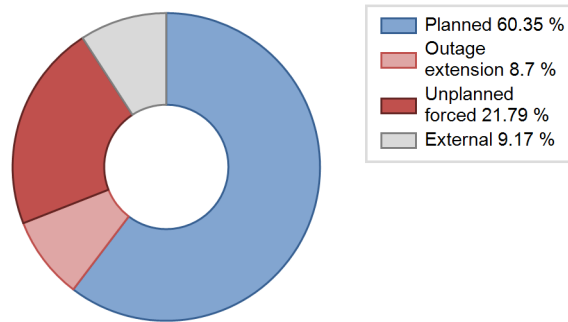
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2017 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 195 | | | 319 | |
| C. Inspection, maintenance or repair combined with refuelling | 1444 | | | 1247 | | |
| Z. Other | | 446 | | | 164 | |
| Subtotal | 1444 | 641 | | 1247 | 483 | |
| Total | | 2085 | | | 1730 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2017 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 14. Safety Systems | | | | 18 |
| 16. Steam generation systems | | | | 3 |
| 31. Turbine and auxiliaries | | | | 65 |
| 32. Feedwater and Main Steam System | | | | 56 |
| 33. Circulating Water System | | | | 31 |
| 41. Main Generator Systems | | | 195 | 139 |
| Total | | | 195 | 312 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-March. Additional electricity generation amounted to 12179 MWh. The unit was in the unit overhaul from 2023.10.01 to 2023.11.15. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-162

NOVOVORONEZH 2-2

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : AEM (Atomenergomash)

Reactor Unit Details

Reactor type and model : PWR / VVER V-392M
 Thermal power : 3200 MWth
 Gross electrical power : 1181 MWe
 Reference unit power (net) : 1101 MWe

Key Dates

Construction Date : 2009-07-12
 Grid Date : 2019-05-01
 Commercial Date : 2019-10-31
 Age at end of year : 4 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : -
 Fuel material : -
 Refuelling type : -
 Moderator material : -
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : -
 Active core diameter [m] : -
 Active core height/length [m] : -
 Number of fissile fuel assemblies/bundles : -
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : -
 Number of external reactor coolant loops : -
 Coolant type : -

Operating coolant pressure [MPa] : -
 Reactor outlet temperature [°C] : -
 Number of SG : -
 Containment type : -
 Containment design pressure [MPa] : -

Secondary systems

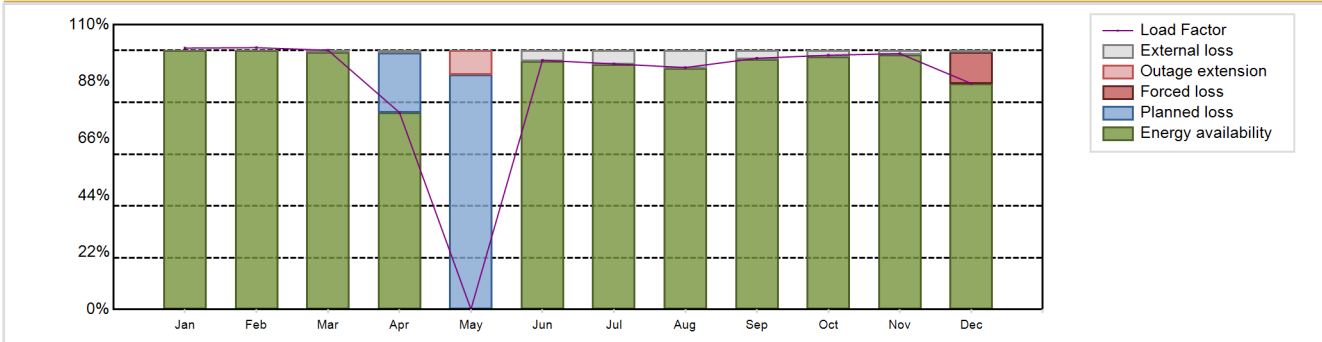
Number of turbine-generators per unit/reactor : -
 Turbine speed [rpm] : -
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : -
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8377.15 GW(e).h
 Energy Availability Factor (EAF) : 86.43 %
 Unit Capability Factor (UCF) : 88.59 %
 Load Factor (LF) : 86.86 %
 Operating Factor (OF) : 88.66 %
 Forced Loss Rate (FLR) : 1.15 %
 Unplanned Capability Loss Factor (UCL) : 1.82 %
 Planned Unavailability Factor (PUF) : 9.59 %
 Externally cause unavailability (XUF) : 2.17 %
 Total off-line time : 993 hours

Annual Summary

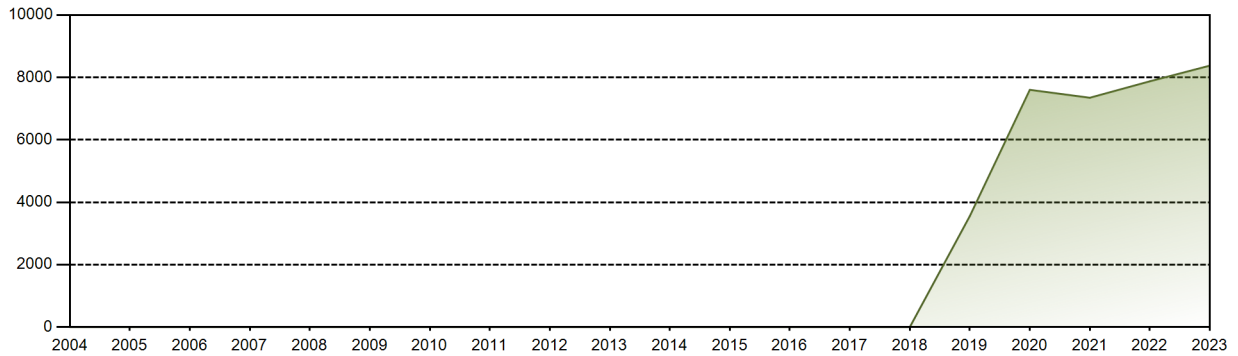


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 827.09 | 748.18 | 820.26 | 603.18 | 0.83 | 763.08 | 777.00 | 765.44 | 769.33 | 804.38 | 783.43 | 714.94 | 8377.15 |
| EAF [%] | 100.00 | 100.00 | 99.47 | 75.97 | 0.13 | 95.89 | 94.56 | 93.25 | 96.61 | 97.73 | 98.32 | 87.20 | 86.43 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 76.95 | 0.13 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.86 | 88.59 |
| LF [%] | 100.97 | 101.12 | 100.14 | 76.09 | 0.10 | 96.26 | 94.86 | 93.44 | 97.05 | 98.20 | 98.83 | 87.28 | 86.86 |
| OF [%] | 100.00 | 100.00 | 100.00 | 77.22 | 0.27 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.31 | 88.66 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.14 | 1.15 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 9.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.14 | 1.82 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 23.05 | 90.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.59 |
| XUF [%] | 0.00 | 0.00 | 0.53 | 0.98 | 0.00 | 4.11 | 5.44 | 6.75 | 3.39 | 2.27 | 1.68 | 0.67 | 2.17 |

Historical Summary

| | | | |
|---|-------------------|---|-----------|
| Lifetime energy generation | : 34760.4 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.97 % |
| Cumulative Energy Availability Factor (EAF) | : 81.73 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.3 % |
| Cumulative Unit Capability Factor (UCF) | : 83.88 % | Cumulative Planned Unavailability Factor (PUF) | : 12.82 % |
| Cumulative Load Factor (LF) | : 80.93 % | Cumulative Externally cause unavailability (XUF) | : 2.14 % |
| Cumulative Operating Factor (OF) | : 84.17 % | | |

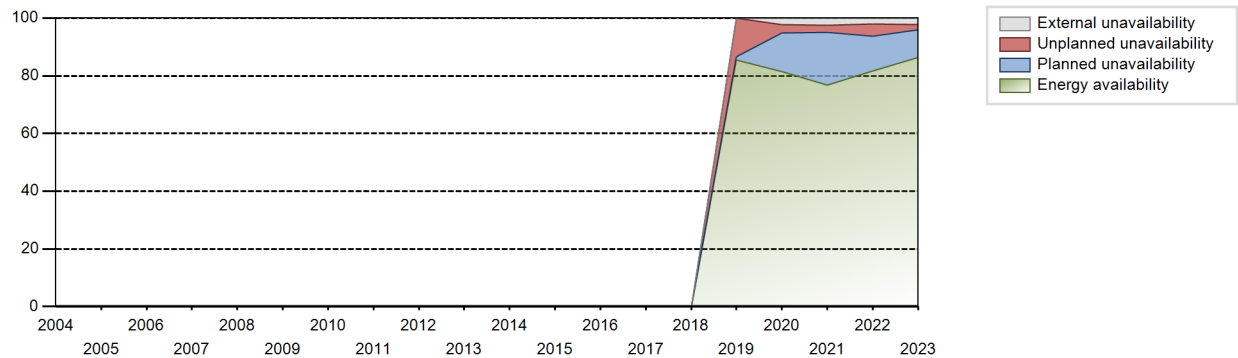
Electricity Production (net) [GWh]



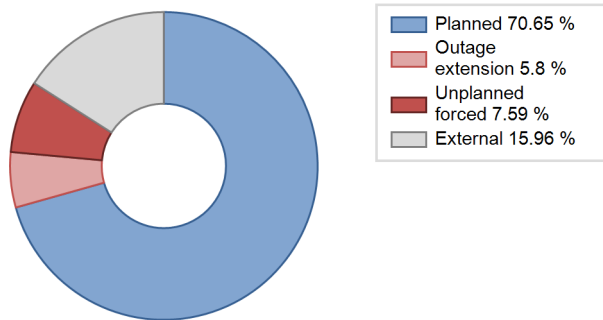
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2019 | 3557.06 | 4222 | 1101 | 85.48 | 85.48 | 83.47 | 88.25 | 13.57 | 13.43 | 1.09 | 0.00 |
| 2020 | 7602.61 | 7367 | 1101 | 81.50 | 83.68 | 78.61 | 83.87 | 3.46 | 3.00 | 13.32 | 2.18 |
| 2021 | 7348.32 | 6953 | 1101 | 76.69 | 79.28 | 76.19 | 79.37 | 0.15 | 2.40 | 18.33 | 2.59 |
| 2022 | 7875.32 | 7368 | 1101 | 81.69 | 83.70 | 81.65 | 84.11 | 4.89 | 4.30 | 12.00 | 2.01 |
| 2023 | 8377.15 | 7767 | 1101 | 86.43 | 88.59 | 86.86 | 88.66 | 1.15 | 1.82 | 9.59 | 2.17 |

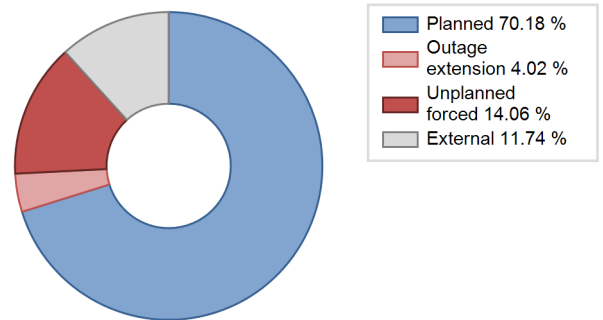
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2019 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 87 | | | 213 | |
| C. Inspection, maintenance or repair combined with refuelling | 837 | | | 1113 | | |
| L. Human factor related | | | | | 5 | |
| Z. Other | | 70 | | | 85 | |
| Subtotal | 837 | 157 | | 1113 | 303 | |
| Total | | 994 | | | 1416 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2019 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 8 |
| 15. Reactor Cooling Systems | | | | 44 |
| 31. Turbine and auxiliaries | | | | 38 |
| 32. Feedwater and Main Steam System | | | | 66 |
| 33. Circulating Water System | | | | 11 |
| 35. All other I&C Systems | | | | 7 |
| 41. Main Generator Systems | | 87 | | 19 |
| 42. Electrical Power Supply Systems | | | | 3 |
| Total | | 87 | | 196 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-February. Additional electricity generation amounted to 5099 MWh. The unit was in the intermediate maintenance outage from 2023.04.24 to 2023.05.29. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-11

NOVOVORONEZH-4

RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-179 | Construction Date | : 1967-07-01 |
| Thermal power | : 1375 MWth | Grid Date | : 1972-12-28 |
| Gross electrical power | : 417 MWe | Commercial Date | : 1973-03-24 |
| Reference unit power (net) | : 385 MWe | Age at end of year | : 51 years |

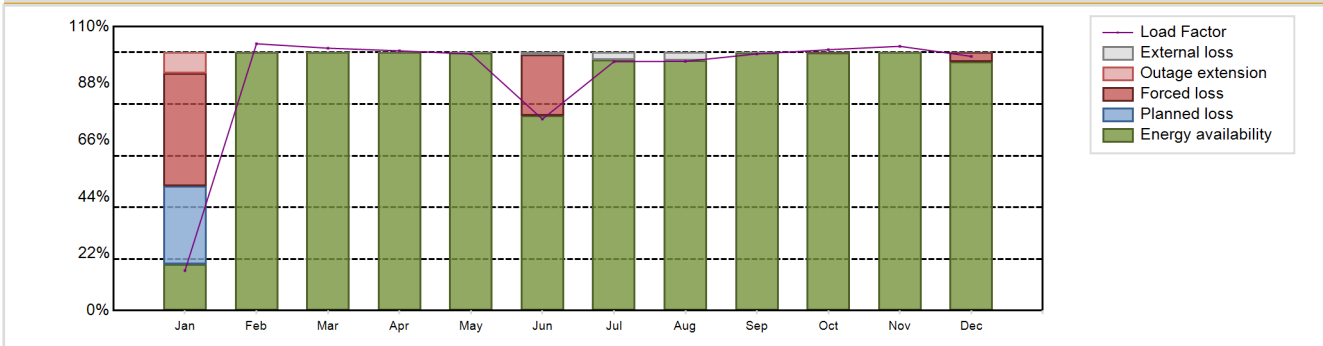
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|---------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 12.5 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 295.8 |
| Refuelling type | : OFF-line | Number of SG | : 6 |
| Moderator material | : H2O | Containment type | : Confinement |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : - |
| Refuelling frequency [month] | : 12 | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 2 |
| Average discharge burnup [MWd/t] | : 28600 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 2.88 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 2.5 | HP cylinder inlet steam pressure [MPa] | : 4.4 |
| Number of fissile fuel assemblies/bundles | : 349 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 13.1 | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : 73 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 6 | Number of FW pumps for full power operation | : 4 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : DH / PH |

Annual Production Results (2023)

| | | | |
|--|-------------------|--|-------------|
| Net Energy Production | : 3055.96 GW(e).h | Forced Loss Rate (FLR) | : 6.18 % |
| Energy Availability Factor (EAF) | : 90.16 % | Unplanned Capability Loss Factor (UCL) | : 6.67 % |
| Unit Capability Factor (UCF) | : 90.76 % | Planned Unavailability Factor (PUF) | : 2.57 % |
| Load Factor (LF) | : 90.61 % | Externally cause unavailability (XUF) | : 0.59 % |
| Operating Factor (OF) | : 91.34 % | Total off-line time | : 759 hours |
| Equivalent non-electrical energy generated (NEG) | : 73.07 GW(e).h | | |

Annual Summary

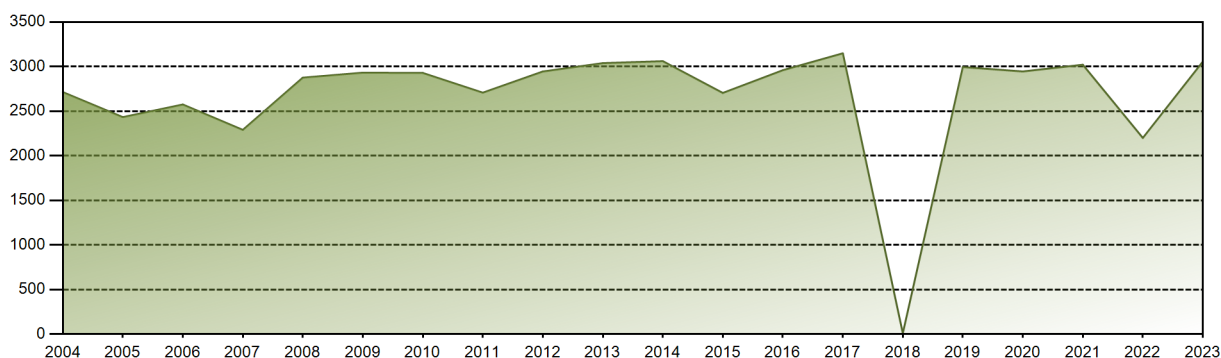


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 44.39 | 267.40 | 291.19 | 278.96 | 284.67 | 205.64 | 276.18 | 276.62 | 275.60 | 289.47 | 283.81 | 282.05 | 3055.96 |
| EAF [%] | 18.02 | 100.00 | 100.00 | 100.00 | 99.87 | 75.45 | 97.04 | 96.95 | 99.94 | 99.80 | 100.00 | 96.32 | 90.16 |
| UCF [%] | 18.02 | 100.00 | 100.00 | 100.00 | 100.00 | 76.26 | 100.00 | 100.00 | 100.00 | 99.80 | 100.00 | 96.32 | 90.76 |
| LF [%] | 15.50 | 103.35 | 101.66 | 100.63 | 99.38 | 74.18 | 96.42 | 96.57 | 99.42 | 101.06 | 102.38 | 98.47 | 90.61 |
| OF [%] | 23.12 | 100.00 | 100.00 | 100.00 | 100.00 | 74.03 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.34 |
| FLR [%] | 70.75 | 0.00 | 0.00 | 0.00 | 0.00 | 23.74 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 3.68 | 6.18 |
| UCL [%] | 51.72 | 0.00 | 0.00 | 0.00 | 0.00 | 23.74 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 3.68 | 6.67 |
| PUF [%] | 30.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.57 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.82 | 2.96 | 3.05 | 0.06 | 0.00 | 0.00 | 0.00 | 0.59 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 134400.54 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.35 % |
| Cumulative Energy Availability Factor (EAF) | : 78.16 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.7 % |
| Cumulative Unit Capability Factor (UCF) | : 79.46 % | Cumulative Planned Unavailability Factor (PUF) | : 16.84 % |
| Cumulative Load Factor (LF) | : 78.06 % | Cumulative Externally cause unavailability (XUF) | : 1.3 % |
| Cumulative Operating Factor (OF) | : 82.69 % | | |

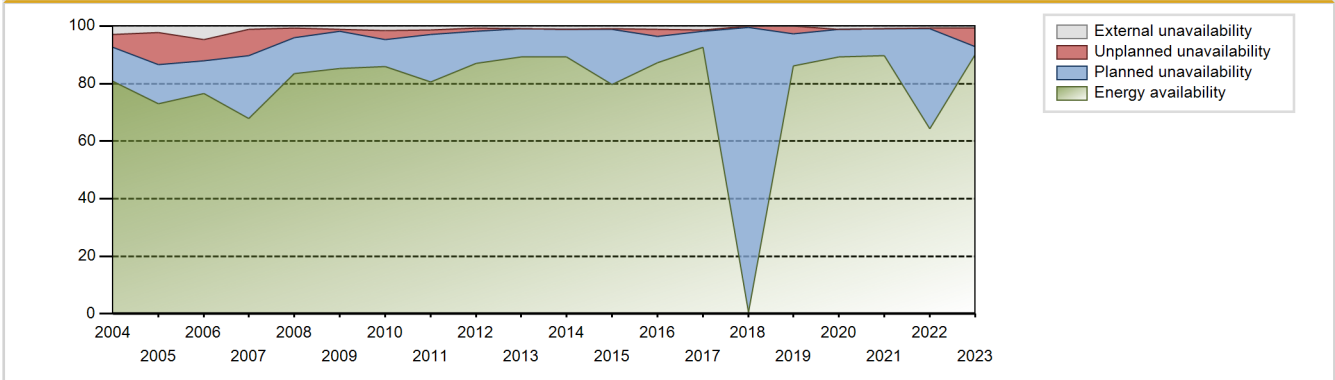
Electricity Production (net) [GWh]



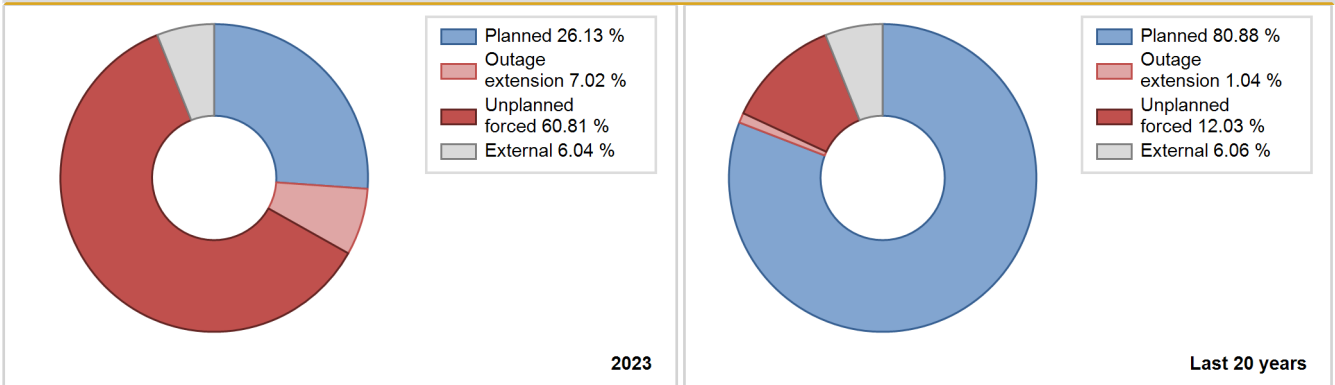
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1973 | 2570.51 | 8072 | 385 | 84.20 | 84.20 | 84.95 | 93.15 | 14.82 | 14.65 | 1.15 | 0.00 |
| 1974 | 2411.84 | 7159 | 385 | 71.28 | 71.28 | 71.51 | 81.72 | 15.90 | 13.48 | 15.24 | 0.00 |
| 1975 | 2644.87 | 7950 | 385 | 75.64 | 75.64 | 78.42 | 90.75 | 9.17 | 7.63 | 16.73 | 0.00 |
| 1976 | 2924.13 | 7963 | 385 | 84.48 | 84.48 | 86.47 | 90.65 | 4.63 | 4.10 | 11.42 | 0.00 |
| 1977 | 2822.95 | 7637 | 385 | 81.34 | 81.34 | 83.70 | 87.18 | 4.88 | 4.17 | 14.49 | 0.00 |
| 1978 | 2658.54 | 7388 | 385 | 78.18 | 78.18 | 78.83 | 84.34 | 3.70 | 3.00 | 18.82 | 0.00 |
| 1979 | 2442.24 | 6888 | 385 | 72.44 | 72.44 | 72.41 | 78.63 | 8.70 | 6.90 | 20.66 | 0.00 |
| 1980 | 2842.93 | 7690 | 385 | 84.08 | 84.08 | 84.06 | 87.55 | 3.15 | 2.74 | 13.18 | 0.00 |
| 1981 | 3019.87 | 8278 | 385 | 90.03 | 90.03 | 89.55 | 94.51 | 4.32 | 4.06 | 5.91 | 0.00 |
| 1982 | 2797.51 | 8278 | 385 | 83.88 | 83.88 | 82.95 | 94.50 | 9.47 | 8.78 | 7.35 | 0.00 |
| 1983 | 2950.30 | 8216 | 385 | 89.15 | 89.15 | 87.48 | 93.79 | 3.80 | 3.52 | 7.33 | 0.00 |
| 1984 | 2974.10 | 7982 | 385 | 87.89 | 87.89 | 87.94 | 90.87 | 3.16 | 2.87 | 9.24 | 0.00 |
| 1985 | 3097.87 | 8250 | 385 | 91.30 | 91.30 | 91.85 | 94.18 | 2.71 | 2.54 | 6.16 | 0.00 |
| 1986 | 2792.21 | 7688 | 385 | 82.62 | 82.62 | 82.79 | 87.76 | 5.57 | 4.88 | 12.51 | 0.00 |
| 1987 | 3262.68 | 8252 | 417 | 91.72 | 91.72 | 89.32 | 94.20 | 0.15 | 0.14 | 8.14 | 0.00 |
| 1988 | 2529.37 | 7152 | 385 | 79.97 | 79.97 | 74.79 | 81.42 | 1.21 | 0.98 | 19.05 | 0.00 |
| 1989 | 2710.26 | 8357 | 385 | 90.16 | 90.19 | 80.36 | 95.40 | 5.71 | 5.46 | 4.35 | 0.04 |
| 1990 | 2244.69 | 6622 | 385 | 69.63 | 70.55 | 66.56 | 75.59 | 11.28 | 8.97 | 20.48 | 0.92 |
| 1991 | 1827.62 | 5540 | 385 | 57.96 | 58.24 | 54.19 | 63.24 | 9.28 | 5.96 | 35.80 | 0.28 |
| 1992 | 2853.44 | 8163 | 385 | 82.38 | 87.35 | 84.38 | 92.94 | 6.01 | 5.58 | 7.07 | 4.97 |
| 1993 | 2613.71 | 7204 | 385 | 76.60 | 79.73 | 77.50 | 82.24 | 2.64 | 2.16 | 18.11 | 3.13 |
| 1994 | 1954.27 | 6033 | 385 | 56.65 | 66.91 | 57.95 | 68.87 | 2.79 | 1.92 | 31.17 | 10.26 |
| 1995 | 2119.99 | 5818 | 385 | 62.15 | 65.50 | 62.86 | 66.42 | 0.64 | 0.42 | 34.08 | 3.35 |
| 1996 | 3080.28 | 8362 | 385 | 90.38 | 93.78 | 91.08 | 95.20 | 1.08 | 1.02 | 5.20 | 3.40 |
| 1997 | 2235.48 | 6690 | 385 | 66.98 | 70.29 | 66.28 | 76.37 | 0.76 | 0.54 | 29.17 | 3.30 |
| 1998 | 2714.87 | 7366 | 385 | 80.18 | 83.16 | 80.50 | 84.09 | 0.98 | 0.82 | 16.02 | 2.98 |
| 1999 | 1791.48 | 4927 | 385 | 53.21 | 54.93 | 53.12 | 56.24 | 17.55 | 11.69 | 33.38 | 1.72 |
| 2000 | 2474.25 | 6784 | 385 | 73.08 | 74.64 | 73.16 | 77.23 | 3.12 | 2.40 | 22.96 | 1.56 |
| 2001 | 2655.95 | 7173 | 385 | 79.22 | 80.72 | 78.75 | 81.88 | 1.24 | 1.01 | 18.26 | 1.51 |
| 2002 | 2184.85 | 5857 | 385 | 64.21 | 65.37 | 64.78 | 66.86 | 4.51 | 3.09 | 31.55 | 1.15 |
| 2003 | 2583.05 | 6950 | 385 | 76.75 | 78.78 | 76.59 | 79.34 | 1.32 | 1.05 | 20.17 | 2.02 |
| 2004 | 2714.01 | 7685 | 385 | 80.75 | 83.75 | 80.25 | 87.49 | 4.90 | 4.32 | 11.94 | 2.99 |
| 2005 | 2433.38 | 7228 | 385 | 73.09 | 75.27 | 72.15 | 82.51 | 12.96 | 11.20 | 13.53 | 2.18 |
| 2006 | 2575.08 | 7636 | 385 | 76.49 | 81.29 | 76.35 | 87.17 | 8.30 | 7.36 | 11.36 | 4.79 |
| 2007 | 2290.27 | 6488 | 385 | 67.88 | 69.12 | 67.91 | 74.06 | 8.19 | 9.08 | 21.80 | 1.24 |
| 2008 | 2876.30 | 7464 | 385 | 83.37 | 84.02 | 85.05 | 84.97 | 3.95 | 3.45 | 12.53 | 0.65 |
| 2009 | 2931.78 | 7580 | 385 | 85.23 | 86.31 | 86.93 | 86.53 | 0.01 | 0.78 | 12.91 | 1.08 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|------|-------|------|
| 2010 | 2928.70 | 7727 | 385 | 85.82 | 87.48 | 86.84 | 88.21 | 3.36 | 3.04 | 9.48 | 1.66 |
| 2011 | 2707.55 | 7263 | 385 | 80.64 | 82.08 | 80.29 | 82.92 | 1.69 | 1.41 | 16.51 | 1.44 |
| 2012 | 2944.86 | 7707 | 385 | 87.14 | 87.87 | 87.08 | 87.74 | 1.22 | 1.09 | 11.04 | 0.73 |
| 2013 | 3038.98 | 7929 | 385 | 89.36 | 90.36 | 90.11 | 90.51 | 0.01 | 0.01 | 9.63 | 1.00 |
| 2014 | 3061.07 | 7932 | 385 | 89.26 | 90.33 | 90.75 | 90.54 | 0.12 | 0.11 | 9.56 | 1.07 |
| 2015 | 2704.38 | 7085 | 385 | 79.59 | 80.43 | 80.19 | 80.88 | 0.45 | 0.36 | 19.21 | 0.83 |
| 2016 | 2959.49 | 7783 | 385 | 87.26 | 88.31 | 87.51 | 88.60 | 2.91 | 2.65 | 9.04 | 1.05 |
| 2017 | 3148.86 | 8259 | 385 | 92.54 | 93.92 | 93.37 | 94.28 | 0.37 | 0.35 | 5.73 | 1.38 |
| 2018 | 8.92 | 73 | 385 | 0.43 | 0.43 | 0.26 | 0.83 | 47.79 | 0.39 | 99.18 | 0.00 |
| 2019 | 2994.94 | 7654 | 385 | 86.23 | 86.33 | 88.80 | 87.37 | 3.00 | 2.67 | 11.01 | 0.09 |
| 2020 | 2945.24 | 7956 | 385 | 89.27 | 90.40 | 87.09 | 90.57 | 0.00 | 0.00 | 9.60 | 1.13 |
| 2021 | 3020.99 | 7951 | 385 | 89.69 | 90.51 | 89.57 | 90.76 | 0.03 | 0.02 | 9.46 | 0.82 |
| 2022 | 2199.85 | 5716 | 385 | 64.37 | 65.15 | 65.23 | 65.25 | 0.13 | 0.09 | 34.76 | 0.78 |
| 2023 | 3055.96 | 8001 | 385 | 90.16 | 90.76 | 90.61 | 91.34 | 6.18 | 6.67 | 2.57 | 0.59 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1973 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 553 | | | 76 | |
| C. Inspection, maintenance or repair combined with refuelling | 186 | | | 1243 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 87 | | |
| E. Testing of plant systems or components | | | | 11 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 53 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 8 |
| L. Human factor related | | | | | 2 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 8 | |
| Z. Other | | | | 2 | 13 | |
| Subtotal | 186 | 553 | | 1396 | 99 | 8 |
| Total | | 739 | | | 1503 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1973 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 7 |
| 12. Reactor I&C Systems | | 13 |
| 13. Reactor Auxiliary Systems | | 2 |
| 15. Reactor Cooling Systems | | 4 |
| 16. Steam generation systems | 530 | 41 |
| 31. Turbine and auxiliaries | 23 | 2 |
| 32. Feedwater and Main Steam System | | 9 |
| 34. Miscellaneous Systems | | 0 |
| 35. All other I&C Systems | | 1 |
| 42. Electrical Power Supply Systems | | 0 |
| Total | 553 | 79 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-April, October-December. Additional electricity generation amounted to 39248 MWh. The unit was in the unit overhaul from 2023.01.01 to 2023.01.08. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

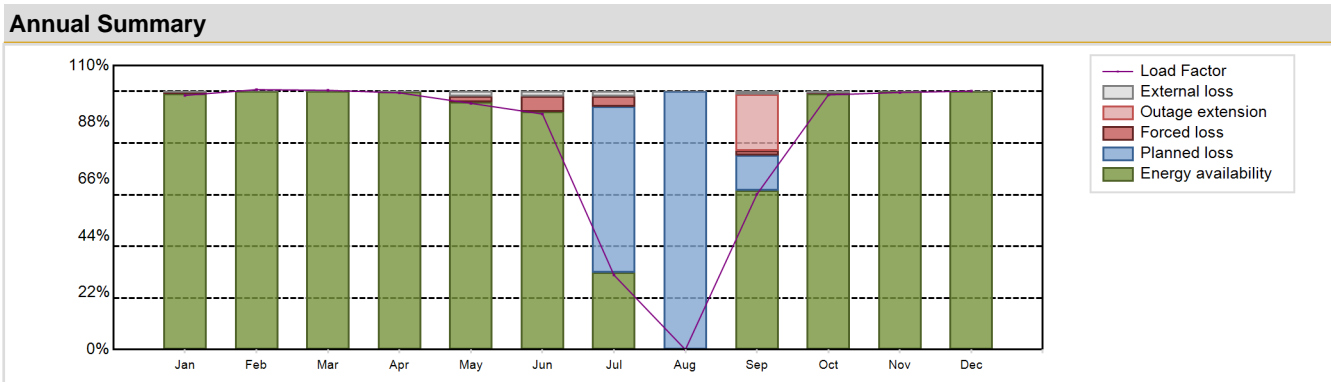
RU-20 **NOVOVORONEZH-5** **RUSSIA**

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-187 | Construction Date | : 1974-03-01 |
| Thermal power | : 3000 MWth | Grid Date | : 1980-05-31 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1981-02-20 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 43 years |

| Design Characteristics | | | |
|---|------------|--|-----------|
| Primary Systems | | Operating coolant pressure [MPa] | : 16 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 324 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : - | Number of turbine-generators per unit/reactor | : 2 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : - |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6.5 |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : - |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 109 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : DH / PH |

| Annual Production Results (2023) | | | |
|--|-------------------|--|--------------|
| Net Energy Production | : 6729.72 GW(e).h | Forced Loss Rate (FLR) | : 1.44 % |
| Energy Availability Factor (EAF) | : 81.27 % | Unplanned Capability Loss Factor (UCL) | : 2.99 % |
| Unit Capability Factor (UCF) | : 81.94 % | Planned Unavailability Factor (PUF) | : 15.07 % |
| Load Factor (LF) | : 80.87 % | Externally cause unavailability (XUF) | : 0.67 % |
| Operating Factor (OF) | : 83.71 % | Total off-line time | : 1427 hours |
| Equivalent non-electrical energy generated (NEG) | : 0 GW(e).h | | |

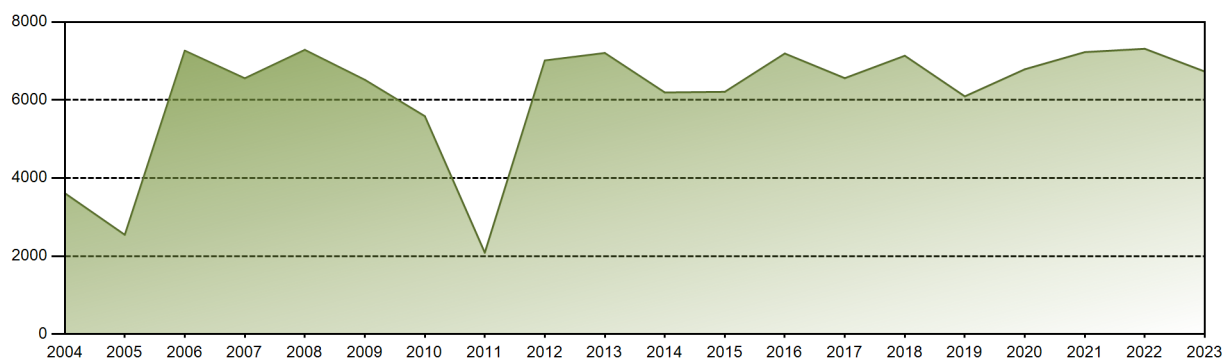


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 695.91 | 642.88 | 709.92 | 680.25 | 674.22 | 624.25 | 204.35 | 0.00 | 411.56 | 697.35 | 681.36 | 707.68 | 6729.73 |
| EAF [%] | 99.16 | 100.00 | 100.00 | 99.94 | 95.98 | 92.10 | 29.99 | 0.00 | 61.66 | 99.12 | 100.00 | 100.00 | 81.27 |
| UCF [%] | 99.60 | 100.00 | 100.00 | 100.00 | 97.79 | 94.08 | 31.92 | 0.00 | 62.90 | 99.71 | 100.00 | 100.00 | 81.94 |
| LF [%] | 98.46 | 100.70 | 100.44 | 99.45 | 95.39 | 91.27 | 28.91 | 0.00 | 60.17 | 98.66 | 99.61 | 100.12 | 80.87 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 36.29 | 0.00 | 70.97 | 100.00 | 100.00 | 100.00 | 83.71 |
| FLR [%] | 0.40 | 0.00 | 0.00 | 0.00 | 2.21 | 5.92 | 10.80 | 0.00 | 2.51 | 0.29 | 0.00 | 0.00 | 1.44 |
| UCL [%] | 0.40 | 0.00 | 0.00 | 0.00 | 2.21 | 5.92 | 3.87 | 0.00 | 23.45 | 0.29 | 0.00 | 0.00 | 2.99 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 64.21 | 100.00 | 13.65 | 0.00 | 0.00 | 0.00 | 15.07 |
| XUF [%] | 0.45 | 0.00 | 0.00 | 0.06 | 1.81 | 1.97 | 1.93 | 0.00 | 1.24 | 0.59 | 0.00 | 0.00 | 0.67 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 235853.65 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 11.18 % |
| Cumulative Energy Availability Factor (EAF) | : 67.81 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 10.58 % |
| Cumulative Unit Capability Factor (UCF) | : 68.63 % | Cumulative Planned Unavailability Factor (PUF) | : 20.79 % |
| Cumulative Load Factor (LF) | : 67.58 % | Cumulative Externally cause unavailability (XUF) | : 0.82 % |
| Cumulative Operating Factor (OF) | : 74.44 % | | |

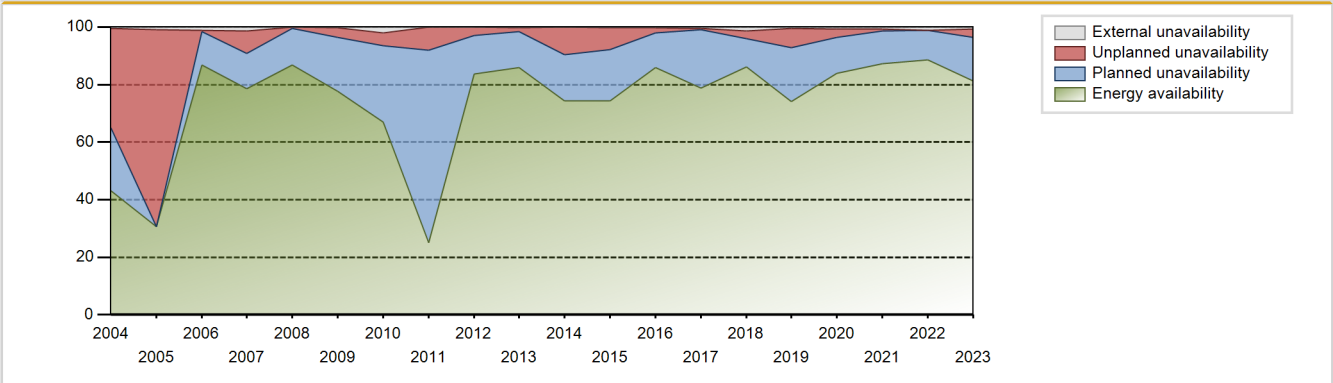
Electricity Production (net) [GWh]



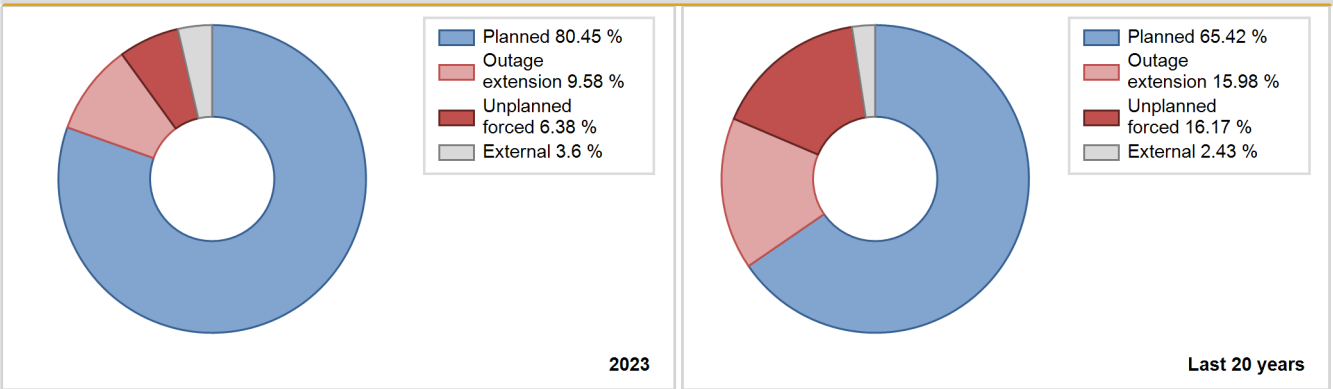
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 4639.79 | 6929 | 950 | 56.62 | 56.62 | 56.10 | 77.77 | 28.48 | 22.54 | 20.83 | 0.00 |
| 1982 | 5042.84 | 6631 | 950 | 60.89 | 60.89 | 60.60 | 75.70 | 25.30 | 20.62 | 18.49 | 0.00 |
| 1983 | 6607.53 | 7716 | 950 | 79.53 | 79.53 | 79.40 | 88.08 | 7.92 | 6.84 | 13.64 | 0.00 |
| 1984 | 6979.64 | 7742 | 950 | 83.42 | 83.42 | 83.64 | 88.14 | 5.18 | 4.56 | 12.02 | 0.00 |
| 1985 | 6894.29 | 7979 | 950 | 83.12 | 83.12 | 82.84 | 91.08 | 8.96 | 8.18 | 8.69 | 0.00 |
| 1986 | 5523.75 | 6806 | 950 | 65.91 | 65.96 | 66.38 | 77.69 | 17.36 | 13.86 | 20.18 | 0.04 |
| 1987 | 7052.70 | 7399 | 1000 | 81.79 | 81.79 | 80.51 | 84.46 | 2.68 | 2.26 | 15.96 | 0.00 |
| 1988 | 3017.85 | 3439 | 950 | 36.51 | 36.51 | 36.16 | 39.15 | 59.88 | 54.50 | 8.98 | 0.00 |
| 1989 | 3308.95 | 3778 | 950 | 40.88 | 40.88 | 39.76 | 43.13 | 25.41 | 13.93 | 45.19 | 0.00 |
| 1990 | 3913.28 | 4715 | 950 | 47.63 | 47.72 | 47.02 | 53.82 | 15.35 | 8.66 | 43.62 | 0.09 |
| 1991 | 5878.22 | 6996 | 950 | 71.54 | 71.54 | 70.63 | 79.86 | 19.86 | 17.72 | 10.74 | 0.00 |
| 1992 | 3752.83 | 5244 | 950 | 45.70 | 45.89 | 44.98 | 59.71 | 8.71 | 4.38 | 49.73 | 0.20 |
| 1993 | 5935.41 | 7448 | 950 | 72.55 | 73.79 | 71.32 | 85.02 | 10.42 | 8.59 | 17.62 | 1.24 |
| 1994 | 2281.89 | 4288 | 950 | 28.94 | 33.19 | 27.42 | 48.95 | 50.98 | 34.51 | 32.29 | 4.26 |
| 1995 | 4753.72 | 6670 | 950 | 57.46 | 63.87 | 57.12 | 76.14 | 14.52 | 10.85 | 25.28 | 6.41 |
| 1996 | 3861.84 | 4759 | 950 | 46.71 | 46.71 | 46.28 | 54.18 | 15.10 | 8.31 | 44.98 | 0.00 |
| 1997 | 5949.25 | 6854 | 950 | 71.37 | 71.69 | 71.49 | 78.24 | 7.84 | 6.10 | 22.21 | 0.33 |
| 1998 | 3771.78 | 4457 | 950 | 44.89 | 45.48 | 45.32 | 50.88 | 28.35 | 17.99 | 36.52 | 0.60 |
| 1999 | 4845.42 | 6062 | 950 | 58.73 | 61.16 | 58.22 | 69.20 | 17.37 | 12.86 | 25.99 | 2.43 |
| 2000 | 5278.64 | 6479 | 950 | 63.54 | 65.56 | 63.26 | 73.76 | 7.30 | 5.17 | 29.27 | 2.02 |
| 2001 | 5984.59 | 7508 | 950 | 72.26 | 73.22 | 71.91 | 85.71 | 6.60 | 5.17 | 21.61 | 0.96 |
| 2002 | 6762.21 | 7430 | 950 | 80.68 | 83.14 | 81.26 | 84.82 | 1.95 | 1.65 | 15.21 | 2.45 |
| 2003 | 6951.21 | 7507 | 950 | 83.05 | 84.51 | 83.53 | 85.70 | 0.93 | 0.79 | 14.70 | 1.46 |
| 2004 | 3610.61 | 4032 | 950 | 43.13 | 43.61 | 43.27 | 45.90 | 44.15 | 34.48 | 21.91 | 0.48 |
| 2005 | 2544.26 | 2861 | 950 | 30.60 | 31.42 | 30.57 | 32.66 | 0.00 | 68.58 | 0.00 | 0.82 |
| 2006 | 7264.41 | 7762 | 950 | 86.70 | 87.75 | 87.29 | 88.61 | 0.61 | 0.54 | 11.71 | 1.05 |
| 2007 | 6556.27 | 7140 | 950 | 78.48 | 79.84 | 78.78 | 81.51 | 7.10 | 7.85 | 12.31 | 1.36 |
| 2008 | 7285.18 | 7718 | 950 | 86.89 | 87.00 | 87.30 | 87.86 | 0.51 | 0.44 | 12.56 | 0.11 |
| 2009 | 6518.11 | 6865 | 950 | 77.59 | 77.86 | 78.32 | 78.37 | 4.04 | 3.28 | 18.86 | 0.27 |
| 2010 | 5585.30 | 6404 | 950 | 66.98 | 69.12 | 67.11 | 73.11 | 5.83 | 4.28 | 26.61 | 2.13 |
| 2011 | 2085.77 | 2422 | 950 | 25.11 | 25.11 | 25.07 | 27.65 | 7.01 | 7.99 | 66.90 | 0.00 |
| 2012 | 7014.58 | 7457 | 950 | 83.60 | 83.72 | 84.06 | 84.89 | 1.80 | 2.89 | 13.38 | 0.13 |
| 2013 | 7205.36 | 7773 | 950 | 85.97 | 86.24 | 86.58 | 88.73 | 1.20 | 1.23 | 12.54 | 0.27 |
| 2014 | 6193.58 | 7712 | 950 | 74.39 | 74.40 | 74.42 | 88.03 | 11.44 | 9.61 | 15.99 | 0.01 |
| 2015 | 6209.76 | 7120 | 950 | 74.34 | 74.50 | 74.62 | 81.28 | 8.43 | 7.73 | 17.77 | 0.16 |
| 2016 | 7191.83 | 7777 | 950 | 85.94 | 86.18 | 86.18 | 88.54 | 1.73 | 1.85 | 11.97 | 0.24 |
| 2017 | 6560.03 | 7811 | 950 | 78.87 | 79.36 | 78.83 | 89.17 | 0.60 | 0.48 | 20.16 | 0.49 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2018 | 7134.80 | 7766 | 950 | 86.22 | 87.70 | 85.73 | 88.65 | 0.99 | 2.46 | 9.84 | 1.48 |
| 2019 | 6092.49 | 6806 | 950 | 74.19 | 74.67 | 73.21 | 77.69 | 8.33 | 6.79 | 18.54 | 0.49 |
| 2020 | 6787.87 | 7483 | 950 | 83.89 | 84.60 | 81.34 | 85.19 | 2.96 | 2.84 | 12.56 | 0.71 |
| 2021 | 7227.84 | 7774 | 950 | 87.16 | 87.84 | 86.85 | 88.74 | 0.45 | 0.77 | 11.40 | 0.68 |
| 2022 | 7312.92 | 7908 | 950 | 88.52 | 89.62 | 87.87 | 90.27 | 0.16 | 0.14 | 10.24 | 1.10 |
| 2023 | 6729.73 | 7333 | 950 | 81.27 | 81.94 | 80.87 | 83.71 | 1.44 | 2.99 | 15.07 | 0.67 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 22 | | | 583 | |
| C. Inspection, maintenance or repair combined with refuelling | 1314 | | | 1420 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 287 | | |
| L. Human factor related | | | | | 2 | |
| Z. Other | | 91 | | | 12 | |
| Subtotal | 1314 | 113 | | 1707 | 597 | |
| Total | | 1427 | | | 2304 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 224 |
| 12. Reactor I&C Systems | | 18 |
| 13. Reactor Auxiliary Systems | | 5 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 48 |
| 16. Steam generation systems | | 203 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | 113 | 15 |
| 32. Feedwater and Main Steam System | | 6 |
| 34. Miscellaneous Systems | | 6 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 46 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | 113 | 583 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. The unit was in the overhaul from 2023.07.12 to 2023.09.05. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

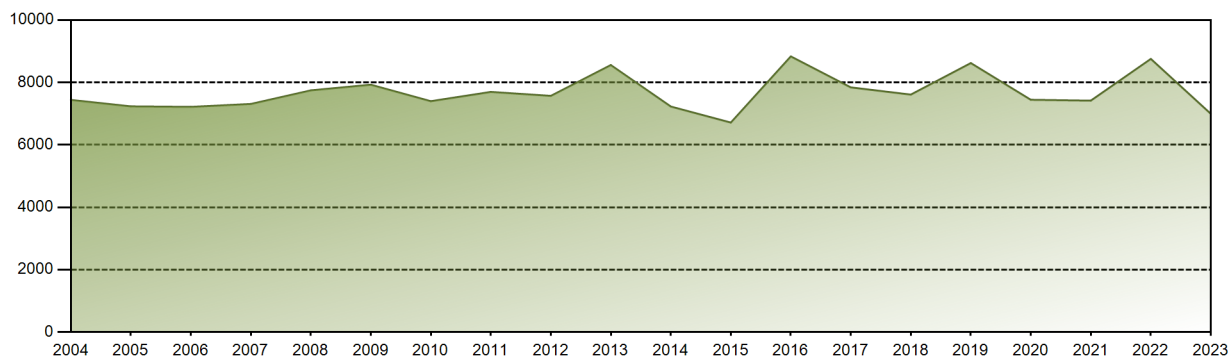
2023 Operating Experience

| RU-59 | | ROSTOV-1 | | RUSSIA | | | | | | | | | |
|---|---|----------|--|--------------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : REA (Joint Stock Company 'Concern Rosenergoatom') | | | | | | | | | | | | |
| Owner | : REA (Joint Stock Company 'Concern Rosenergoatom') | | | | | | | | | | | | |
| Reactor Supplier | : AEM (Atomenergomash) | | | | | | | | | | | | |
| Turbine Supplier | : KTF (Kharkiv Turbine Factory) | | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | | |
| Reactor type and model | : PWR / VVER V-320 | | Construction Date | : 1981-09-01 | | | | | | | | | |
| Thermal power | : 3200 MWth | | Grid Date | : 2001-03-30 | | | | | | | | | |
| Gross electrical power | : 1041 MWe | | Commercial Date | : 2001-12-25 | | | | | | | | | |
| Reference unit power (net) | : 989 MWe | | Age at end of year | : 22 years | | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | Operating coolant pressure [MPa] | | | | | | | | | | |
| Reactor vessel centreline orientation | : Vertical | | Reactor outlet temperature [°C] | : 322 | | | | | | | | | |
| Fuel material | : UO2 | | Number of SG | : 4 | | | | | | | | | |
| Refuelling type | : OFF-line | | Containment type | : Single | | | | | | | | | |
| Moderator material | : H2O | | Containment design pressure [MPa] | : 5 | | | | | | | | | |
| Average fuel enrichment [% of U235] | : - | | Secondary systems | | | | | | | | | | |
| Refuelling frequency [month] | : 12 | | Number of turbine-generators per unit/reactor | : 1 | | | | | | | | | |
| Part of the core refuelled [%] | : 30 | | Turbine speed [rpm] | : 1500 | | | | | | | | | |
| Average discharge burnup [MWd/t] | : 40000 | | Number of LP cylinders per turbine | : - | | | | | | | | | |
| Active core diameter [m] | : 3.16 | | HP cylinder inlet steam pressure [MPa] | : 6 | | | | | | | | | |
| Active core height/length [m] | : 3.53 | | Output voltage [kV] | : - | | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : 163 | | Primary means of condenser cooling | : - | | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : - | | Number of main condensate pumps | : - | | | | | | | | | |
| Number of control rod assemblies | : 61 | | Number of FW pumps for full power operation | : 2 | | | | | | | | | |
| Number of external reactor coolant loops | : 4 | | Number of on-site safety related diesel generators | : 3 | | | | | | | | | |
| Coolant type | : H2O | | Non-electrical applications | : none | | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : 6993.42 GW(e).h | | Forced Loss Rate (FLR) | : 0.39 % | | | | | | | | | |
| Energy Availability Factor (EAF) | : 79.28 % | | Unplanned Capability Loss Factor (UCL) | : 1.52 % | | | | | | | | | |
| Unit Capability Factor (UCF) | : 79.95 % | | Planned Unavailability Factor (PUF) | : 18.53 % | | | | | | | | | |
| Load Factor (LF) | : 80.72 % | | Externally cause unavailability (XUF) | : 0.67 % | | | | | | | | | |
| Operating Factor (OF) | : 80.03 % | | Total off-line time | : 1749 hours | | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 765.57 | 690.00 | 459.70 | 0.00 | 0.00 | 652.26 | 729.23 | 723.02 | 713.39 | 759.12 | 740.56 | 760.56 | 6993.42 |
| EAF [%] | 100.00 | 100.00 | 63.14 | 1.10 | 1.10 | 91.42 | 98.91 | 98.49 | 98.82 | 100.00 | 100.00 | 99.52 | 79.28 |
| UCF [%] | 100.00 | 100.00 | 68.28 | 1.10 | 1.10 | 91.57 | 100.00 | 100.00 | 98.85 | 100.00 | 100.00 | 99.52 | 79.95 |
| LF [%] | 104.04 | 103.82 | 62.48 | 0.00 | 0.00 | 91.60 | 99.11 | 98.26 | 100.18 | 103.17 | 104.00 | 103.36 | 80.72 |
| OF [%] | 100.00 | 100.00 | 68.28 | 0.00 | 0.00 | 93.19 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 80.03 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.28 | 0.00 | 0.00 | 1.15 | 0.00 | 0.00 | 0.48 | 0.39 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 9.57 | 7.01 | 0.00 | 0.00 | 1.15 | 0.00 | 0.00 | 0.48 | 1.52 |
| PUF [%] | 0.00 | 0.00 | 31.72 | 98.90 | 89.33 | 1.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.53 |
| XUF [%] | 0.00 | 0.00 | 5.15 | 0.00 | 0.00 | 0.15 | 1.09 | 1.51 | 0.04 | 0.00 | 0.00 | 0.00 | 0.67 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 171664.95 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.09 % |
| Cumulative Energy Availability Factor (EAF) | : 88.04 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.26 % |
| Cumulative Unit Capability Factor (UCF) | : 88.42 % | Cumulative Planned Unavailability Factor (PUF) | : 10.33 % |
| Cumulative Load Factor (LF) | : 91.03 % | Cumulative Externally cause unavailability (XUF) | : 0.38 % |
| Cumulative Operating Factor (OF) | : 88.71 % | | |

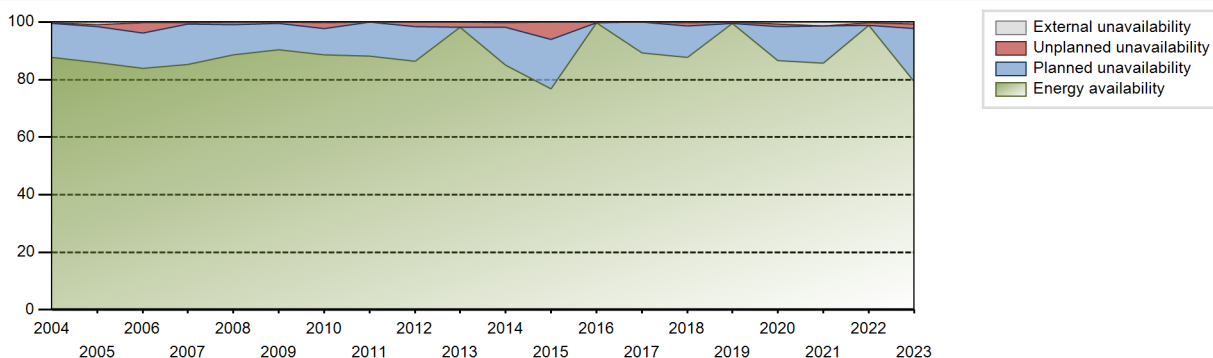
Electricity Production (net) [GWh]



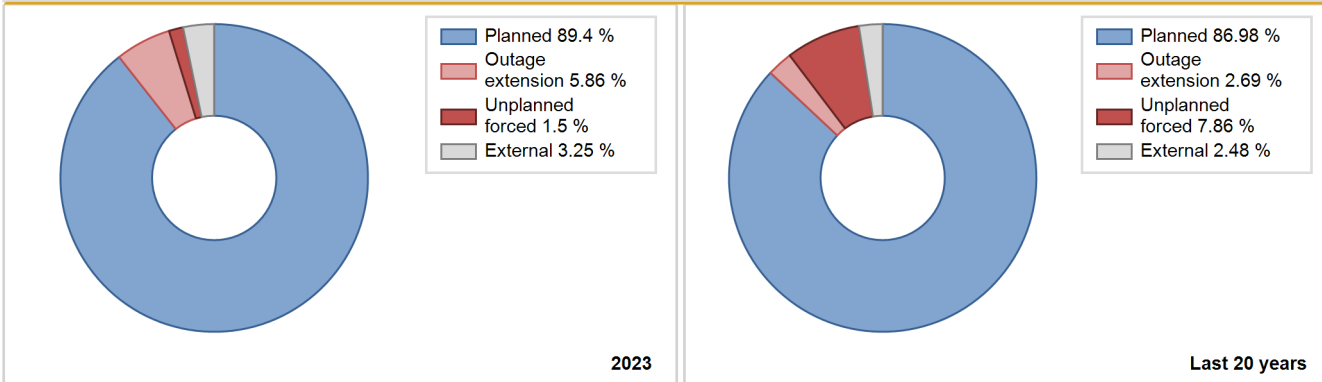
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|-------------------|------------------------|------------------------------|-------|-------|--------|-------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2001 | Data not provided | | | | | | | | | | |
| 2002 | 7176.18 | 7543 | 950 | 84.06 | 85.51 | 86.23 | 86.11 | 1.33 | 1.16 | 13.33 | 1.45 |
| 2003 | 6973.93 | 7154 | 950 | 81.33 | 82.56 | 83.80 | 81.67 | 2.81 | 2.39 | 15.05 | 1.23 |
| 2004 | 7439.31 | 7766 | 950 | 87.75 | 87.96 | 89.15 | 88.41 | 0.19 | 0.17 | 11.87 | 0.21 |
| 2005 | 7232.86 | 7628 | 950 | 85.85 | 86.87 | 86.90 | 87.07 | 0.60 | 0.52 | 12.60 | 1.02 |
| 2006 | 7216.42 | 7386 | 950 | 83.82 | 84.19 | 86.71 | 84.32 | 0.29 | 3.46 | 12.35 | 0.38 |
| 2007 | 7309.44 | 7536 | 950 | 85.28 | 85.48 | 87.83 | 86.03 | 0.55 | 0.47 | 14.04 | 0.20 |
| 2008 | 7745.73 | 7799 | 950 | 88.53 | 88.56 | 92.82 | 88.79 | 1.00 | 0.89 | 10.54 | 0.03 |
| 2009 | 7927.02 | 7916 | 950 | 90.27 | 90.29 | 95.25 | 90.37 | 0.52 | 0.47 | 9.25 | 0.01 |
| 2010 | 7398.47 | 7828 | 950 | 88.60 | 88.91 | 88.90 | 89.36 | 2.23 | 2.02 | 9.06 | 0.32 |
| 2011 | 7695.35 | 7736 | 950 | 88.24 | 88.24 | 92.48 | 88.32 | 0.09 | 0.08 | 11.68 | 0.00 |
| 2012 | 7569.03 | 7614 | 950 | 86.42 | 86.51 | 90.70 | 86.68 | 0.10 | 1.40 | 12.09 | 0.09 |
| 2013 | 8557.12 | 8618 | 950 | 98.15 | 98.15 | 102.83 | 98.38 | 1.85 | 1.85 | 0.00 | 0.00 |
| 2014 | 7227.67 | 7498 | 950 | 85.13 | 85.37 | 86.84 | 85.58 | 1.82 | 1.58 | 13.05 | 0.25 |
| 2015 | 6713.50 | 6980 | 950 | 76.83 | 76.83 | 80.67 | 79.68 | 7.21 | 5.97 | 17.21 | 0.00 |
| 2016 | 8833.60 | 8753 | 950 | 99.63 | 99.63 | 105.86 | 99.65 | 0.37 | 0.37 | 0.00 | 0.00 |
| 2017 | 7840.38 | 7825 | 950 | 89.24 | 89.24 | 94.21 | 89.33 | 0.01 | 0.01 | 10.76 | 0.00 |
| 2018 | 7609.90 | 7719 | 950 | 87.71 | 87.98 | 91.44 | 88.12 | 0.74 | 1.07 | 10.95 | 0.27 |
| 2019 | 8620.25 | 8723 | 950 | 99.49 | 99.52 | 103.58 | 99.58 | 0.48 | 0.48 | 0.00 | 0.03 |
| 2020 | 7443.25 | 7689 | 950 | 86.60 | 87.29 | 89.20 | 87.53 | 0.96 | 0.85 | 11.86 | 0.68 |
| 2021 | 7416.99 | 7622 | 989 | 85.73 | 87.04 | 85.61 | 87.01 | 0.00 | 0.00 | 12.96 | 1.31 |
| 2022 | 8753.70 | 8728 | 989 | 98.87 | 99.02 | 101.04 | 99.63 | 0.98 | 0.98 | 0.00 | 0.14 |
| 2023 | 6993.42 | 7011 | 989 | 79.28 | 79.95 | 80.72 | 80.03 | 0.39 | 1.52 | 18.53 | 0.67 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2001 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 121 | | | 85 | |
| C. Inspection, maintenance or repair combined with refuelling | 1629 | | | 890 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 6 | | |
| E. Testing of plant systems or components | | | | | 2 | |
| L. Human factor related | | | | | 3 | |
| Subtotal | 1629 | 121 | | 896 | 90 | |
| Total | | 1750 | | | 986 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2001 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 3 |
| 14. Safety Systems | | 2 |
| 16. Steam generation systems | | 31 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 1 |
| 33. Circulating Water System | | 3 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | 13 | 28 |
| 42. Electrical Power Supply Systems | 108 | 19 |
| Total | 121 | 89 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-March, June, September-December. Additional electricity generation amounted to 127515 MWh. The unit was in the overhaul outage from 2023.03.22 to 2023.06.02. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-62
ROSTOV-2
RUSSIA

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : FAEA (Federal Atomic Energy Agency)

Reactor Unit Details

Reactor type and model : PWR / VVER V-320
 Thermal power : 3200 MWth
 Gross electrical power : 1000 MWe
 Reference unit power (net) : 950 MWe

Key Dates

Construction Date : 1983-05-01
 Grid Date : 2010-03-18
 Commercial Date : 2010-12-10
 Age at end of year : 13 years

Design Characteristics
Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 30
 Average discharge burnup [MWd/t] : 40000
 Active core diameter [m] : 3.16
 Active core height/length [m] : 3.53
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 0.7
 Reactor outlet temperature [°C] : 322
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

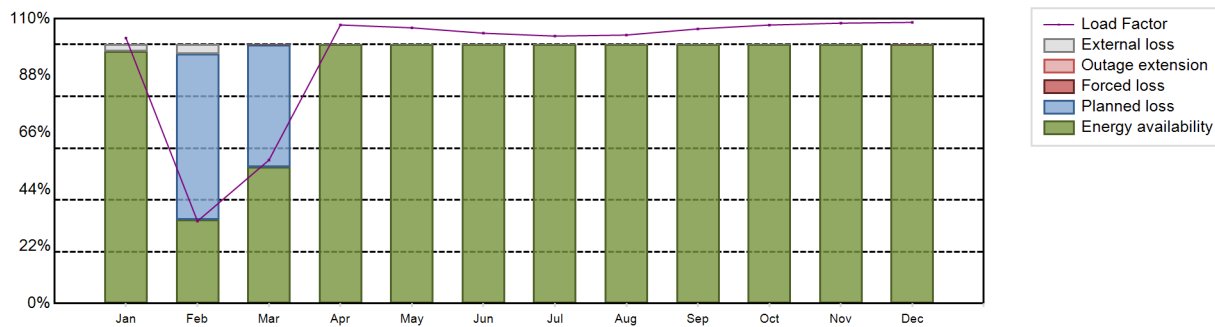
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7978.3 GW(e).h
 Energy Availability Factor (EAF) : 90.55 %
 Unit Capability Factor (UCF) : 91.06 %
 Load Factor (LF) : 95.87 %
 Operating Factor (OF) : 91.15 %

Forced Loss Rate (FLR) : 0.02 %
 Unplanned Capability Loss Factor (UCL) : 0.02 %
 Planned Unavailability Factor (PUF) : 8.93 %
 Externally cause unavailability (XUF) : 0.51 %
 Total off-line time : 775 hours

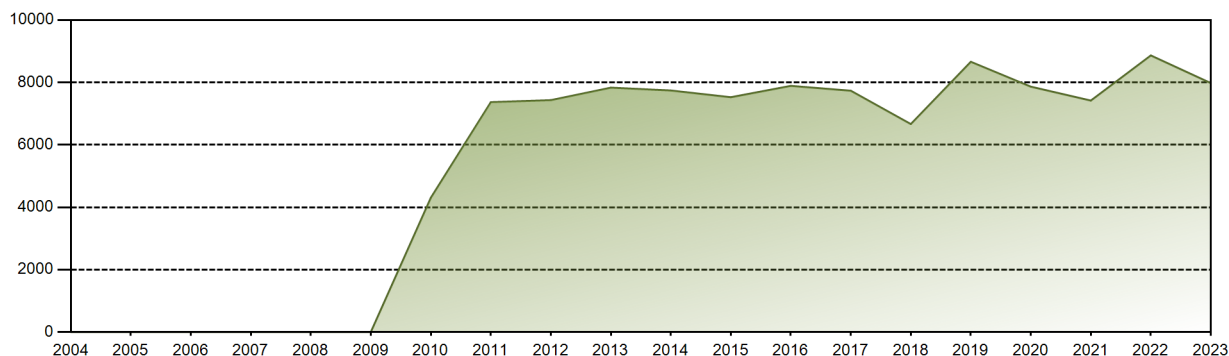
Annual Summary


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 724.65 | 203.03 | 391.54 | 735.85 | 752.60 | 714.06 | 730.02 | 732.82 | 725.44 | 760.17 | 740.65 | 767.47 | 7978.31 |
| EAF [%] | 97.33 | 32.29 | 52.60 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 | 90.55 |
| UCF [%] | 100.00 | 35.93 | 52.60 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 | 91.06 |
| LF [%] | 102.53 | 31.80 | 55.40 | 107.58 | 106.48 | 104.39 | 103.28 | 103.68 | 106.06 | 107.55 | 108.28 | 108.58 | 95.87 |
| OF [%] | 100.00 | 36.31 | 53.36 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.15 |
| FLR [%] | 0.00 | 0.00 | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 |
| UCL [%] | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 |
| PUF [%] | 0.00 | 64.07 | 47.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.93 |
| XUF [%] | 2.67 | 3.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.51 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 105284.27 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.49 % |
| Cumulative Energy Availability Factor (EAF) | : 89.88 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.35 % |
| Cumulative Unit Capability Factor (UCF) | : 90.2 % | Cumulative Planned Unavailability Factor (PUF) | : 7.44 % |
| Cumulative Load Factor (LF) | : 93.31 % | Cumulative Externally cause unavailability (XUF) | : 0.32 % |
| Cumulative Operating Factor (OF) | : 90.44 % | | |

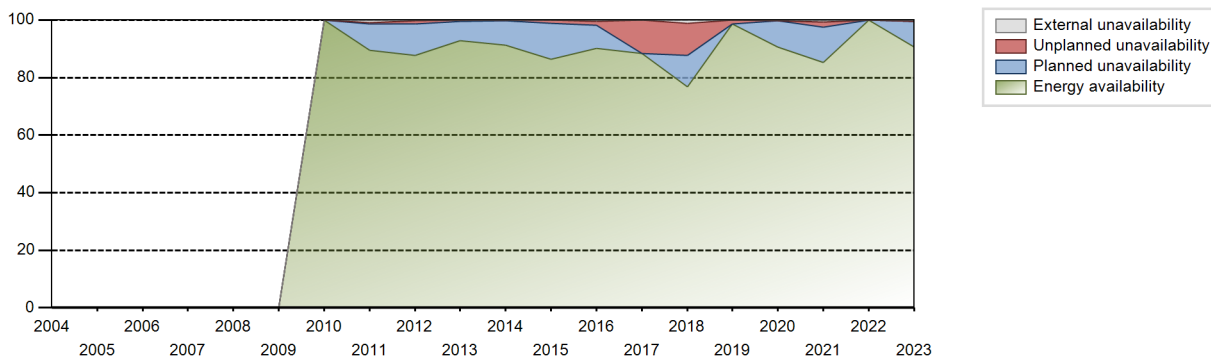
Electricity Production (net) [GWh]



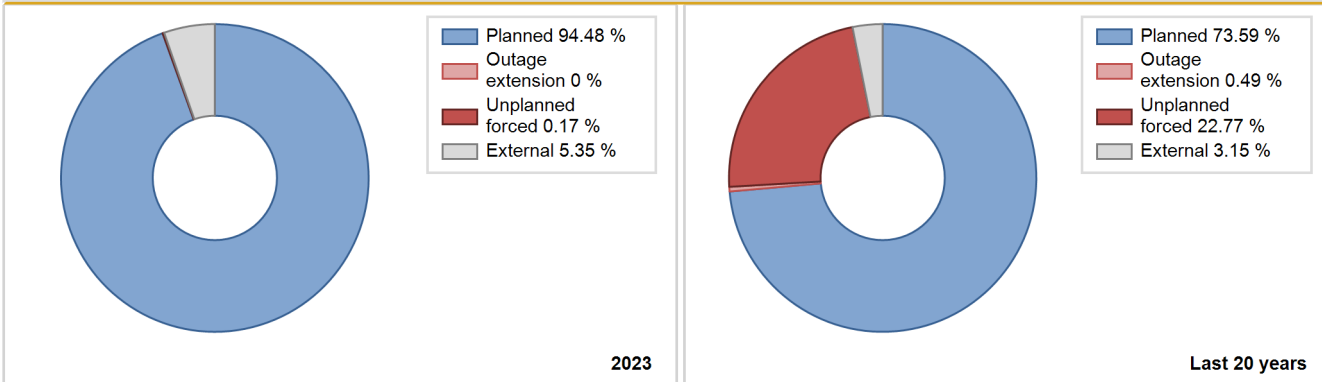
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|--------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2010 | 4303.76 | 6133 | 950 | 100.00 | 100.00 | 97.93 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 7368.43 | 7944 | 950 | 89.41 | 90.23 | 88.55 | 90.70 | 0.63 | 0.58 | 9.19 | 0.82 |
| 2012 | 7433.18 | 7781 | 950 | 87.61 | 87.79 | 89.08 | 88.58 | 1.30 | 1.16 | 11.05 | 0.18 |
| 2013 | 7832.67 | 8151 | 950 | 92.80 | 92.80 | 94.12 | 93.05 | 0.55 | 0.51 | 6.69 | 0.00 |
| 2014 | 7741.45 | 8018 | 950 | 91.20 | 91.29 | 93.01 | 91.52 | 0.26 | 0.24 | 8.47 | 0.09 |
| 2015 | 7525.83 | 7610 | 950 | 86.39 | 86.41 | 90.43 | 86.87 | 1.26 | 1.11 | 12.48 | 0.03 |
| 2016 | 7890.03 | 7974 | 950 | 90.15 | 90.69 | 94.55 | 90.78 | 1.44 | 1.33 | 7.98 | 0.54 |
| 2017 | 7734.15 | 7755 | 950 | 88.29 | 88.31 | 92.94 | 88.53 | 11.64 | 11.63 | 0.06 | 0.01 |
| 2018 | 6666.68 | 6845 | 950 | 76.80 | 77.90 | 80.11 | 78.14 | 12.50 | 11.13 | 10.98 | 1.09 |
| 2019 | 8662.06 | 8650 | 950 | 98.71 | 98.72 | 104.09 | 98.74 | 1.28 | 1.28 | 0.00 | 0.01 |
| 2020 | 7864.15 | 7982 | 950 | 90.61 | 90.79 | 94.24 | 90.87 | 0.01 | 0.01 | 9.21 | 0.18 |
| 2021 | 7418.56 | 7532 | 950 | 85.14 | 85.85 | 89.14 | 85.98 | 1.31 | 1.79 | 12.36 | 0.71 |
| 2022 | 8865.36 | 8760 | 950 | 99.97 | 99.97 | 106.53 | 100.00 | 0.03 | 0.03 | 0.00 | 0.00 |
| 2023 | 7978.31 | 7985 | 950 | 90.55 | 91.06 | 95.87 | 91.15 | 0.02 | 0.02 | 8.93 | 0.51 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2010 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 188 | |
| C. Inspection, maintenance or repair combined with refuelling | 776 | | | 598 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 44 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| Z. Other | | | | | 4 | |
| Subtotal | 776 | | | 642 | 192 | 1 |
| Total | | 776 | | | 835 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2010 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 7 |
| 15. Reactor Cooling Systems | | 5 |
| 16. Steam generation systems | | 10 |
| 31. Turbine and auxiliaries | | 35 |
| 41. Main Generator Systems | | 79 |
| 42. Electrical Power Supply Systems | | 42 |
| Total | | 178 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January, March-December. Additional electricity generation amounted to 410474 MWh. The unit was in the intermediate maintenance outage from 2023.02.11 to 2023.03.15. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-63 **ROSTOV-3** **RUSSIA**

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : AEM (Atomenergomash)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 2009-09-15 |
| Thermal power | : 3000 MWth | Grid Date | : 2014-12-27 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 2015-09-17 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 9 years |

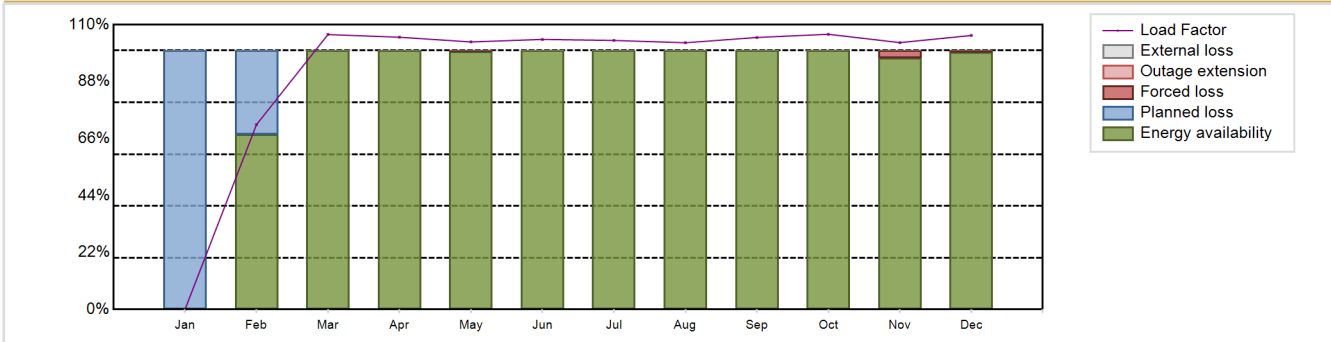
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|-----|--|--------|
| Reactor vessel centreline orientation | : - | Operating coolant pressure [MPa] | : - |
| Fuel material | : - | Reactor outlet temperature [°C] | : - |
| Refuelling type | : - | Number of SG | : - |
| Moderator material | : - | Containment type | : - |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : - |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : - |
| Average discharge burnup [MWd/t] | : - | Turbine speed [rpm] | : - |
| Active core diameter [m] | : - | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : - | HP cylinder inlet steam pressure [MPa] | : - |
| Number of fissile fuel assemblies/bundles | : - | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : - | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : - | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : - | Number of FW pumps for full power operation | : - |
| Coolant type | : - | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 7755.53 GW(e).h | Forced Loss Rate (FLR) | : 0.38 % |
| Energy Availability Factor (EAF) | : 88.69 % | Unplanned Capability Loss Factor (UCL) | : 0.34 % |
| Unit Capability Factor (UCF) | : 88.69 % | Planned Unavailability Factor (PUF) | : 10.97 % |
| Load Factor (LF) | : 93.19 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 88.85 % | Total off-line time | : 977 hours |

Annual Summary

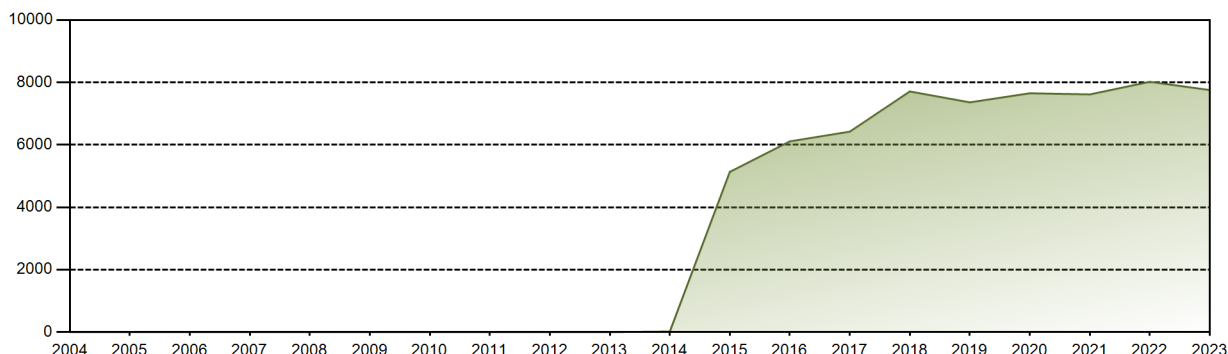


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 455.92 | 750.58 | 719.25 | 730.41 | 713.51 | 734.47 | 728.19 | 718.69 | 751.38 | 705.07 | 748.07 | 7755.53 |
| EAF [%] | 0.00 | 67.68 | 100.00 | 100.00 | 99.54 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.04 | 99.31 | 88.69 |
| UCF [%] | 0.00 | 67.68 | 100.00 | 100.00 | 99.54 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.04 | 99.31 | 88.69 |
| LF [%] | 0.00 | 71.42 | 106.19 | 105.15 | 103.34 | 104.31 | 103.91 | 103.03 | 105.07 | 106.31 | 103.08 | 105.84 | 93.19 |
| OF [%] | 0.00 | 68.01 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.50 | 100.00 | 88.85 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.96 | 0.69 | 0.38 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.96 | 0.69 | 0.34 |
| PUF [%] | 100.00 | 32.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.97 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 63776.23 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.41 % |
| Cumulative Energy Availability Factor (EAF) | : 86.21 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.47 % |
| Cumulative Unit Capability Factor (UCF) | : 87.04 % | Cumulative Planned Unavailability Factor (PUF) | : 10.49 % |
| Cumulative Load Factor (LF) | : 88.53 % | Cumulative Externally cause unavailability (XUF) | : 0.83 % |
| Cumulative Operating Factor (OF) | : 87.82 % | | |

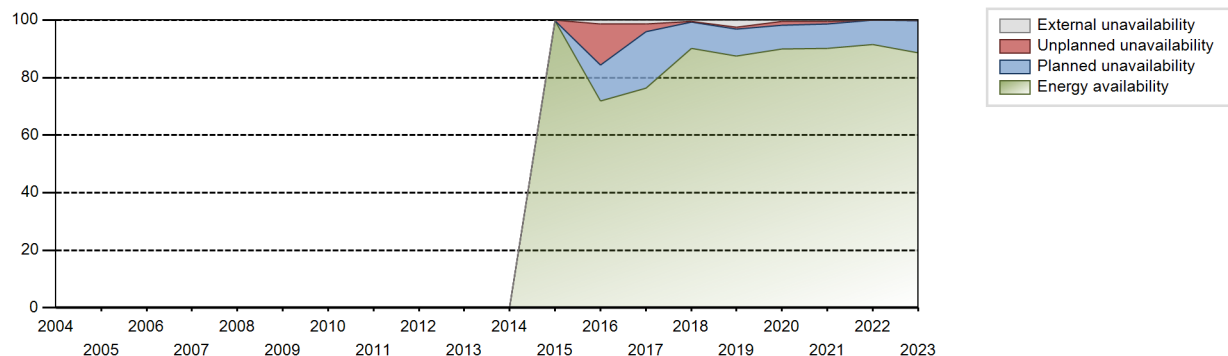
Electricity Production (net) [GWh]



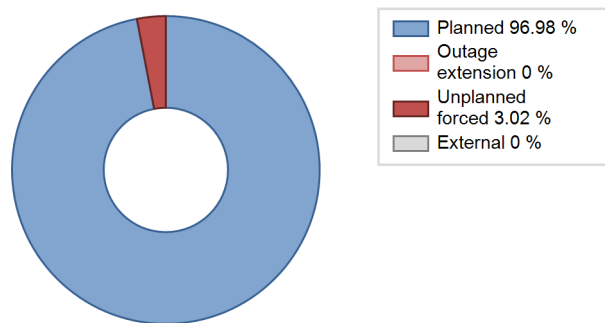
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|---------------|---------------------|---------------------------|-------|-------|--------|--------|------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2015 | 5132.22 | 7040 | 950 | 99.65 | 99.65 | 104.56 | 100.00 | 0.35 | 0.35 | 0.00 | 0.00 |
| 2016 | 6110.00 | 6728 | 950 | 71.98 | 73.43 | 73.22 | 76.59 | 5.40 | 14.24 | 12.33 | 1.45 |
| 2017 | 6422.53 | 6888 | 950 | 76.35 | 77.80 | 77.18 | 78.63 | 3.24 | 2.60 | 19.60 | 1.45 |
| 2018 | 7709.57 | 7962 | 950 | 90.24 | 90.77 | 92.64 | 90.89 | 0.30 | 0.27 | 8.95 | 0.53 |
| 2019 | 7360.63 | 7848 | 950 | 87.53 | 89.97 | 88.45 | 89.59 | 0.71 | 0.64 | 9.39 | 2.44 |
| 2020 | 7651.88 | 8081 | 950 | 89.89 | 90.36 | 91.70 | 92.00 | 1.38 | 1.26 | 8.38 | 0.47 |
| 2021 | 7615.55 | 8010 | 950 | 90.16 | 90.67 | 91.51 | 91.44 | 0.97 | 0.89 | 8.45 | 0.51 |
| 2022 | 8018.57 | 8016 | 950 | 91.52 | 91.52 | 96.35 | 91.51 | 0.00 | 0.00 | 8.48 | 0.00 |
| 2023 | 7755.53 | 7783 | 950 | 88.69 | 88.69 | 93.19 | 88.85 | 0.38 | 0.34 | 10.97 | 0.00 |

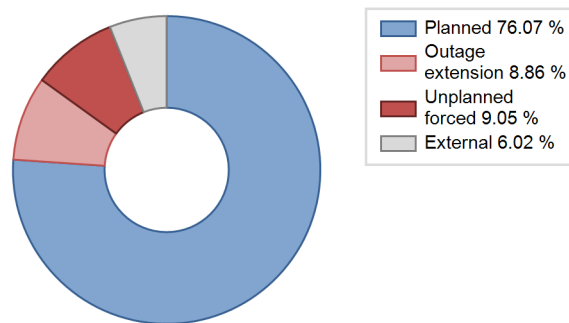
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2015 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 19 | | | 156 | |
| C. Inspection, maintenance or repair combined with refuelling | 959 | | | 695 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 12 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 203 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 8 |
| Subtotal | 959 | 19 | | 910 | 156 | 8 |
| Total | | 978 | | | 1074 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2015 to 2023 | |
|--|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 15. Reactor Cooling Systems | | | | 22 |
| 16. Steam generation systems | | | | 2 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 2 |
| 31. Turbine and auxiliaries | | | | 12 |
| 32. Feedwater and Main Steam System | | | | 2 |
| 33. Circulating Water System | | | | 1 |
| 41. Main Generator Systems | | | 19 | 2 |
| 42. Electrical Power Supply Systems | | | | 100 |
| Total | | | 19 | 143 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in February-December. Additional electricity generation amounted to 455149 MWh. The unit was in the overhaul outage from 2023.01.01 to 2023.02.09. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

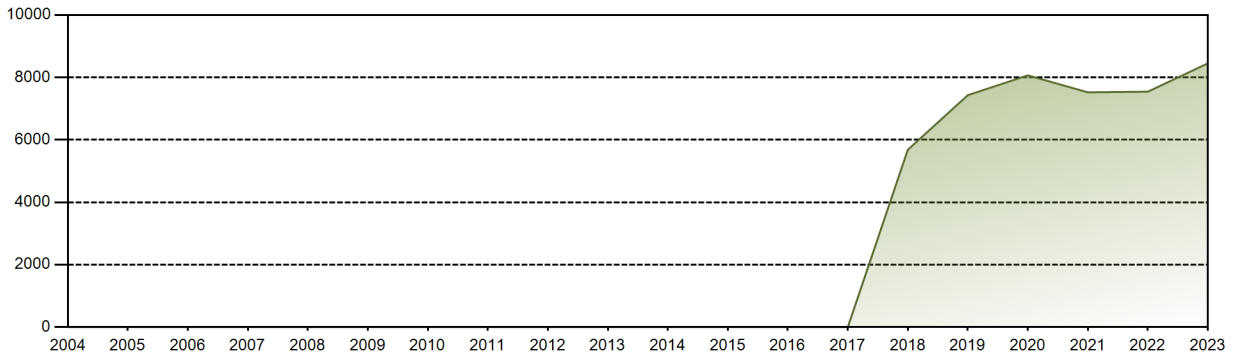
2023 Operating Experience

| | | | | | | | | | | | | | |
|---|---|--|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| RU-64 | ROSTOV-4 | RUSSIA | | | | | | | | | | | |
| Status at end of year | : Operational | | | | | | | | | | | | |
| Operator | : REA (Joint Stock Company 'Concern Rosenergoatom') | | | | | | | | | | | | |
| Owner | : REA (Joint Stock Company 'Concern Rosenergoatom') | | | | | | | | | | | | |
| Reactor Supplier | : AEM (Atomenergomash) | | | | | | | | | | | | |
| Turbine Supplier | : AEM (Atomenergomash) | | | | | | | | | | | | |
| Reactor Unit Details | | | | | | | | | | | | | |
| Reactor type and model | : PWR / VVER V-320 | | | | | | | | | | | | |
| Thermal power | : 3000 MWth | | | | | | | | | | | | |
| Gross electrical power | : 1030 MWe | | | | | | | | | | | | |
| Reference unit power (net) | : 979 MWe | | | | | | | | | | | | |
| Key Dates | | | | | | | | | | | | | |
| Construction Date | : 2010-06-16 | | | | | | | | | | | | |
| Grid Date | : 2018-02-02 | | | | | | | | | | | | |
| Commercial Date | : 2018-09-28 | | | | | | | | | | | | |
| Age at end of year | : 5 years | | | | | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | | |
| Primary Systems | | | | | | | | | | | | | |
| Reactor vessel centreline orientation | : - | | | | | | | | | | | | |
| Fuel material | : - | | | | | | | | | | | | |
| Refuelling type | : - | | | | | | | | | | | | |
| Moderator material | : - | | | | | | | | | | | | |
| Average fuel enrichment [% of U235] | : - | | | | | | | | | | | | |
| Refuelling frequency [month] | : - | | | | | | | | | | | | |
| Part of the core refuelled [%] | : - | | | | | | | | | | | | |
| Average discharge burnup [MWd/t] | : - | | | | | | | | | | | | |
| Active core diameter [m] | : - | | | | | | | | | | | | |
| Active core height/length [m] | : - | | | | | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : - | | | | | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : - | | | | | | | | | | | | |
| Number of control rod assemblies | : - | | | | | | | | | | | | |
| Number of external reactor coolant loops | : - | | | | | | | | | | | | |
| Coolant type | : - | | | | | | | | | | | | |
| Operating coolant pressure [MPa] | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Reactor outlet temperature [°C] | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Number of SG | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Containment type | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Containment design pressure [MPa] | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Secondary systems | | | | | | | | | | | | | |
| Number of turbine-generators per unit/reactor | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Turbine speed [rpm] | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Number of LP cylinders per turbine | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| HP cylinder inlet steam pressure [MPa] | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Output voltage [kV] | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Primary means of condenser cooling | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Number of main condensate pumps | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Number of FW pumps for full power operation | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Number of on-site safety related diesel generators | | | | | | | | | | | | | |
| | : - | | | | | | | | | | | | |
| Non-electrical applications | | | | | | | | | | | | | |
| | : - | none | | | | | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | | |
| Net Energy Production | : 8450.68 GW(e).h | Forced Loss Rate (FLR) | : 0 % | | | | | | | | | | |
| Energy Availability Factor (EAF) | : 97.92 % | Unplanned Capability Loss Factor (UCL) | : 0 % | | | | | | | | | | |
| Unit Capability Factor (UCF) | : 100 % | Planned Unavailability Factor (PUF) | : 0 % | | | | | | | | | | |
| Load Factor (LF) | : 98.54 % | Externally cause unavailability (XUF) | : 2.08 % | | | | | | | | | | |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours | | | | | | | | | | |
| Annual Summary | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
| GW(e)-h | 754.76 | 680.96 | 744.99 | 714.77 | 726.93 | 687.04 | 665.83 | 623.54 | 684.11 | 722.58 | 706.04 | 739.13 | 8450.68 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.76 | 98.34 | 92.61 | 87.23 | 98.08 | 99.54 | 99.89 | 99.90 | 97.92 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| LF [%] | 103.62 | 103.51 | 102.28 | 101.40 | 99.80 | 97.47 | 91.41 | 85.61 | 97.05 | 99.20 | 100.17 | 101.48 | 98.54 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 1.66 | 7.39 | 12.77 | 1.92 | 0.46 | 0.11 | 0.10 | 2.08 |

Historical Summary

| | | | |
|---|-------------------|---|----------|
| Lifetime energy generation | : 44626.9 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.92 % |
| Cumulative Energy Availability Factor (EAF) | : 91.44 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.87 % |
| Cumulative Unit Capability Factor (UCF) | : 93.03 % | Cumulative Planned Unavailability Factor (PUF) | : 6.1 % |
| Cumulative Load Factor (LF) | : 91.53 % | Cumulative Externally cause unavailability (XUF) | : 1.59 % |
| Cumulative Operating Factor (OF) | : 93.23 % | | |

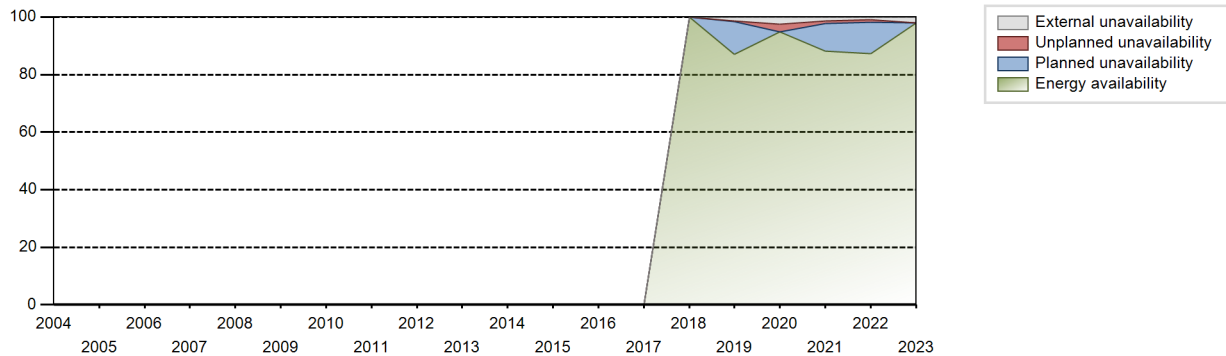
Electricity Production (net) [GWh]



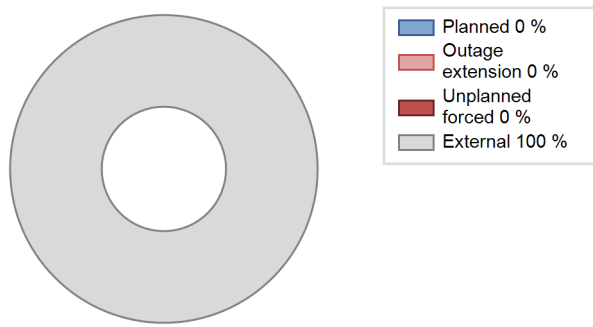
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|--------|--------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2018 | 5681.92 | 6556 | 950 | 99.97 | 99.99 | 103.76 | 100.00 | 0.01 | 0.01 | 0.00 | 0.01 |
| 2019 | 7430.57 | 7751 | 979 | 87.01 | 88.29 | 86.64 | 88.48 | 0.40 | 0.35 | 11.36 | 1.28 |
| 2020 | 8066.50 | 8573 | 979 | 94.86 | 97.45 | 93.80 | 97.60 | 2.50 | 2.50 | 0.05 | 2.58 |
| 2021 | 7521.96 | 7862 | 979 | 88.05 | 89.52 | 87.71 | 89.75 | 0.91 | 0.82 | 9.66 | 1.47 |
| 2022 | 7542.06 | 7761 | 979 | 87.28 | 88.19 | 87.94 | 88.60 | 0.98 | 0.87 | 10.94 | 0.91 |
| 2023 | 8450.68 | 8760 | 979 | 97.92 | 100.00 | 98.54 | 100.00 | 0.00 | 0.00 | 0.00 | 2.08 |

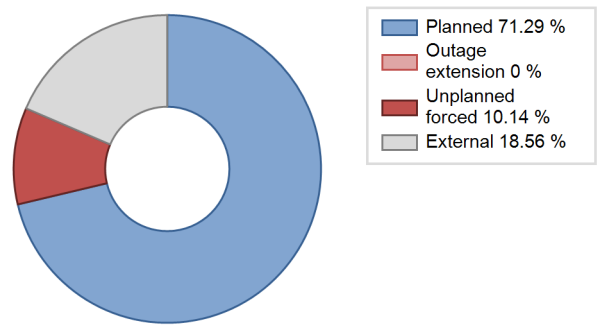
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2018 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 67 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 555 | | |
| L. Human factor related | | | | | 2 | |
| Subtotal | | | | 555 | 69 | |
| Total | 0 | | | 624 | | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2018 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 16. Steam generation systems | | | | 18 |
| 31. Turbine and auxiliaries | | | | 11 |
| 32. Feedwater and Main Steam System | | | | 38 |
| 33. Circulating Water System | | | | 2 |
| Total | | | | 69 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-June, October-December. Additional electricity generation amounted to 122728 MWh. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-23 **SMOLENSK-1** **RUSSIA**

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : LWGR / RBMK-1000 | Construction Date | : 1975-10-01 |
| Thermal power | : 3200 MWth | Grid Date | : 1982-12-09 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1983-09-30 |
| Reference unit power (net) | : 925 MWe | Age at end of year | : 41 years |

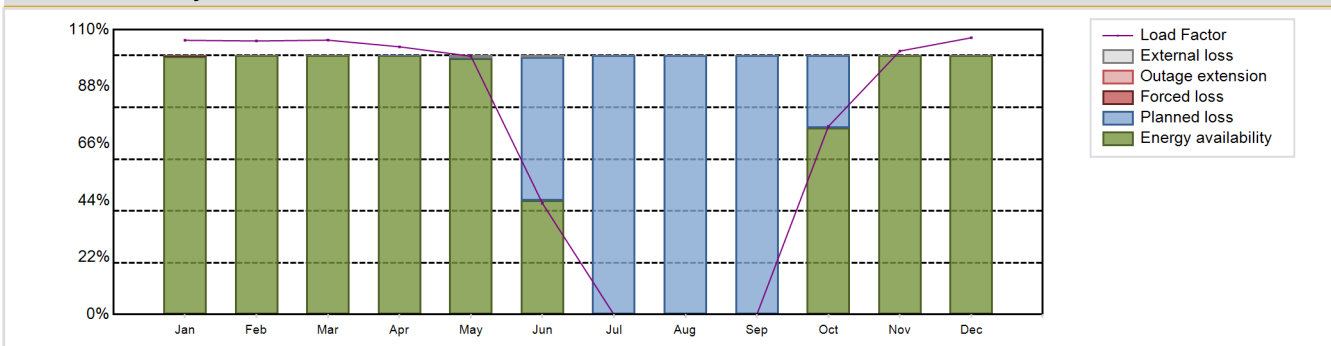
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|------------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 284 |
| Refuelling type | : ON-line | Number of SG | : NA |
| Moderator material | : GRAPHITE | Containment type | : Confinement |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : - |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 2 |
| Average discharge burnup [MWd/t] | : 22200 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 11.8 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 7 | HP cylinder inlet steam pressure [MPa] | : 6.59 |
| Number of fissile fuel assemblies/bundles | : 1661 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 14.5 | Primary means of condenser cooling | : River (once-through) |
| Number of control rod assemblies | : 175 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : PH / DH |

Annual Production Results (2023)

| | | | |
|--|-------------------|--|--------------|
| Net Energy Production | : 5689.02 GW(e).h | Forced Loss Rate (FLR) | : 0.03 % |
| Energy Availability Factor (EAF) | : 67.72 % | Unplanned Capability Loss Factor (UCL) | : 0.02 % |
| Unit Capability Factor (UCF) | : 67.85 % | Planned Unavailability Factor (PUF) | : 32.13 % |
| Load Factor (LF) | : 70.21 % | Externally cause unavailability (XUF) | : 0.13 % |
| Operating Factor (OF) | : 70.24 % | Total off-line time | : 2607 hours |
| Equivalent non-electrical energy generated (NEG) | : 63.68 GW(e).h | | |

Annual Summary

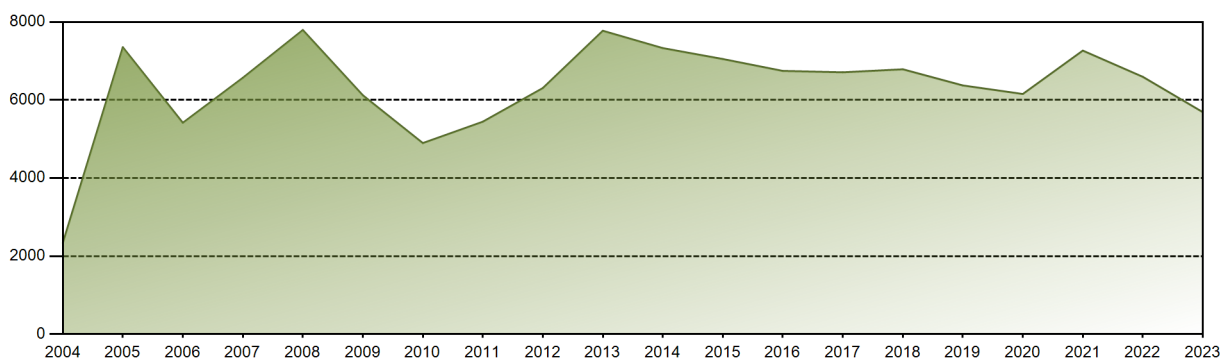


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 728.79 | 656.66 | 729.25 | 688.63 | 686.58 | 285.99 | 0.00 | 0.00 | 0.00 | 499.95 | 677.57 | 735.59 | 5689.02 |
| EAF [%] | 99.72 | 100.00 | 100.00 | 100.00 | 98.97 | 44.11 | 0.00 | 0.00 | 0.00 | 72.08 | 100.00 | 100.00 | 67.72 |
| UCF [%] | 99.72 | 100.00 | 100.00 | 100.00 | 99.89 | 44.77 | 0.00 | 0.00 | 0.00 | 72.08 | 100.00 | 100.00 | 67.85 |
| LF [%] | 105.90 | 105.64 | 105.96 | 103.40 | 99.76 | 42.94 | 0.00 | 0.00 | 0.00 | 72.65 | 101.74 | 106.89 | 70.21 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 46.94 | 0.00 | 0.00 | 0.00 | 97.72 | 100.00 | 100.00 | 70.24 |
| FLR [%] | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| UCL [%] | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 55.23 | 100.00 | 100.00 | 100.00 | 27.92 | 0.00 | 0.00 | 32.13 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.92 | 0.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 247123.06 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.44 % |
| Cumulative Energy Availability Factor (EAF) | : 74.14 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.01 % |
| Cumulative Unit Capability Factor (UCF) | : 75.8 % | Cumulative Planned Unavailability Factor (PUF) | : 22.19 % |
| Cumulative Load Factor (LF) | : 74.87 % | Cumulative Externally cause unavailability (XUF) | : 1.66 % |
| Cumulative Operating Factor (OF) | : 77.31 % | | |

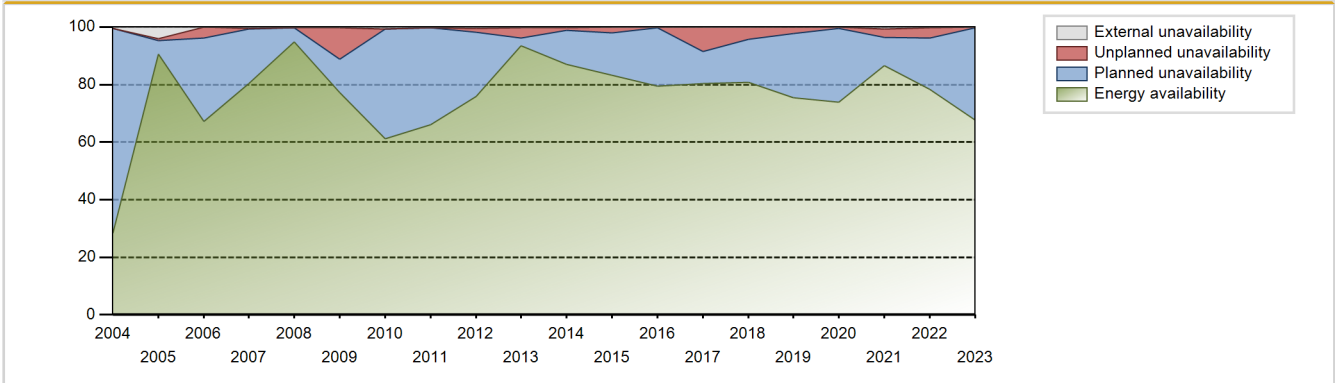
Electricity Production (net) [GWh]



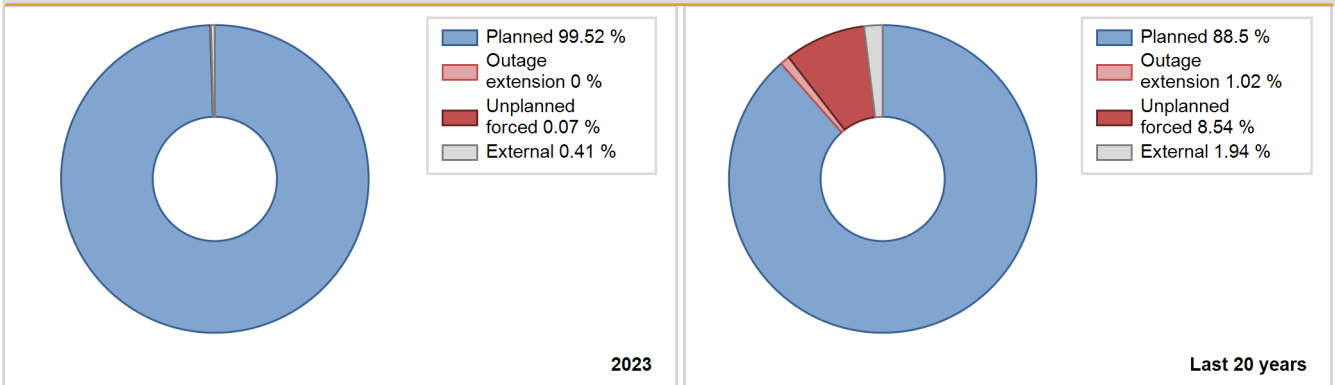
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 4744.20 | 7223 | 925 | 99.64 | 99.64 | 100.76 | 99.86 | 0.36 | 0.36 | 0.00 | 0.00 |
| 1984 | 6921.35 | 7830 | 925 | 84.23 | 84.23 | 85.18 | 89.14 | 2.64 | 2.28 | 13.49 | 0.00 |
| 1985 | 5850.24 | 6806 | 925 | 72.40 | 74.87 | 72.20 | 77.69 | 1.52 | 1.15 | 23.97 | 2.47 |
| 1986 | 3039.75 | 3472 | 925 | 37.79 | 37.79 | 37.51 | 39.63 | 0.05 | 0.02 | 62.20 | 0.00 |
| 1987 | 7445.76 | 7620 | 1000 | 86.72 | 86.72 | 85.00 | 86.99 | 2.08 | 1.84 | 11.44 | 0.00 |
| 1988 | 6695.59 | 7288 | 925 | 81.89 | 81.89 | 82.41 | 82.97 | 0.44 | 0.36 | 17.75 | 0.00 |
| 1989 | 6506.46 | 7177 | 925 | 79.32 | 79.70 | 80.30 | 81.93 | 6.44 | 5.49 | 14.82 | 0.38 |
| 1990 | 6227.84 | 6851 | 925 | 76.14 | 76.59 | 76.86 | 78.21 | 3.90 | 3.11 | 20.30 | 0.45 |
| 1991 | 6693.92 | 7252 | 925 | 81.29 | 81.29 | 82.61 | 82.79 | 3.68 | 3.11 | 15.60 | 0.00 |
| 1992 | 6849.38 | 7563 | 925 | 83.69 | 83.69 | 84.31 | 86.11 | 2.55 | 2.19 | 14.12 | 0.00 |
| 1993 | 6290.56 | 6993 | 925 | 78.01 | 78.41 | 77.63 | 79.83 | 0.38 | 0.30 | 21.29 | 0.40 |
| 1994 | 4217.84 | 6286 | 925 | 57.81 | 71.04 | 52.05 | 71.76 | 0.20 | 0.14 | 28.82 | 13.23 |
| 1995 | 5002.47 | 6390 | 925 | 62.97 | 77.35 | 61.74 | 72.95 | 1.91 | 1.50 | 21.15 | 14.38 |
| 1996 | 5666.43 | 6604 | 925 | 71.56 | 71.73 | 69.74 | 75.18 | 1.05 | 0.76 | 27.51 | 0.17 |
| 1997 | 4674.51 | 5366 | 925 | 57.82 | 59.14 | 57.69 | 61.26 | 2.88 | 1.75 | 39.11 | 1.32 |
| 1998 | 3554.08 | 5411 | 925 | 45.04 | 58.85 | 43.86 | 61.77 | 3.49 | 2.13 | 39.02 | 13.81 |
| 1999 | 6478.89 | 7417 | 925 | 80.06 | 83.51 | 79.96 | 84.67 | 3.29 | 2.84 | 13.65 | 3.45 |
| 2000 | 5228.48 | 5738 | 925 | 63.83 | 64.36 | 64.35 | 65.32 | 0.06 | 0.04 | 35.60 | 0.53 |
| 2001 | 5165.12 | 5940 | 925 | 63.24 | 67.43 | 63.74 | 67.81 | 2.61 | 1.81 | 30.76 | 4.19 |
| 2002 | 6866.73 | 7587 | 925 | 83.69 | 85.10 | 84.74 | 86.61 | 2.59 | 2.26 | 12.64 | 1.41 |
| 2003 | 6711.76 | 7533 | 925 | 82.90 | 84.38 | 82.83 | 85.99 | 3.18 | 2.77 | 12.85 | 1.48 |
| 2004 | 2337.12 | 2592 | 925 | 28.50 | 29.09 | 28.76 | 29.51 | 0.00 | 0.00 | 70.91 | 0.59 |
| 2005 | 7354.10 | 8414 | 925 | 90.63 | 94.66 | 90.75 | 96.04 | 0.80 | 0.76 | 4.58 | 4.03 |
| 2006 | 5417.08 | 6021 | 925 | 67.09 | 67.09 | 66.85 | 68.73 | 1.33 | 3.79 | 29.12 | 0.00 |
| 2007 | 6569.65 | 7138 | 925 | 80.25 | 80.82 | 81.08 | 81.48 | 0.20 | 0.16 | 19.02 | 0.57 |
| 2008 | 7794.93 | 8430 | 925 | 94.94 | 95.19 | 95.94 | 95.97 | 0.01 | 0.01 | 4.79 | 0.25 |
| 2009 | 6122.29 | 6974 | 925 | 77.32 | 77.60 | 75.56 | 79.61 | 12.28 | 10.86 | 11.54 | 0.28 |
| 2010 | 4896.26 | 5424 | 925 | 61.10 | 61.75 | 60.43 | 61.92 | 0.02 | 0.01 | 38.24 | 0.65 |
| 2011 | 5444.54 | 5899 | 925 | 65.97 | 66.24 | 67.20 | 67.35 | 0.05 | 0.03 | 33.73 | 0.27 |
| 2012 | 6306.76 | 6741 | 925 | 75.88 | 76.32 | 77.62 | 76.74 | 1.76 | 1.37 | 22.31 | 0.45 |
| 2013 | 7775.27 | 8267 | 925 | 93.47 | 93.80 | 95.96 | 94.37 | 3.63 | 3.53 | 2.67 | 0.34 |
| 2014 | 7330.99 | 7691 | 925 | 87.06 | 87.27 | 90.46 | 87.79 | 0.92 | 0.83 | 11.89 | 0.21 |
| 2015 | 7050.99 | 7394 | 925 | 83.24 | 83.37 | 87.02 | 84.41 | 2.18 | 1.86 | 14.77 | 0.14 |
| 2016 | 6746.07 | 7003 | 925 | 79.38 | 79.45 | 83.03 | 79.72 | 0.15 | 0.12 | 20.42 | 0.07 |
| 2017 | 6710.68 | 7720 | 925 | 80.35 | 80.44 | 82.82 | 88.13 | 9.47 | 8.41 | 11.15 | 0.08 |
| 2018 | 6788.06 | 7256 | 925 | 80.82 | 80.92 | 83.77 | 82.83 | 4.80 | 4.08 | 15.00 | 0.10 |
| 2019 | 6373.86 | 6673 | 925 | 75.51 | 75.51 | 78.66 | 76.18 | 0.54 | 2.32 | 22.17 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2020 | 6155.00 | 6930 | 925 | 73.88 | 73.96 | 75.75 | 78.89 | 0.51 | 0.38 | 25.66 | 0.08 |
| 2021 | 7267.29 | 7736 | 925 | 86.52 | 87.17 | 89.69 | 88.31 | 3.27 | 2.94 | 9.89 | 0.66 |
| 2022 | 6594.48 | 7001 | 925 | 78.31 | 78.56 | 81.38 | 79.92 | 4.46 | 3.67 | 17.78 | 0.24 |
| 2023 | 5689.02 | 6153 | 925 | 67.72 | 67.85 | 70.21 | 70.24 | 0.03 | 0.02 | 32.13 | 0.13 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 102 | |
| C. Inspection, maintenance or repair combined with refuelling | 2607 | | | 1218 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 265 | | |
| E. Testing of plant systems or components | | | | 19 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 255 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| L. Human factor related | | | | | 1 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 11 |
| Subtotal | 2607 | | | 1757 | 103 | 15 |
| Total | | 2607 | | | 1875 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 20 |
| 12. Reactor I&C Systems | | 13 |
| 13. Reactor Auxiliary Systems | | 12 |
| 14. Safety Systems | | 13 |
| 15. Reactor Cooling Systems | | 22 |
| 16. Steam generation systems | | 0 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 2 |
| 31. Turbine and auxiliaries | | 0 |
| 32. Feedwater and Main Steam System | | 9 |
| 34. Miscellaneous Systems | | 5 |
| 42. Electrical Power Supply Systems | | 7 |
| Total | | 104 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-June, October-December. Additional electricity generation amounted to 200803 MWh. The unit was in the routine maintenance from 2023.06.15 to 2023.10.01. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-24 **SMOLENSK-2** **RUSSIA**

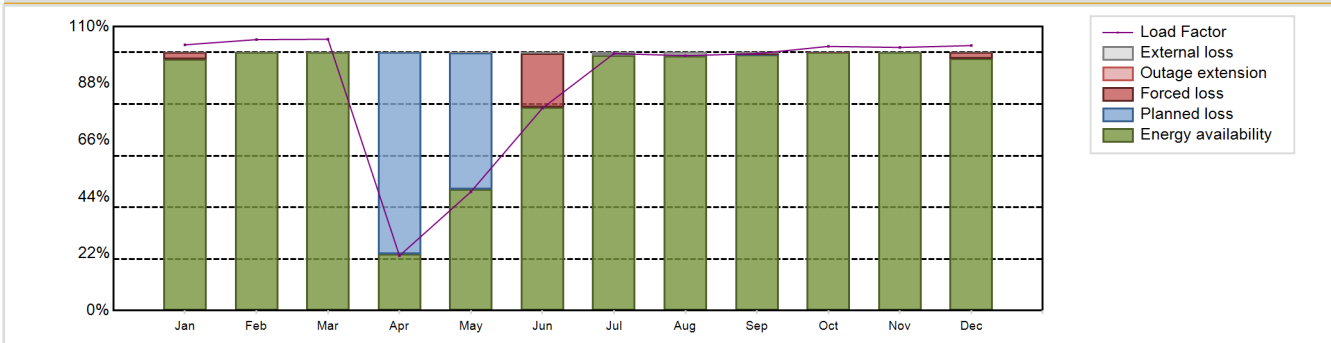
Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : LWGR / RBMK-1000 | Construction Date | : 1976-06-01 |
| Thermal power | : 3200 MWth | Grid Date | : 1985-05-31 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1985-07-02 |
| Reference unit power (net) | : 925 MWe | Age at end of year | : 38 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 284 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : ON-line | Containment type | : Confinement |
| Moderator material | : GRAPHITE | Containment design pressure [MPa] | : - |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : - | Number of turbine-generators per unit/reactor | : 2 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 22200 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 11.8 | HP cylinder inlet steam pressure [MPa] | : 6.59 |
| Active core height/length [m] | : 7 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 1661 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 14.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 175 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : PH / DH |

| Annual Production Results (2023) | | | |
|--|-------------------|--|--------------|
| Net Energy Production | : 7182.68 GW(e).h | Forced Loss Rate (FLR) | : 2.43 % |
| Energy Availability Factor (EAF) | : 86.63 % | Unplanned Capability Loss Factor (UCL) | : 2.17 % |
| Unit Capability Factor (UCF) | : 86.91 % | Planned Unavailability Factor (PUF) | : 10.92 % |
| Load Factor (LF) | : 88.64 % | Externally cause unavailability (XUF) | : 0.29 % |
| Operating Factor (OF) | : 88 % | Total off-line time | : 1051 hours |
| Equivalent non-electrical energy generated (NEG) | : 58.29 GW(e).h | | |

Annual Summary

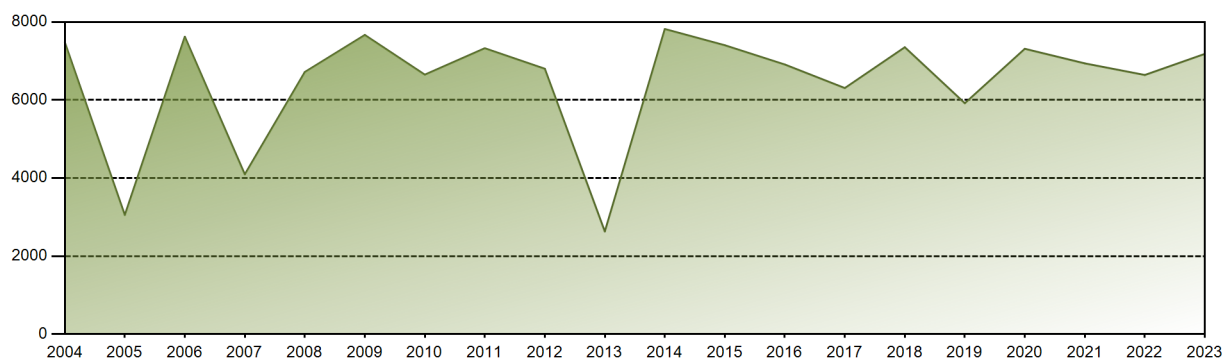


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 708.51 | 652.54 | 723.47 | 141.57 | 316.94 | 522.21 | 685.12 | 679.57 | 662.99 | 704.36 | 678.83 | 706.56 | 7182.68 |
| EAF [%] | 97.36 | 100.00 | 100.00 | 21.91 | 47.04 | 78.72 | 98.93 | 98.50 | 99.12 | 100.00 | 100.00 | 97.73 | 86.63 |
| UCF [%] | 97.36 | 100.00 | 100.00 | 21.91 | 47.06 | 79.13 | 100.00 | 100.00 | 99.53 | 100.00 | 100.00 | 97.73 | 86.91 |
| LF [%] | 102.95 | 104.98 | 105.13 | 21.26 | 46.05 | 78.41 | 99.55 | 98.75 | 99.55 | 102.35 | 101.93 | 102.67 | 88.64 |
| OF [%] | 100.00 | 100.00 | 100.00 | 23.75 | 50.54 | 81.39 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.00 |
| FLR [%] | 2.64 | 0.00 | 0.00 | 0.00 | 0.00 | 20.87 | 0.00 | 0.00 | 0.43 | 0.00 | 0.00 | 2.27 | 2.43 |
| UCL [%] | 2.64 | 0.00 | 0.00 | 0.00 | 0.00 | 20.87 | 0.00 | 0.00 | 0.43 | 0.00 | 0.00 | 2.27 | 2.17 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 78.09 | 52.94 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 10.92 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.41 | 1.07 | 1.50 | 0.41 | 0.00 | 0.00 | 0.00 | 0.29 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 240742.14 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.73 % |
| Cumulative Energy Availability Factor (EAF) | : 76.3 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.35 % |
| Cumulative Unit Capability Factor (UCF) | : 78.06 % | Cumulative Planned Unavailability Factor (PUF) | : 19.59 % |
| Cumulative Load Factor (LF) | : 76.94 % | Cumulative Externally cause unavailability (XUF) | : 1.75 % |
| Cumulative Operating Factor (OF) | : 80.08 % | | |

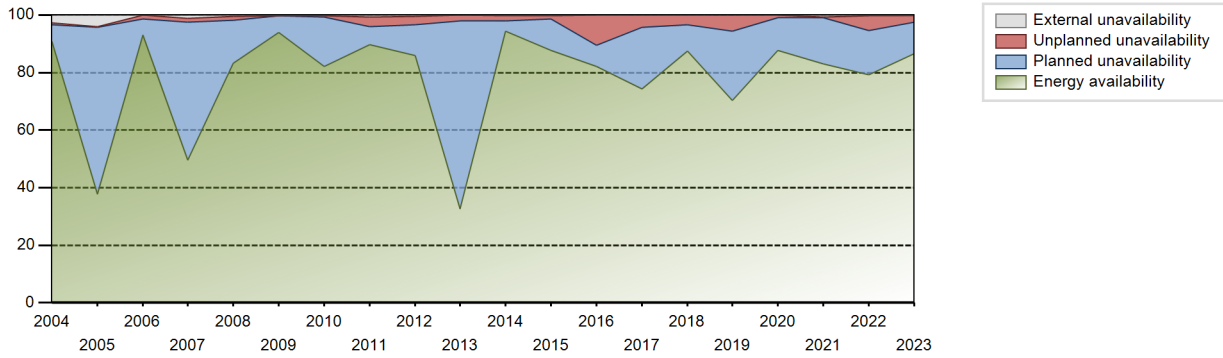
Electricity Production (net) [GWh]



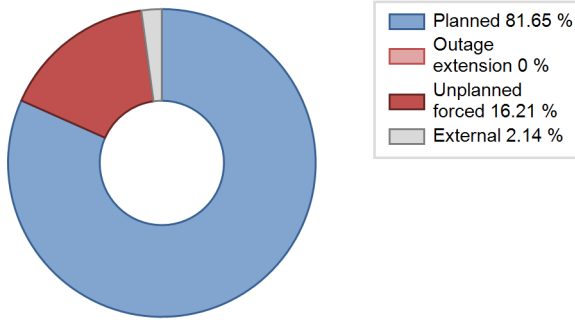
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 3623.94 | 4593 | 925 | 81.32 | 90.61 | 80.97 | 91.89 | 6.31 | 6.10 | 3.29 | 9.28 |
| 1986 | 6667.30 | 7442 | 925 | 82.57 | 82.57 | 82.28 | 84.95 | 1.56 | 1.31 | 16.12 | 0.00 |
| 1987 | 6364.93 | 6707 | 1000 | 74.52 | 74.52 | 72.66 | 76.56 | 4.46 | 3.48 | 22.01 | 0.00 |
| 1988 | 6757.16 | 7594 | 925 | 83.49 | 83.55 | 83.16 | 86.45 | 1.83 | 1.56 | 14.89 | 0.06 |
| 1989 | 6627.33 | 7336 | 925 | 81.50 | 81.85 | 81.79 | 83.74 | 2.69 | 2.26 | 15.88 | 0.36 |
| 1990 | 6710.59 | 7453 | 925 | 82.52 | 82.97 | 82.82 | 85.08 | 5.48 | 4.81 | 12.22 | 0.45 |
| 1991 | 5796.72 | 6495 | 925 | 71.36 | 71.36 | 71.54 | 74.14 | 3.36 | 2.48 | 26.16 | 0.00 |
| 1992 | 6731.61 | 7472 | 925 | 82.63 | 83.90 | 82.86 | 85.07 | 1.14 | 0.96 | 15.13 | 1.28 |
| 1993 | 6634.11 | 7492 | 925 | 82.69 | 84.90 | 81.87 | 85.53 | 0.29 | 0.25 | 14.86 | 2.21 |
| 1994 | 5259.83 | 7044 | 925 | 66.56 | 80.25 | 64.91 | 80.41 | 0.03 | 0.02 | 19.73 | 13.69 |
| 1995 | 5337.40 | 6738 | 925 | 66.84 | 80.32 | 65.87 | 76.92 | 0.26 | 0.21 | 19.47 | 13.49 |
| 1996 | 6127.71 | 7010 | 925 | 77.82 | 79.09 | 75.42 | 79.80 | 0.89 | 0.71 | 20.20 | 1.27 |
| 1997 | 4991.02 | 5642 | 925 | 61.57 | 61.70 | 61.59 | 64.41 | 4.41 | 2.84 | 35.46 | 0.13 |
| 1998 | 5297.02 | 6576 | 925 | 65.58 | 73.88 | 65.37 | 75.07 | 1.37 | 1.03 | 25.09 | 8.30 |
| 1999 | 5362.50 | 6090 | 925 | 66.03 | 69.14 | 66.18 | 69.52 | 0.12 | 0.09 | 30.78 | 3.11 |
| 2000 | 6566.15 | 7108 | 925 | 80.10 | 80.54 | 80.81 | 80.92 | 3.91 | 3.28 | 16.19 | 0.44 |
| 2001 | 6457.64 | 7537 | 925 | 78.96 | 81.02 | 79.69 | 86.04 | 6.08 | 5.25 | 13.73 | 2.06 |
| 2002 | 3431.09 | 3890 | 925 | 41.69 | 43.60 | 42.34 | 44.41 | 1.66 | 0.74 | 55.66 | 1.91 |
| 2003 | 6438.59 | 7734 | 925 | 79.13 | 81.42 | 79.46 | 88.29 | 8.45 | 7.52 | 11.06 | 2.29 |
| 2004 | 7480.14 | 8312 | 925 | 90.85 | 93.66 | 92.06 | 94.63 | 0.62 | 0.59 | 5.75 | 2.80 |
| 2005 | 3053.40 | 3734 | 925 | 37.72 | 41.71 | 37.68 | 42.63 | 0.42 | 0.17 | 58.11 | 4.00 |
| 2006 | 7623.87 | 8306 | 925 | 93.15 | 93.15 | 94.09 | 94.82 | 0.16 | 1.27 | 5.58 | 0.00 |
| 2007 | 4096.43 | 4878 | 925 | 49.68 | 50.76 | 50.55 | 55.68 | 2.50 | 1.30 | 47.94 | 1.08 |
| 2008 | 6718.76 | 7823 | 925 | 83.20 | 83.66 | 82.69 | 89.06 | 1.71 | 1.46 | 14.89 | 0.46 |
| 2009 | 7668.41 | 8279 | 925 | 93.84 | 94.10 | 94.64 | 94.51 | 0.09 | 0.08 | 5.82 | 0.26 |
| 2010 | 6651.23 | 7626 | 925 | 82.04 | 82.31 | 82.08 | 87.05 | 0.56 | 0.46 | 17.23 | 0.27 |
| 2011 | 7328.17 | 8314 | 925 | 89.65 | 90.28 | 90.45 | 94.92 | 3.58 | 3.36 | 6.36 | 0.63 |
| 2012 | 6802.21 | 7767 | 925 | 85.94 | 86.34 | 83.72 | 88.42 | 3.24 | 2.89 | 10.76 | 0.41 |
| 2013 | 2630.28 | 3045 | 925 | 32.61 | 32.62 | 32.46 | 34.76 | 5.82 | 2.02 | 65.36 | 0.01 |
| 2014 | 7821.17 | 8524 | 925 | 94.28 | 94.57 | 96.51 | 97.29 | 1.89 | 1.82 | 3.61 | 0.29 |
| 2015 | 7404.36 | 7809 | 925 | 87.61 | 87.79 | 91.38 | 89.14 | 1.26 | 1.12 | 11.09 | 0.17 |
| 2016 | 6910.57 | 7360 | 925 | 82.20 | 82.32 | 85.05 | 83.79 | 11.12 | 10.30 | 7.39 | 0.12 |
| 2017 | 6307.00 | 6734 | 925 | 74.22 | 74.29 | 77.84 | 76.87 | 5.42 | 4.26 | 21.45 | 0.07 |
| 2018 | 7352.87 | 7772 | 925 | 87.37 | 87.42 | 90.74 | 88.72 | 3.77 | 3.43 | 9.16 | 0.05 |
| 2019 | 5918.57 | 6573 | 925 | 70.29 | 70.31 | 73.04 | 75.03 | 7.33 | 5.56 | 24.13 | 0.03 |
| 2020 | 7313.92 | 7838 | 925 | 87.74 | 87.86 | 90.02 | 89.23 | 0.86 | 0.76 | 11.38 | 0.11 |
| 2021 | 6939.32 | 7444 | 925 | 83.12 | 83.80 | 85.64 | 84.98 | 0.39 | 0.33 | 15.87 | 0.68 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 6641.85 | 7002 | 925 | 79.30 | 79.46 | 81.97 | 79.93 | 0.06 | 5.34 | 15.21 | 0.16 |
| 2023 | 7182.68 | 7709 | 925 | 86.63 | 86.91 | 88.64 | 88.00 | 2.43 | 2.17 | 10.92 | 0.29 |

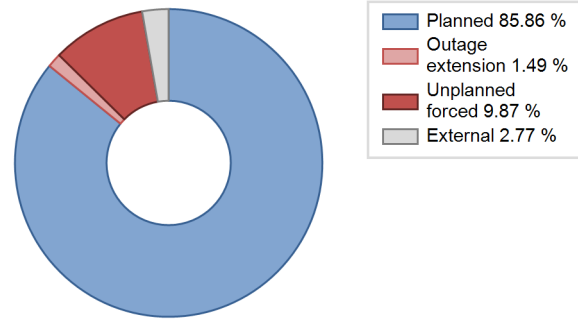
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 134 | | | 95 | |
| C. Inspection, maintenance or repair combined with refuelling | 917 | | | 1025 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 250 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 125 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 229 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 10 |
| L. Human factor related | | | | | 2 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 9 |
| Z. Other | | | | | 2 | |
| Subtotal | 917 | 134 | | 1629 | 99 | 19 |
| Total | | 1051 | | | 1747 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 16 |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 5 |
| 14. Safety Systems | | 0 |
| 15. Reactor Cooling Systems | 134 | 37 |
| 16. Steam generation systems | | 1 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 5 |
| 32. Feedwater and Main Steam System | | 8 |
| 34. Miscellaneous Systems | | 3 |
| 42. Electrical Power Supply Systems | | 13 |
| Total | 134 | 97 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-June, September-December. Additional electricity generation amounted to 162578 MWh. The unit was in the routine maintenance from 2023.04.08 to 2023.05.16. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

RU-67 **SMOLENSK-3** **RUSSIA**

Status at end of year : **Operational**
 Operator : REA (Joint Stock Company 'Concern Rosenergoatom')
 Owner : REA (Joint Stock Company 'Concern Rosenergoatom')
 Reactor Supplier : AEM (Atomenergomash)
 Turbine Supplier : KTF (Kharkiv Turbine Factory)

| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : LWGR / RBMK-1000 | Construction Date | : 1984-05-01 |
| Thermal power | : 3200 MWth | Grid Date | : 1990-01-17 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1990-10-12 |
| Reference unit power (net) | : 925 MWe | Age at end of year | : 33 years |

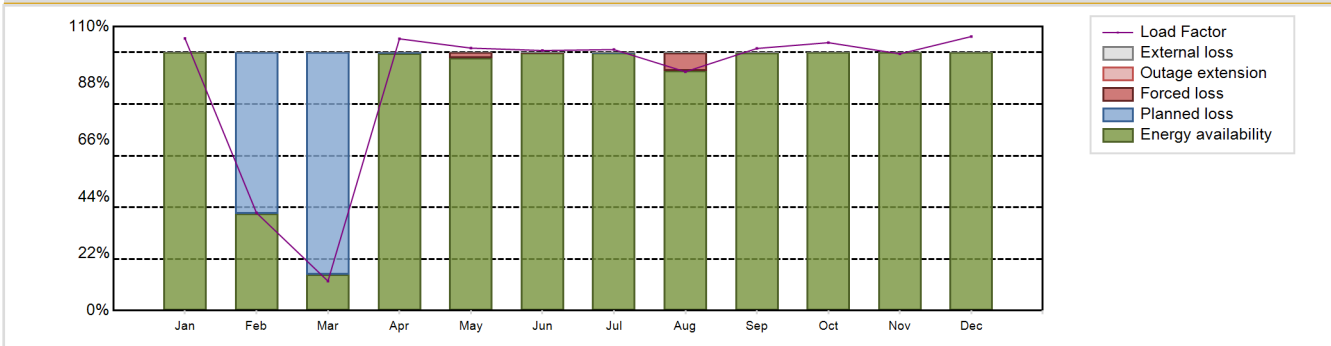
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|------------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 284 |
| Refuelling type | : ON-line | Number of SG | : NA |
| Moderator material | : GRAPHITE | Containment type | : Confinement |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : - |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 2 |
| Average discharge burnup [MWd/t] | : 22200 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 11.8 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 7 | HP cylinder inlet steam pressure [MPa] | : 6.59 |
| Number of fissile fuel assemblies/bundles | : 1661 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 14.5 | Primary means of condenser cooling | : River (once-through) |
| Number of control rod assemblies | : 175 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : PH / DH |

Annual Production Results (2023)

| | | | |
|--|-------------------|--|-------------|
| Net Energy Production | : 7227.81 GW(e).h | Forced Loss Rate (FLR) | : 0.89 % |
| Energy Availability Factor (EAF) | : 87.06 % | Unplanned Capability Loss Factor (UCL) | : 0.78 % |
| Unit Capability Factor (UCF) | : 87.1 % | Planned Unavailability Factor (PUF) | : 12.12 % |
| Load Factor (LF) | : 89.2 % | Externally cause unavailability (XUF) | : 0.03 % |
| Operating Factor (OF) | : 88.77 % | Total off-line time | : 984 hours |
| Equivalent non-electrical energy generated (NEG) | : 47.28 GW(e).h | | |

Annual Summary

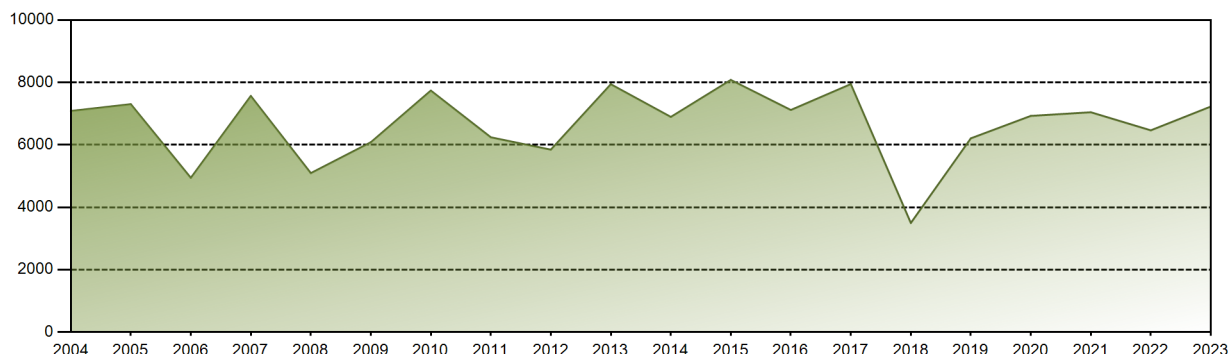


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 725.43 | 235.53 | 78.70 | 701.17 | 699.78 | 670.99 | 695.84 | 636.70 | 676.29 | 714.29 | 662.44 | 730.66 | 7227.81 |
| EAF [%] | 100.00 | 37.69 | 14.03 | 99.54 | 97.82 | 99.82 | 99.92 | 92.84 | 99.97 | 100.00 | 100.00 | 100.00 | 87.06 |
| UCF [%] | 100.00 | 37.69 | 14.03 | 99.54 | 97.82 | 99.90 | 99.96 | 93.09 | 100.00 | 100.00 | 100.00 | 100.00 | 87.10 |
| LF [%] | 105.41 | 37.89 | 11.44 | 105.28 | 101.68 | 100.75 | 101.11 | 92.52 | 101.54 | 103.79 | 99.47 | 106.17 | 89.20 |
| OF [%] | 100.00 | 39.73 | 27.69 | 100.00 | 100.00 | 100.00 | 100.00 | 94.49 | 100.00 | 100.00 | 100.00 | 100.00 | 88.77 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 2.18 | 0.10 | 0.00 | 6.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.89 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 2.18 | 0.10 | 0.00 | 6.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.78 |
| PUF [%] | 0.00 | 62.31 | 85.97 | 0.46 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.12 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.04 | 0.25 | 0.03 | 0.00 | 0.00 | 0.00 | 0.03 |

Historical Summary

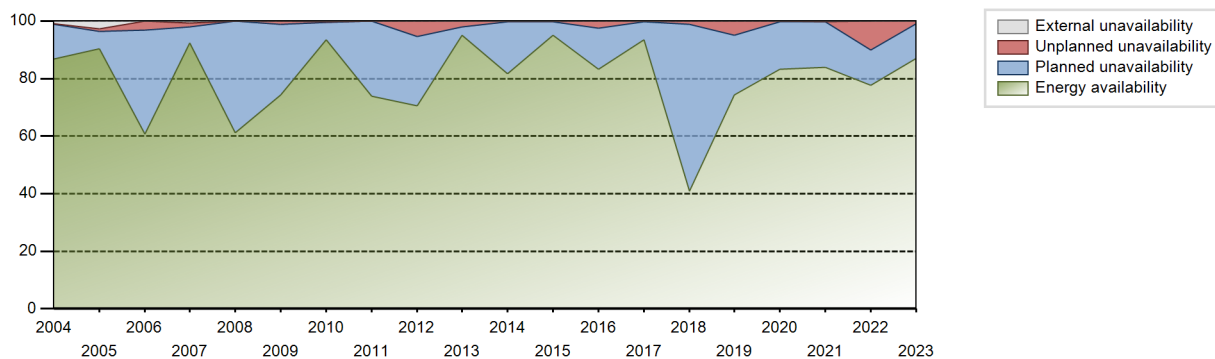
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 219914.21 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.24 % |
| Cumulative Energy Availability Factor (EAF) | : 79.29 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.92 % |
| Cumulative Unit Capability Factor (UCF) | : 80.76 % | Cumulative Planned Unavailability Factor (PUF) | : 17.32 % |
| Cumulative Load Factor (LF) | : 80.54 % | Cumulative Externally cause unavailability (XUF) | : 1.47 % |
| Cumulative Operating Factor (OF) | : 81.55 % | | |

Electricity Production (net) [GWh]

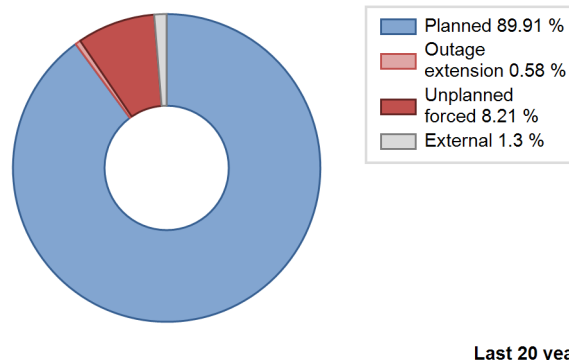
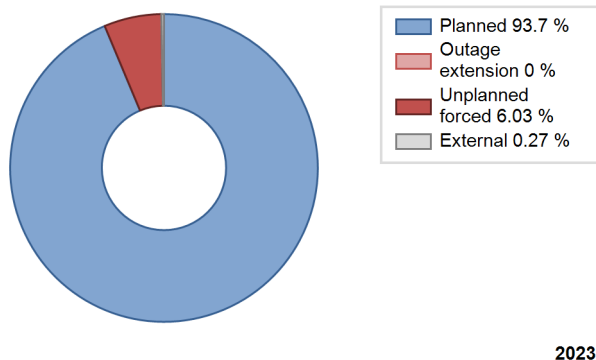


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1990 | 4570.76 | 6767 | 925 | 99.06 | 99.06 | 101.20 | 100.00 | 0.62 | 0.62 | 0.32 | 0.00 |
| 1991 | 6561.74 | 7338 | 925 | 80.87 | 80.87 | 80.98 | 83.77 | 3.91 | 3.29 | 15.84 | 0.00 |
| 1992 | 6866.56 | 7515 | 925 | 83.90 | 83.92 | 84.52 | 85.56 | 6.83 | 6.15 | 9.93 | 0.03 |
| 1993 | 6595.99 | 7419 | 925 | 81.42 | 82.61 | 81.40 | 84.69 | 1.76 | 1.48 | 15.91 | 1.19 |
| 1994 | 5513.66 | 6701 | 925 | 72.50 | 82.28 | 68.04 | 76.50 | 0.43 | 0.35 | 17.37 | 9.78 |
| 1995 | 5090.97 | 5844 | 925 | 63.17 | 78.19 | 62.83 | 66.71 | 1.13 | 0.89 | 20.92 | 15.02 |
| 1996 | 6496.64 | 7268 | 925 | 80.83 | 82.16 | 79.96 | 82.74 | 7.42 | 6.58 | 11.25 | 1.34 |
| 1997 | 5559.27 | 6469 | 925 | 69.32 | 69.32 | 68.61 | 73.85 | 6.03 | 4.45 | 26.23 | 0.00 |
| 1998 | 4575.89 | 6162 | 925 | 57.53 | 68.95 | 56.47 | 70.34 | 3.48 | 2.49 | 28.56 | 11.42 |
| 1999 | 6410.98 | 7063 | 925 | 78.19 | 79.31 | 79.12 | 80.63 | 0.39 | 0.31 | 20.38 | 1.12 |
| 2000 | 6970.48 | 7542 | 925 | 84.58 | 84.70 | 85.79 | 85.86 | 2.37 | 2.06 | 13.24 | 0.12 |
| 2001 | 6951.72 | 7823 | 925 | 85.39 | 87.30 | 85.79 | 89.30 | 0.15 | 0.13 | 12.57 | 1.91 |
| 2002 | 7204.90 | 7831 | 925 | 87.67 | 88.71 | 88.92 | 89.39 | 0.30 | 0.27 | 11.02 | 1.03 |
| 2003 | 7038.23 | 7697 | 925 | 86.26 | 87.09 | 86.86 | 87.87 | 0.20 | 0.18 | 12.73 | 0.82 |
| 2004 | 7085.74 | 7765 | 925 | 86.88 | 87.86 | 87.21 | 88.40 | 0.00 | 0.08 | 12.05 | 0.99 |
| 2005 | 7303.68 | 8192 | 925 | 90.36 | 93.06 | 90.14 | 93.52 | 1.07 | 1.01 | 5.93 | 2.70 |
| 2006 | 4942.96 | 5631 | 925 | 60.71 | 60.71 | 61.00 | 64.28 | 4.39 | 3.15 | 36.14 | 0.00 |
| 2007 | 7566.25 | 8247 | 925 | 92.46 | 93.15 | 93.38 | 94.14 | 1.48 | 1.40 | 5.44 | 0.70 |
| 2008 | 5093.44 | 5396 | 925 | 61.23 | 61.29 | 62.69 | 61.43 | 0.07 | 0.04 | 38.67 | 0.06 |
| 2009 | 6082.98 | 6706 | 925 | 74.30 | 74.31 | 75.07 | 76.55 | 1.66 | 1.26 | 24.44 | 0.00 |
| 2010 | 7738.82 | 8233 | 925 | 93.55 | 93.71 | 95.51 | 93.98 | 0.12 | 0.38 | 5.91 | 0.16 |
| 2011 | 6241.79 | 6579 | 925 | 73.98 | 74.01 | 77.04 | 75.11 | 0.15 | 0.11 | 25.88 | 0.03 |
| 2012 | 5845.23 | 6279 | 925 | 70.62 | 70.62 | 71.94 | 71.48 | 7.04 | 5.35 | 24.03 | 0.00 |
| 2013 | 7942.17 | 8471 | 925 | 95.12 | 95.19 | 98.02 | 96.70 | 2.12 | 2.06 | 2.75 | 0.07 |
| 2014 | 6894.49 | 7219 | 925 | 81.72 | 81.82 | 85.08 | 82.40 | 0.30 | 0.24 | 17.94 | 0.10 |
| 2015 | 8079.91 | 8364 | 925 | 95.01 | 95.01 | 99.71 | 95.48 | 0.33 | 0.31 | 4.67 | 0.00 |
| 2016 | 7116.59 | 7352 | 925 | 83.34 | 83.35 | 87.59 | 83.70 | 2.89 | 2.48 | 14.17 | 0.02 |
| 2017 | 7946.26 | 8266 | 925 | 93.42 | 93.49 | 98.07 | 94.36 | 0.12 | 0.11 | 6.40 | 0.06 |
| 2018 | 3494.62 | 3601 | 925 | 40.84 | 40.84 | 43.13 | 41.11 | 0.66 | 1.09 | 58.07 | 0.00 |
| 2019 | 6207.98 | 6723 | 925 | 74.43 | 74.46 | 76.61 | 76.75 | 5.25 | 4.90 | 20.64 | 0.03 |
| 2020 | 6927.47 | 7624 | 925 | 83.21 | 83.22 | 85.26 | 86.79 | 0.35 | 0.29 | 16.49 | 0.00 |
| 2021 | 7044.34 | 7418 | 925 | 83.94 | 84.13 | 86.93 | 84.68 | 0.02 | 0.01 | 15.85 | 0.19 |
| 2022 | 6464.67 | 6991 | 925 | 77.70 | 77.76 | 79.78 | 79.81 | 11.48 | 10.09 | 12.15 | 0.06 |
| 2023 | 7227.81 | 7776 | 925 | 87.06 | 87.10 | 89.20 | 88.77 | 0.89 | 0.78 | 12.12 | 0.03 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1990 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 41 | | | 92 | |
| C. Inspection, maintenance or repair combined with refuelling | 943 | | | 1012 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 238 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 162 | | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 94 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 2 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 48 |
| Z. Other | | | | | 16 | |
| Subtotal | 943 | 41 | | 1506 | 110 | 49 |
| Total | | 984 | | | 1665 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1990 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 13 |
| 12. Reactor I&C Systems | | 12 |
| 13. Reactor Auxiliary Systems | | 3 |
| 15. Reactor Cooling Systems | | 8 |
| 16. Steam generation systems | | 27 |
| 31. Turbine and auxiliaries | | 8 |
| 32. Feedwater and Main Steam System | | 4 |
| 34. Miscellaneous Systems | | 4 |
| 35. All other I&C Systems | | 3 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | 41 | 8 |
| Total | 41 | 92 |

Highlights (2023)

The Russian NPPs are operating in the baseload mode agreed with the Russia's Federal Energy Commission. Unit operation at power level above installed capacity took place in January-February, April-December. Additional electricity generation amounted to 236885 MWh. The unit was in the intermediate maintenance outage from 2023.02.12 to 2023.03.23. Radionuclides content in the monitored environmental objects in the plant vicinity was on the level of average background values typical for the European part of the Russian Federation.

2023 Operating Experience

SK-13

BOHUNICE-3

SLOVAKIA

Status at end of year : **Operational**
 Operator : SE (SLOVENSKÉ ELEKTRÁRNE, A.S.)
 Owner : SE (SLOVENSKÉ ELEKTRÁRNE, A.S.)
 Reactor Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1471 MWth
 Gross electrical power : 500 MWe
 Reference unit power (net) : 466 MWe

Key Dates

Construction Date : 1976-12-01
 Grid Date : 1984-08-20
 Commercial Date : 1985-02-14
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.25
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 23
 Average discharge burnup [MWd/t] : 55000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.49
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.3
 Reactor outlet temperature [°C] : 297
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.245

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.32
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 6
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

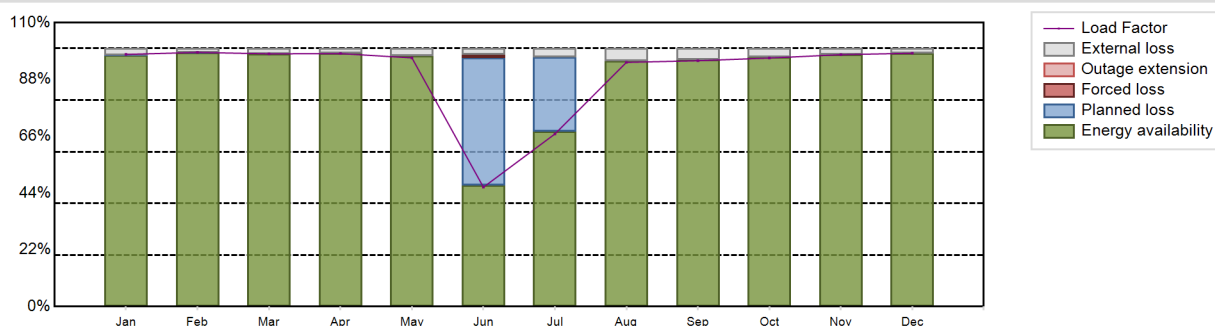
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 3685.7 GW(e).h
 Energy Availability Factor (EAF) : 90.55 %
 Unit Capability Factor (UCF) : 93.37 %
 Load Factor (LF) : 90.29 %
 Operating Factor (OF) : 93.57 %
 Equivalent non-electrical energy generated (NEG) : 46.78 GW(e).h

Forced Loss Rate (FLR) : 0.1 %
 Unplanned Capability Loss Factor (UCL) : 0.09 %
 Planned Unavailability Factor (PUF) : 6.54 %
 Externally cause unavailability (XUF) : 2.83 %
 Total off-line time : 563 hours

Annual Summary

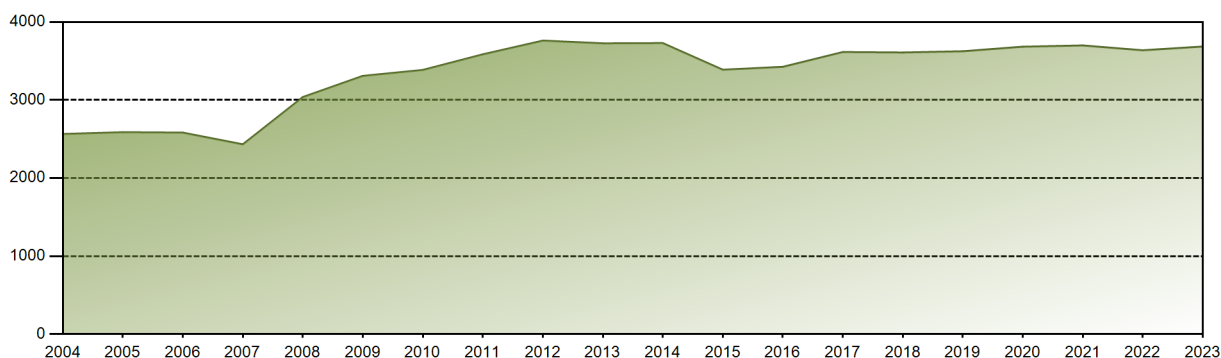


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 338.71 | 308.38 | 339.48 | 328.86 | 334.02 | 155.24 | 231.86 | 328.02 | 319.55 | 333.82 | 327.45 | 340.31 | 3685.70 |
| EAF [%] | 97.49 | 98.33 | 98.00 | 98.17 | 97.08 | 46.88 | 67.77 | 95.03 | 95.56 | 96.57 | 97.62 | 98.04 | 90.55 |
| UCF [%] | 99.99 | 99.94 | 100.00 | 100.00 | 100.00 | 49.36 | 71.06 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.37 |
| LF [%] | 97.69 | 98.48 | 97.92 | 98.01 | 96.34 | 46.27 | 66.88 | 94.61 | 95.24 | 96.28 | 97.60 | 98.15 | 90.29 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 50.42 | 72.31 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.57 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 |
| PUF [%] | 0.01 | 0.06 | 0.00 | 0.00 | 0.00 | 49.55 | 28.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.54 |
| XUF [%] | 2.50 | 1.61 | 2.00 | 1.83 | 2.92 | 2.48 | 3.30 | 4.97 | 4.44 | 3.43 | 2.38 | 1.96 | 2.83 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 120150.69 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.11 % |
| Cumulative Energy Availability Factor (EAF) | : 82.15 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.1 % |
| Cumulative Unit Capability Factor (UCF) | : 85.36 % | Cumulative Planned Unavailability Factor (PUF) | : 13.55 % |
| Cumulative Load Factor (LF) | : 80.75 % | Cumulative Externally cause unavailability (XUF) | : 3.21 % |
| Cumulative Operating Factor (OF) | : 86.2 % | | |

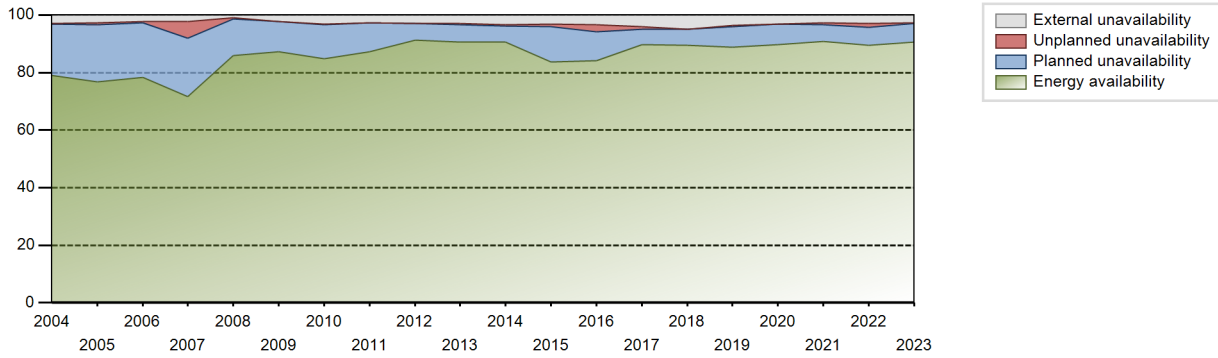
Electricity Production (net) [GWh]



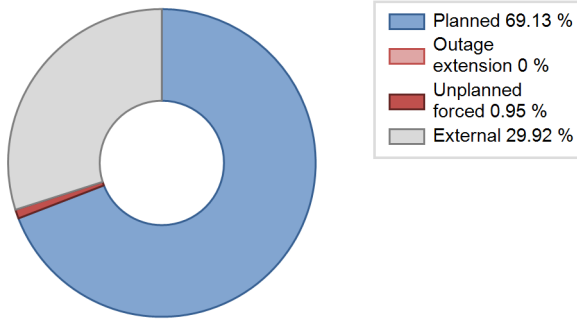
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 2721.56 | 7057 | 408 | 76.82 | 76.82 | 74.45 | 78.87 | 1.66 | 1.30 | 21.89 | 0.00 |
| 1986 | 2674.14 | 7089 | 408 | 75.40 | 75.43 | 74.82 | 80.92 | 7.77 | 6.35 | 18.22 | 0.03 |
| 1987 | 1997.38 | 5181 | 408 | 53.70 | 55.54 | 55.89 | 59.14 | 2.29 | 1.30 | 43.16 | 1.83 |
| 1988 | 2866.88 | 7329 | 408 | 79.89 | 80.24 | 79.99 | 83.44 | 0.42 | 0.34 | 19.43 | 0.35 |
| 1989 | 2992.32 | 7633 | 408 | 84.14 | 85.01 | 83.72 | 87.13 | 0.57 | 0.49 | 14.50 | 0.88 |
| 1990 | 2829.10 | 7376 | 408 | 79.25 | 80.49 | 79.16 | 84.20 | 5.39 | 4.59 | 14.93 | 1.24 |
| 1991 | 2585.64 | 6717 | 408 | 71.95 | 74.16 | 72.34 | 76.68 | 1.36 | 1.03 | 24.81 | 2.21 |
| 1992 | 3140.69 | 7528 | 408 | 82.77 | 83.89 | 87.63 | 85.70 | 0.75 | 0.63 | 15.48 | 1.12 |
| 1993 | 2973.14 | 7721 | 408 | 83.19 | 86.52 | 83.19 | 88.14 | 1.24 | 1.09 | 12.39 | 3.34 |
| 1994 | 2806.83 | 7423 | 405 | 79.05 | 84.03 | 79.11 | 84.74 | 0.73 | 0.62 | 15.36 | 4.97 |
| 1995 | 2536.71 | 6440 | 408 | 70.14 | 78.13 | 70.98 | 73.52 | 1.74 | 1.39 | 20.48 | 8.00 |
| 1996 | 3045.91 | 7504 | 436 | 82.50 | 85.56 | 79.53 | 85.43 | 1.45 | 1.26 | 13.18 | 3.06 |
| 1997 | 3096.42 | 7711 | 440 | 84.04 | 87.73 | 80.33 | 88.03 | 0.49 | 0.43 | 11.84 | 3.69 |
| 1998 | 2804.63 | 7571 | 408 | 81.80 | 85.32 | 78.47 | 86.43 | 2.30 | 2.00 | 12.68 | 3.52 |
| 1999 | 2468.54 | 6620 | 408 | 69.65 | 76.46 | 69.07 | 75.57 | 3.81 | 3.03 | 20.51 | 6.81 |
| 2000 | 2806.72 | 7776 | 408 | 79.82 | 87.92 | 78.32 | 88.52 | 1.07 | 0.95 | 11.13 | 8.10 |
| 2001 | 2686.99 | 7680 | 408 | 76.48 | 86.60 | 75.18 | 87.67 | 1.03 | 0.90 | 12.50 | 10.12 |
| 2002 | 2690.74 | 7711 | 408 | 83.86 | 87.38 | 75.28 | 88.03 | 0.22 | 0.19 | 12.43 | 3.52 |
| 2003 | 2484.97 | 6908 | 408 | 75.46 | 78.28 | 69.53 | 78.86 | 0.16 | 0.13 | 21.59 | 2.82 |
| 2004 | 2564.55 | 7228 | 408 | 79.03 | 81.97 | 71.56 | 82.29 | 0.39 | 0.32 | 17.72 | 2.93 |
| 2005 | 2587.73 | 7034 | 408 | 76.69 | 79.44 | 72.40 | 80.30 | 0.91 | 0.73 | 19.83 | 2.74 |
| 2006 | 2582.58 | 7106 | 408 | 78.36 | 80.73 | 72.26 | 81.12 | 0.29 | 0.24 | 19.03 | 2.37 |
| 2007 | 2432.56 | 6687 | 408 | 71.57 | 73.84 | 68.06 | 76.34 | 7.18 | 5.71 | 20.45 | 2.27 |
| 2008 | 3038.40 | 7680 | 429 | 85.82 | 86.69 | 83.70 | 87.43 | 0.56 | 0.49 | 12.82 | 0.87 |
| 2009 | 3309.67 | 8176 | 442 | 87.18 | 89.33 | 87.40 | 93.33 | 0.12 | 0.10 | 10.56 | 2.15 |
| 2010 | 3385.92 | 8194 | 472 | 84.80 | 87.97 | 85.98 | 93.54 | 0.26 | 0.23 | 11.80 | 3.17 |
| 2011 | 3586.04 | 7890 | 472 | 87.25 | 89.94 | 86.73 | 90.07 | 0.04 | 0.04 | 10.03 | 2.69 |
| 2012 | 3761.71 | 8295 | 472 | 91.28 | 94.17 | 90.73 | 94.43 | 0.02 | 0.02 | 5.81 | 2.90 |
| 2013 | 3726.97 | 8245 | 472 | 90.67 | 93.71 | 90.14 | 94.12 | 0.38 | 0.36 | 5.93 | 3.04 |
| 2014 | 3730.20 | 8235 | 471 | 90.60 | 93.90 | 90.41 | 94.01 | 0.01 | 0.58 | 5.53 | 3.30 |
| 2015 | 3388.98 | 7635 | 471 | 83.58 | 86.81 | 82.14 | 87.16 | 0.40 | 0.73 | 12.46 | 3.23 |
| 2016 | 3425.51 | 7738 | 471 | 84.12 | 87.53 | 82.80 | 88.09 | 0.45 | 2.46 | 10.00 | 3.42 |
| 2017 | 3615.51 | 8231 | 471 | 89.61 | 93.73 | 87.63 | 93.96 | 0.05 | 0.89 | 5.38 | 4.12 |
| 2018 | 3609.99 | 8288 | 471 | 89.51 | 94.39 | 87.49 | 94.61 | 0.00 | 0.12 | 5.49 | 4.88 |
| 2019 | 3625.03 | 8135 | 471 | 88.72 | 92.26 | 87.86 | 92.87 | 0.33 | 0.59 | 7.14 | 3.55 |
| 2020 | 3683.59 | 8236 | 466 | 89.64 | 92.78 | 89.11 | 93.76 | 0.09 | 0.08 | 7.14 | 3.14 |
| 2021 | 3699.61 | 8307 | 466 | 90.90 | 93.67 | 90.63 | 94.83 | 0.32 | 0.54 | 5.79 | 2.76 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|------|------|
| 2022 | 3637.81 | 8248 | 466 | 89.43 | 92.26 | 89.11 | 94.16 | 1.11 | 1.53 | 6.20 | 2.83 |
| 2023 | 3685.70 | 8197 | 466 | 90.55 | 93.37 | 90.29 | 93.57 | 0.10 | 0.09 | 6.54 | 2.83 |

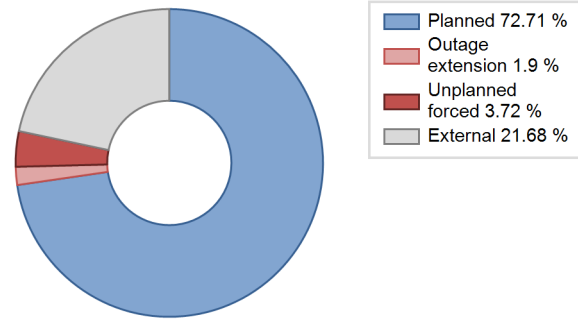
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 75 | |
| C. Inspection, maintenance or repair combined with refuelling | 563 | | | 1040 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 85 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 5 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 0 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 1 | |
| Subtotal | 563 | | | 1125 | 76 | 7 |
| Total | | 563 | | | 1208 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 7 |
| 12. Reactor I&C Systems | | 4 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 11 |
| 16. Steam generation systems | | 23 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 0 |
| 32. Feedwater and Main Steam System | | 7 |
| 33. Circulating Water System | | 1 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 1 |
| 42. Electrical Power Supply Systems | | 17 |
| Total | | 76 |

Highlights (2023)

31.01.2023, 07.02.-08.02.2023 ancillary services testing and certification (aFRR-, mFRR-). Operation without any planned or unplanned power decreasing. Steam extraction for district heating exchanger.

11.06. - 14.06.2023 coast-down operation.

14.06.-16.06.2023 reactor power decreasing to 82 % due to water level increasing in moisture separator/reheater (SPP) TG31.

16.06. - 11.07.2023 annual maintenance and refuelling, start-up operation, scheduled measuring and testing.

From 14.07.2023 steam extraction for district heating exchanger.

2023 Operating Experience

SK-14

BOHUNICE-4

SLOVAKIA

Status at end of year : **Operational**
 Operator : SE (SLOVENSKÉ ELEKTRÁRNE, A.S.)
 Owner : SE (SLOVENSKÉ ELEKTRÁRNE, A.S.)
 Reactor Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1471 MWth
 Gross electrical power : 500 MWe
 Reference unit power (net) : 466 MWe

Key Dates

Construction Date : 1976-12-01
 Grid Date : 1985-08-09
 Commercial Date : 1985-12-18
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.25
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 22
 Average discharge burnup [MWd/t] : 54000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.49
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.3
 Reactor outlet temperature [°C] : 297
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.245

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.32
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 6
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

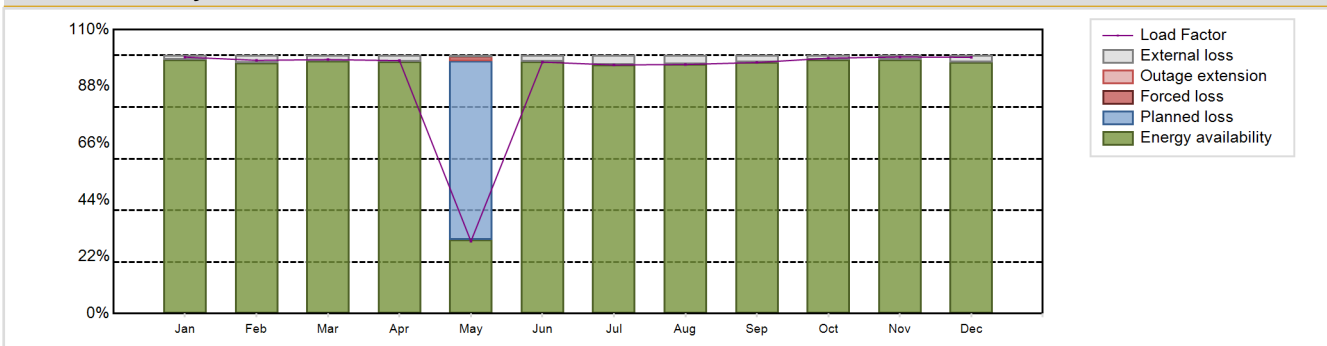
Non-electrical applications : DH / PH

Annual Production Results (2023)

Net Energy Production : 3761.34 GW(e).h
 Energy Availability Factor (EAF) : 91.75 %
 Unit Capability Factor (UCF) : 93.99 %
 Load Factor (LF) : 92.14 %
 Operating Factor (OF) : 94.11 %
 Equivalent non-electrical energy generated (NEG) : 49.76 GW(e).h

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0.13 %
 Planned Unavailability Factor (PUF) : 5.87 %
 Externally cause unavailability (XUF) : 2.25 %
 Total off-line time : 516 hours

Annual Summary

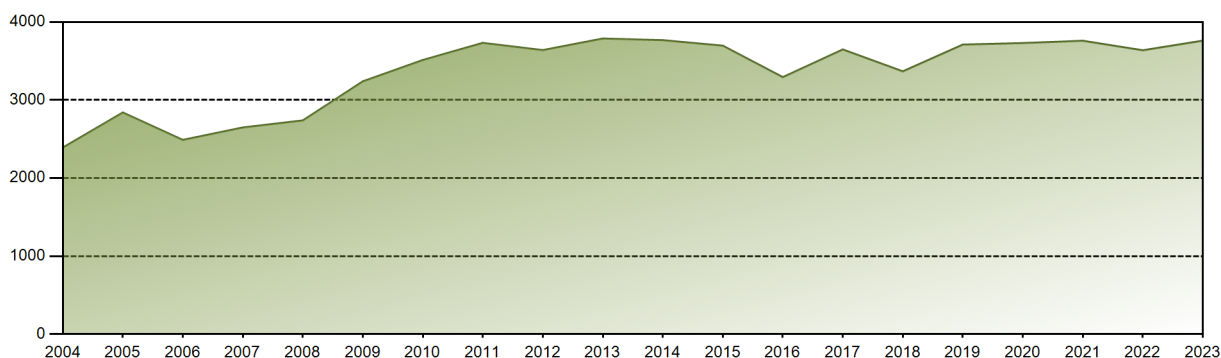


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 344.48 | 307.23 | 341.16 | 328.85 | 97.17 | 326.84 | 333.95 | 334.55 | 326.35 | 343.02 | 333.54 | 344.19 | 3761.34 |
| EAF [%] | 98.37 | 97.04 | 97.98 | 97.66 | 28.74 | 97.66 | 96.48 | 96.67 | 97.40 | 98.42 | 98.37 | 97.45 | 91.75 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 29.29 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.99 |
| LF [%] | 99.36 | 98.11 | 98.40 | 98.01 | 28.03 | 97.41 | 96.32 | 96.49 | 97.27 | 98.94 | 99.41 | 99.27 | 92.14 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 30.65 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.11 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 69.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.87 |
| XUF [%] | 1.63 | 2.96 | 2.02 | 2.34 | 0.54 | 2.34 | 3.52 | 3.33 | 2.60 | 1.58 | 1.63 | 2.55 | 2.25 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 119266.46 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.12 % |
| Cumulative Energy Availability Factor (EAF) | : 83.15 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.25 % |
| Cumulative Unit Capability Factor (UCF) | : 86.15 % | Cumulative Planned Unavailability Factor (PUF) | : 12.6 % |
| Cumulative Load Factor (LF) | : 81.92 % | Cumulative Externally cause unavailability (XUF) | : 3.01 % |
| Cumulative Operating Factor (OF) | : 86.98 % | | |

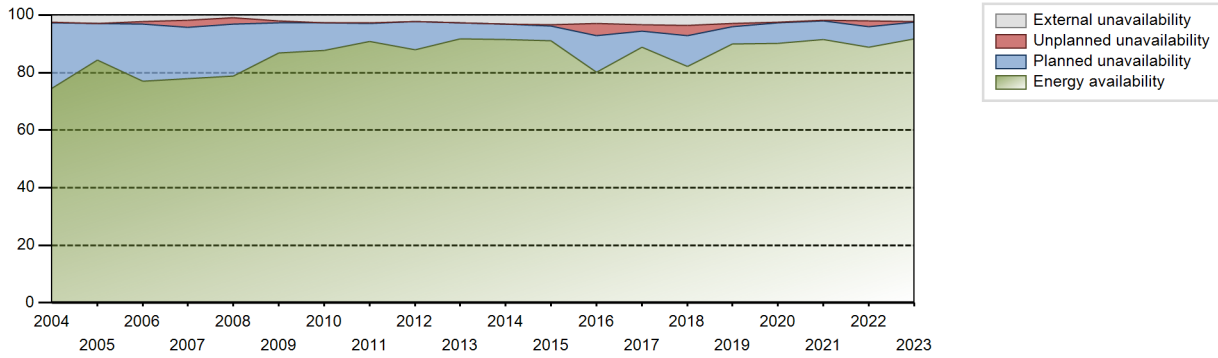
Electricity Production (net) [GWh]



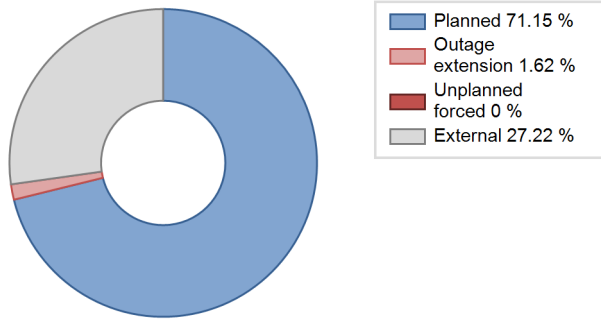
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 1083.50 | 3177 | 408 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1986 | 2887.85 | 7294 | 408 | 80.98 | 80.98 | 80.80 | 83.26 | 3.11 | 2.60 | 16.42 | 0.00 |
| 1987 | 3084.68 | 7783 | 408 | 86.11 | 86.60 | 86.31 | 88.85 | 0.89 | 0.78 | 12.63 | 0.49 |
| 1988 | 2786.46 | 7248 | 408 | 77.76 | 78.01 | 77.75 | 82.51 | 1.22 | 0.96 | 21.02 | 0.25 |
| 1989 | 2827.66 | 7548 | 408 | 79.20 | 79.98 | 79.12 | 86.16 | 5.84 | 4.96 | 15.06 | 0.78 |
| 1990 | 2873.81 | 7427 | 408 | 80.71 | 81.99 | 80.41 | 84.78 | 1.42 | 1.18 | 16.83 | 1.29 |
| 1991 | 2850.52 | 7438 | 408 | 80.36 | 82.88 | 79.76 | 84.91 | 0.54 | 0.45 | 16.66 | 2.52 |
| 1992 | 2711.90 | 6714 | 408 | 70.43 | 73.33 | 75.67 | 76.43 | 2.61 | 1.96 | 24.71 | 2.89 |
| 1993 | 2847.62 | 7341 | 408 | 79.68 | 82.63 | 79.67 | 83.80 | 5.40 | 4.72 | 12.65 | 2.95 |
| 1994 | 2791.41 | 7389 | 405 | 78.68 | 83.87 | 78.68 | 84.35 | 0.30 | 0.25 | 15.88 | 5.19 |
| 1995 | 2823.67 | 7211 | 408 | 79.29 | 88.47 | 79.00 | 82.32 | 0.96 | 0.86 | 10.67 | 9.18 |
| 1996 | 2834.89 | 6953 | 436 | 76.13 | 79.21 | 74.02 | 79.16 | 0.18 | 0.14 | 20.65 | 3.08 |
| 1997 | 2953.49 | 7469 | 440 | 80.22 | 84.66 | 76.63 | 85.26 | 2.41 | 2.09 | 13.25 | 4.43 |
| 1998 | 2822.41 | 7525 | 408 | 82.45 | 85.68 | 78.97 | 85.90 | 1.62 | 1.41 | 12.92 | 3.23 |
| 1999 | 2656.54 | 7283 | 408 | 75.13 | 81.68 | 74.33 | 83.14 | 2.00 | 1.66 | 16.66 | 6.54 |
| 2000 | 2431.85 | 6791 | 408 | 68.88 | 76.32 | 67.86 | 77.31 | 1.40 | 1.08 | 22.60 | 7.44 |
| 2001 | 2793.27 | 7721 | 408 | 79.25 | 86.73 | 78.15 | 88.14 | 1.29 | 1.13 | 12.14 | 7.48 |
| 2002 | 2823.23 | 7742 | 408 | 84.99 | 87.88 | 78.99 | 88.38 | 0.36 | 0.32 | 11.81 | 2.89 |
| 2003 | 2814.89 | 7737 | 408 | 84.35 | 87.76 | 78.76 | 88.32 | 0.42 | 0.37 | 11.87 | 3.41 |
| 2004 | 2390.94 | 6786 | 408 | 74.44 | 76.95 | 66.71 | 77.25 | 0.24 | 0.18 | 22.86 | 2.51 |
| 2005 | 2840.98 | 7671 | 408 | 84.31 | 87.29 | 79.49 | 87.57 | 0.06 | 0.05 | 12.66 | 2.98 |
| 2006 | 2489.28 | 7035 | 408 | 77.03 | 79.27 | 69.65 | 80.31 | 1.06 | 0.85 | 19.89 | 2.24 |
| 2007 | 2648.45 | 7053 | 408 | 77.97 | 79.87 | 74.10 | 80.51 | 2.90 | 2.39 | 17.74 | 1.90 |
| 2008 | 2739.03 | 7254 | 410 | 78.82 | 79.65 | 76.27 | 82.58 | 2.90 | 2.38 | 17.98 | 0.83 |
| 2009 | 3239.57 | 8118 | 448 | 86.87 | 88.92 | 87.05 | 92.67 | 0.67 | 0.60 | 10.48 | 2.06 |
| 2010 | 3513.14 | 8214 | 472 | 87.73 | 90.33 | 87.55 | 93.77 | 0.05 | 0.05 | 9.62 | 2.60 |
| 2011 | 3732.88 | 8225 | 472 | 90.80 | 93.43 | 90.28 | 93.89 | 0.27 | 0.25 | 6.32 | 2.62 |
| 2012 | 3640.36 | 7952 | 472 | 87.88 | 90.12 | 87.80 | 90.53 | 0.00 | 0.00 | 9.88 | 2.23 |
| 2013 | 3788.68 | 8313 | 471 | 91.81 | 94.54 | 91.83 | 94.90 | 0.07 | 0.07 | 5.40 | 2.72 |
| 2014 | 3767.52 | 8314 | 471 | 91.44 | 94.56 | 91.31 | 94.91 | 0.00 | 0.00 | 5.44 | 3.12 |
| 2015 | 3697.16 | 8285 | 471 | 91.11 | 94.40 | 89.61 | 94.58 | 0.05 | 0.54 | 5.06 | 3.28 |
| 2016 | 3293.87 | 7371 | 471 | 80.22 | 83.23 | 79.61 | 83.91 | 0.63 | 4.05 | 12.72 | 3.01 |
| 2017 | 3648.54 | 8115 | 471 | 88.85 | 92.33 | 88.43 | 92.64 | 0.12 | 2.03 | 5.64 | 3.49 |
| 2018 | 3367.93 | 7553 | 471 | 82.13 | 85.75 | 81.63 | 86.22 | 3.42 | 3.57 | 10.68 | 3.62 |
| 2019 | 3711.18 | 8157 | 471 | 90.02 | 92.85 | 89.95 | 93.12 | 0.01 | 1.28 | 5.87 | 2.82 |
| 2020 | 3730.79 | 8163 | 466 | 90.19 | 92.71 | 90.26 | 92.93 | 0.00 | 0.23 | 7.06 | 2.52 |
| 2021 | 3760.12 | 8227 | 466 | 91.51 | 93.37 | 92.11 | 93.92 | 0.14 | 0.13 | 6.50 | 1.87 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|------|------|
| 2022 | 3638.00 | 8061 | 466 | 88.79 | 90.84 | 89.12 | 92.02 | 0.95 | 2.06 | 7.11 | 2.04 |
| 2023 | 3761.34 | 8244 | 466 | 91.75 | 93.99 | 92.14 | 94.11 | 0.00 | 0.13 | 5.87 | 2.25 |

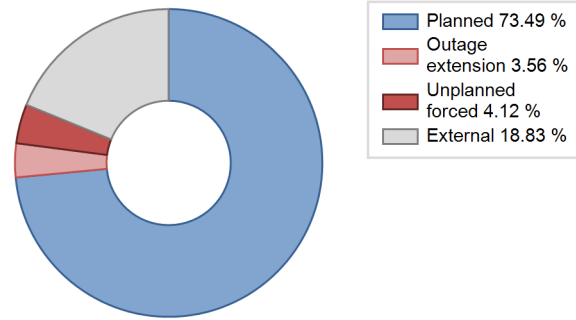
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 12 | | | 53 | |
| C. Inspection, maintenance or repair combined with refuelling | 504 | | | 1003 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 43 | | |
| E. Testing of plant systems or components | | | | 1 | 0 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 14 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 8 | |
| Subtotal | 504 | 12 | | 1061 | 61 | 0 |
| Total | | 516 | | | 1122 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 15 |
| 12. Reactor I&C Systems | | 4 |
| 15. Reactor Cooling Systems | 12 | 6 |
| 16. Steam generation systems | | 26 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 32. Feedwater and Main Steam System | | 5 |
| 33. Circulating Water System | | 0 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 0 |
| 42. Electrical Power Supply Systems | | 1 |
| Total | 12 | 61 |

Highlights (2023)

01.-05. 2023, operation without any planned or unplanned power decreasing. Steam extraction for district heating exchanger.

05.05. - 29.05.2023 planned unit shutdown, annual maintenance and refuelling, outage unplanned extension, unit start-up, scheduled measuring and testing.

From 15.10.2023 steam extraction for district heating exchanger.

2023 Operating Experience

SK-6

MOCHOVCE-1

SLOVAKIA

Status at end of year : **Operational**
 Operator : SE (SLOVENSKÉ ELEKTRÁRNE, A.S.)
 Owner : SE (SLOVENSKÉ ELEKTRÁRNE, A.S.)
 Reactor Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1471 MWth
 Gross electrical power : 500 MWe
 Reference unit power (net) : 467 MWe

Key Dates

Construction Date : 1983-10-13
 Grid Date : 1998-07-04
 Commercial Date : 1998-10-29
 Age at end of year : 25 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.415
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 22
 Average discharge burnup [MWd/t] : 54000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.49
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.0
 Reactor outlet temperature [°C] : 295
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.245

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.3
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 6
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

Non-electrical applications

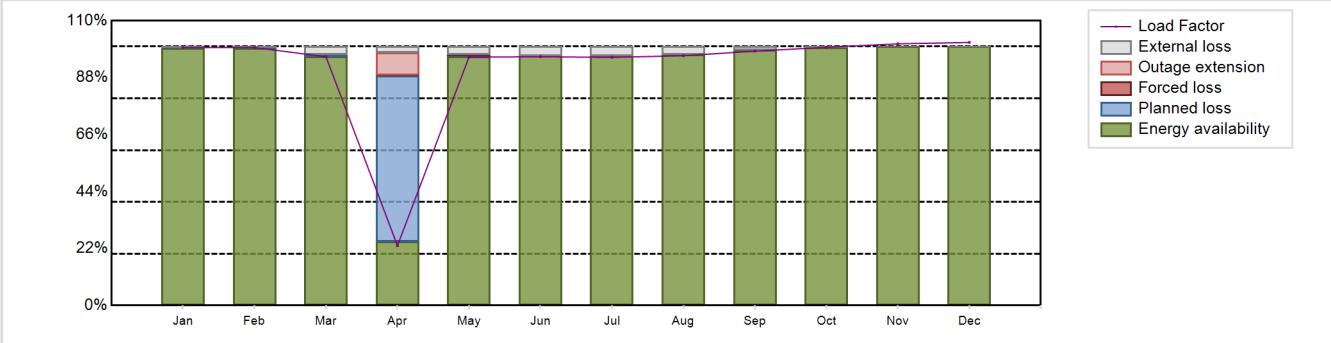
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3764.66 GW(e).h
 Energy Availability Factor (EAF) : 92.04 %
 Unit Capability Factor (UCF) : 93.87 %
 Load Factor (LF) : 92.02 %
 Operating Factor (OF) : 94.25 %

Forced Loss Rate (FLR) : 0.07 %
 Unplanned Capability Loss Factor (UCL) : 0.76 %
 Planned Unavailability Factor (PUF) : 5.37 %
 Externally cause unavailability (XUF) : 1.83 %
 Total off-line time : 504 hours

Annual Summary

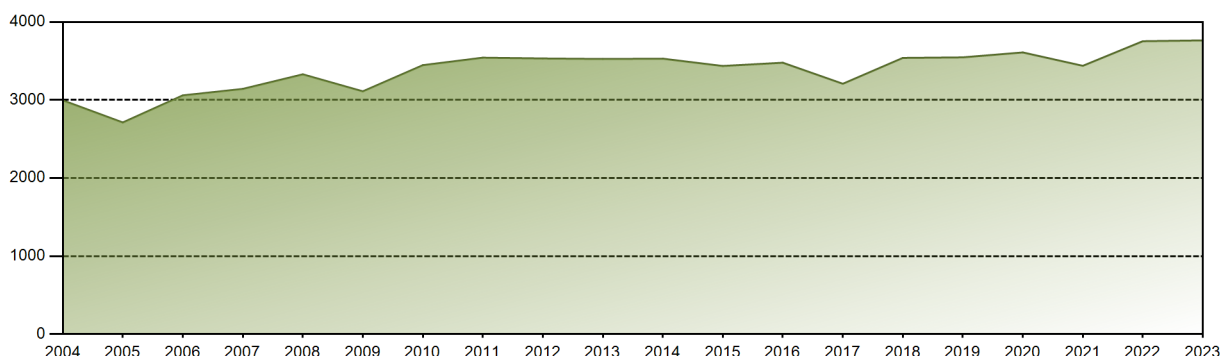


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 346.22 | 312.67 | 333.83 | 77.72 | 333.24 | 323.08 | 332.96 | 335.19 | 330.35 | 346.51 | 339.83 | 353.06 | 3764.66 |
| EAF [%] | 99.42 | 99.37 | 96.26 | 24.74 | 96.16 | 96.45 | 96.32 | 96.85 | 98.52 | 99.52 | 100.00 | 100.00 | 92.04 |
| UCF [%] | 99.72 | 99.75 | 99.43 | 27.23 | 99.31 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.87 |
| LF [%] | 99.65 | 99.63 | 96.08 | 23.12 | 95.91 | 96.09 | 95.83 | 96.47 | 98.25 | 99.73 | 101.07 | 101.61 | 92.02 |
| OF [%] | 100.00 | 100.00 | 100.00 | 30.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.25 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 1.11 | 0.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 8.76 | 0.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.76 |
| PUF [%] | 0.28 | 0.25 | 0.57 | 64.01 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.37 |
| XUF [%] | 0.30 | 0.37 | 3.17 | 2.49 | 3.15 | 3.55 | 3.68 | 3.15 | 1.48 | 0.48 | 0.00 | 0.00 | 1.83 |

Historical Summary

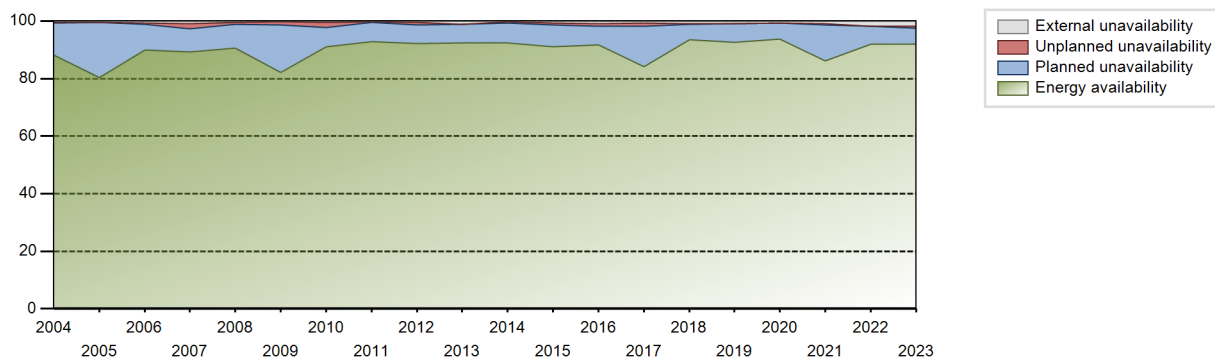
| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 81898.91 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.85 % |
| Cumulative Energy Availability Factor (EAF) | : 87.3 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.93 % |
| Cumulative Unit Capability Factor (UCF) | : 88.91 % | Cumulative Planned Unavailability Factor (PUF) | : 10.16 % |
| Cumulative Load Factor (LF) | : 86.58 % | Cumulative Externally cause unavailability (XUF) | : 1.6 % |
| Cumulative Operating Factor (OF) | : 89.9 % | | |

Electricity Production (net) [GWh]

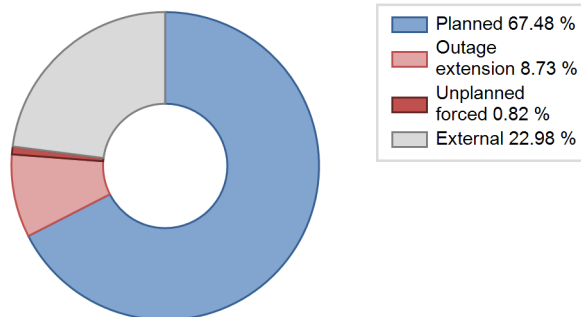


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1998 | 936.28 | 3343 | 408 | 94.96 | 96.83 | 93.54 | 98.98 | 3.17 | 3.17 | 0.00 | 1.87 |
| 1999 | 2376.14 | 6397 | 404 | 65.82 | 70.37 | 67.14 | 73.03 | 3.19 | 2.32 | 27.30 | 4.55 |
| 2000 | 2816.90 | 8311 | 404 | 79.38 | 89.96 | 79.38 | 94.62 | 2.46 | 2.27 | 7.77 | 10.58 |
| 2001 | 2423.59 | 6648 | 404 | 68.15 | 74.98 | 68.48 | 75.89 | 2.49 | 1.92 | 23.10 | 6.83 |
| 2002 | 2914.76 | 7628 | 405 | 83.31 | 86.32 | 82.16 | 87.08 | 0.24 | 0.21 | 13.47 | 3.02 |
| 2003 | 2796.62 | 7324 | 405 | 82.28 | 82.97 | 78.83 | 83.61 | 5.91 | 5.21 | 11.82 | 0.69 |
| 2004 | 2995.97 | 7801 | 405 | 88.10 | 88.58 | 84.22 | 88.81 | 0.15 | 0.13 | 11.28 | 0.48 |
| 2005 | 2712.57 | 7128 | 405 | 80.33 | 80.76 | 76.46 | 81.37 | 0.10 | 0.08 | 19.16 | 0.43 |
| 2006 | 3059.75 | 7977 | 405 | 90.01 | 90.72 | 86.23 | 91.05 | 0.43 | 0.39 | 8.88 | 0.71 |
| 2007 | 3142.72 | 7954 | 405 | 89.21 | 90.03 | 88.58 | 90.80 | 0.28 | 1.79 | 8.18 | 0.82 |
| 2008 | 3329.40 | 8064 | 436 | 90.62 | 91.05 | 89.58 | 91.80 | 0.21 | 0.76 | 8.19 | 0.43 |
| 2009 | 3111.64 | 7466 | 436 | 82.05 | 82.37 | 81.47 | 85.23 | 1.27 | 1.06 | 16.57 | 0.32 |
| 2010 | 3446.79 | 8074 | 436 | 91.02 | 91.51 | 90.25 | 92.17 | 1.92 | 1.79 | 6.70 | 0.49 |
| 2011 | 3542.88 | 8235 | 436 | 92.92 | 93.27 | 92.76 | 94.01 | 0.05 | 0.04 | 6.69 | 0.35 |
| 2012 | 3532.61 | 8188 | 436 | 92.14 | 92.63 | 92.24 | 93.21 | 0.81 | 0.82 | 6.55 | 0.49 |
| 2013 | 3526.15 | 8195 | 436 | 92.29 | 93.33 | 92.32 | 93.55 | 0.00 | 0.00 | 6.67 | 1.04 |
| 2014 | 3530.12 | 8259 | 436 | 92.38 | 92.55 | 92.43 | 94.28 | 0.13 | 0.55 | 6.90 | 0.18 |
| 2015 | 3436.31 | 8067 | 436 | 90.98 | 91.59 | 89.97 | 92.09 | 0.76 | 0.71 | 7.71 | 0.61 |
| 2016 | 3478.22 | 8185 | 436 | 91.64 | 92.67 | 90.82 | 93.18 | 0.42 | 0.73 | 6.60 | 1.03 |
| 2017 | 3208.45 | 7542 | 436 | 84.20 | 84.97 | 84.00 | 86.10 | 1.05 | 1.07 | 13.96 | 0.77 |
| 2018 | 3539.85 | 8299 | 436 | 93.39 | 94.37 | 92.68 | 94.74 | 0.27 | 0.25 | 5.38 | 0.98 |
| 2019 | 3547.11 | 8225 | 436 | 92.50 | 93.44 | 92.87 | 93.89 | 0.09 | 0.09 | 6.47 | 0.94 |
| 2020 | 3610.01 | 8322 | 436 | 93.82 | 94.52 | 94.27 | 94.75 | 0.02 | 0.07 | 5.42 | 0.69 |
| 2021 | 3438.55 | 8083 | 467 | 86.07 | 87.05 | 86.91 | 92.27 | 0.06 | 0.37 | 12.57 | 0.99 |
| 2022 | 3753.95 | 8253 | 467 | 91.89 | 93.65 | 91.76 | 94.21 | 0.11 | 0.10 | 6.25 | 1.76 |
| 2023 | 3764.66 | 8256 | 467 | 92.04 | 93.87 | 92.02 | 94.25 | 0.07 | 0.76 | 5.37 | 1.83 |

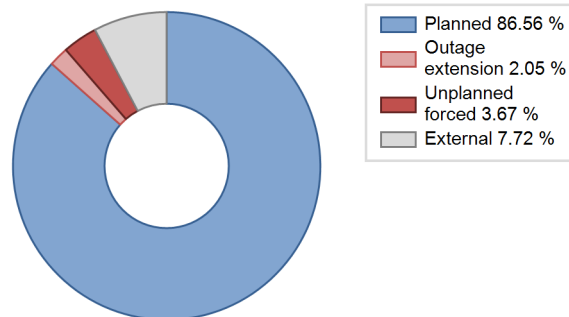
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1998 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 61 | | | 46 | |
| C. Inspection, maintenance or repair combined with refuelling | 444 | | | 797 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 28 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 7 | |
| Z. Other | | | | | 3 | |
| Subtotal | 444 | 61 | | 825 | 56 | 3 |
| Total | | 505 | | | 884 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1998 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 15 |
| 12. Reactor I&C Systems | | 5 |
| 14. Safety Systems | 61 | 9 |
| 15. Reactor Cooling Systems | | 1 |
| 16. Steam generation systems | | 1 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 1 |
| 32. Feedwater and Main Steam System | | 2 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 1 |
| 42. Electrical Power Supply Systems | | 14 |
| Total | | 61 |
| | | 52 |

Highlights (2023)

MOCHOVCE 1 unit was operated at full power in base load mode in 2023. Throughout the year there were no reactor scram and no unplanned full outage. The total unplanned losses of 31.1 GWh were largely due to the extended general overhaul of the unit. During the start-up after the general overhaul TG12 was shut down unscheduled due to overheating of current connections on TG exciter. Another manual shutdown of TG12 occurred in May. Planned production losses of 219.8 GWh included general overhaul with fuel replacement in April, execution of planned tests and losses due to cooling tower refurbishment between January and March. Other factors affecting energy generation were limitations due to environmental conditions and site heating. During the year the unit provided supporting services for grid adjustment.

2023 Operating Experience

SK-7

MOCHOVCE-2

SLOVAKIA

Status at end of year : **Operational**
 Operator : SE (SLOVENSKÉ ELEKTRÁRNE, A.S.)
 Owner : SE (SLOVENSKÉ ELEKTRÁRNE, A.S.)
 Reactor Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)
 Turbine Supplier : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS)



Reactor Unit Details

Reactor type and model : PWR / VVER V-213
 Thermal power : 1471 MWth
 Gross electrical power : 500 MWe
 Reference unit power (net) : 469 MWe

Key Dates

Construction Date : 1983-10-13
 Grid Date : 1999-12-20
 Commercial Date : 2000-04-11
 Age at end of year : 24 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.415
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 22
 Average discharge burnup [MWd/t] : 54000
 Active core diameter [m] : 2.88
 Active core height/length [m] : 2.5
 Number of fissile fuel assemblies/bundles : 349
 Fuel linear heat generation rate [kW/m] : 13.49
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 6
 Coolant type : H2O

Operating coolant pressure [MPa] : 12.0
 Reactor outlet temperature [°C] : 295
 Number of SG : 6
 Containment type : Confinement
 Containment design pressure [MPa] : 0.245

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 4.3
 Output voltage [kV] : 15.75
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 6
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 3

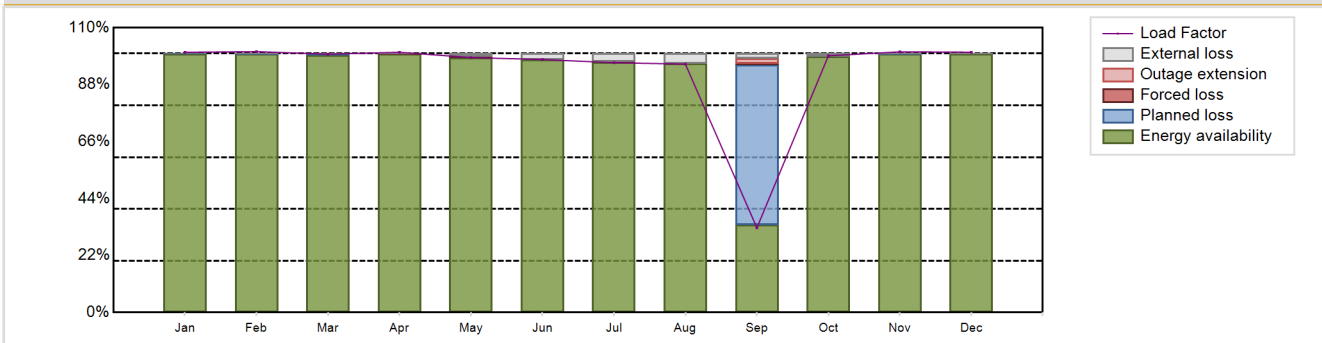
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 3848.01 GW(e).h
 Energy Availability Factor (EAF) : 93.46 %
 Unit Capability Factor (UCF) : 94.63 %
 Load Factor (LF) : 93.66 %
 Operating Factor (OF) : 95.06 %
 Forced Loss Rate (FLR) : 0.09 %
 Unplanned Capability Loss Factor (UCL) : 0.23 %
 Planned Unavailability Factor (PUF) : 5.13 %
 Externally cause unavailability (XUF) : 1.18 %
 Total off-line time : 433 hours

Annual Summary

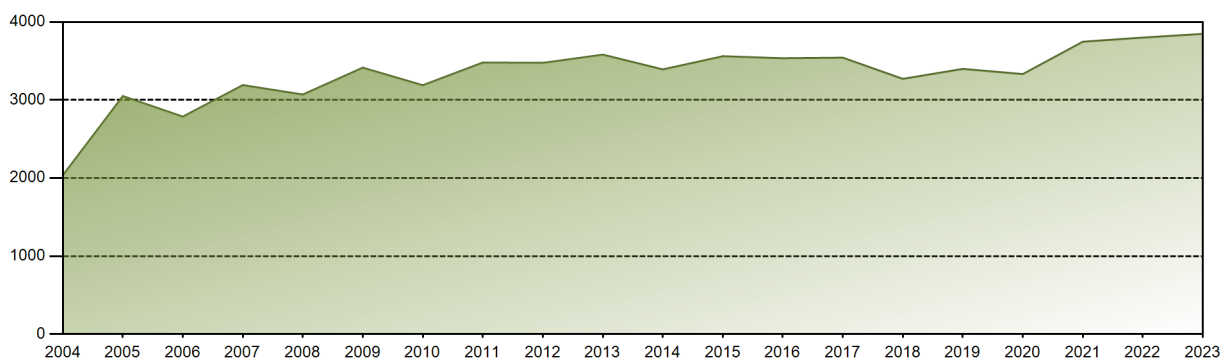


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 350.71 | 317.57 | 348.22 | 339.39 | 343.57 | 329.93 | 336.63 | 334.79 | 110.43 | 345.97 | 339.98 | 350.82 | 3848.01 |
| EAF [%] | 99.93 | 99.85 | 99.48 | 99.95 | 98.43 | 97.72 | 96.59 | 96.16 | 33.92 | 98.94 | 99.87 | 99.91 | 93.46 |
| UCF [%] | 99.93 | 99.87 | 99.67 | 100.00 | 99.66 | 100.00 | 99.79 | 100.00 | 35.90 | 100.00 | 99.90 | 100.00 | 94.63 |
| LF [%] | 100.51 | 100.76 | 99.80 | 100.51 | 98.46 | 97.71 | 96.47 | 95.95 | 32.70 | 99.15 | 100.68 | 100.54 | 93.66 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 39.86 | 100.00 | 100.00 | 100.00 | 95.06 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.34 | 0.00 | 0.21 | 0.00 | 1.22 | 0.00 | 0.00 | 0.00 | 0.09 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.34 | 0.00 | 0.21 | 0.00 | 2.27 | 0.00 | 0.00 | 0.00 | 0.23 |
| PUF [%] | 0.07 | 0.13 | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 61.83 | 0.00 | 0.10 | 0.00 | 5.13 |
| XUF [%] | 0.00 | 0.03 | 0.19 | 0.04 | 1.24 | 2.28 | 3.20 | 3.84 | 1.99 | 1.06 | 0.03 | 0.09 | 1.18 |

Historical Summary

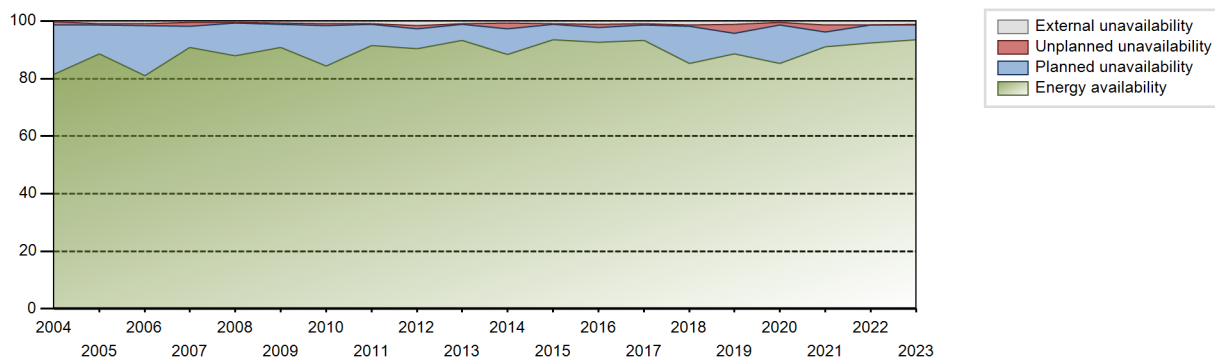
| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 77341.42 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.7 % |
| Cumulative Energy Availability Factor (EAF) | : 87.79 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.09 % |
| Cumulative Unit Capability Factor (UCF) | : 89.13 % | Cumulative Planned Unavailability Factor (PUF) | : 9.78 % |
| Cumulative Load Factor (LF) | : 86.14 % | Cumulative Externally cause unavailability (XUF) | : 1.34 % |
| Cumulative Operating Factor (OF) | : 89.86 % | | |

Electricity Production (net) [GWh]

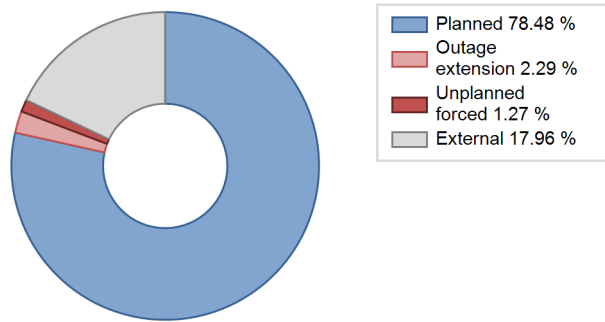


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2000 | 2641.42 | 7513 | 404 | 87.87 | 91.55 | 83.34 | 89.56 | 1.67 | 1.56 | 6.89 | 3.68 |
| 2001 | 2540.88 | 6967 | 404 | 72.10 | 78.17 | 71.80 | 79.53 | 6.46 | 5.40 | 16.43 | 6.07 |
| 2002 | 2498.36 | 6862 | 405 | 71.67 | 76.02 | 70.42 | 78.33 | 2.28 | 1.78 | 22.20 | 4.36 |
| 2003 | 2964.87 | 7729 | 405 | 87.37 | 87.81 | 83.57 | 88.23 | 0.52 | 0.46 | 11.73 | 0.43 |
| 2004 | 2034.50 | 7210 | 405 | 81.41 | 81.61 | 57.19 | 82.08 | 0.43 | 1.11 | 17.28 | 0.20 |
| 2005 | 3050.88 | 7900 | 405 | 88.52 | 89.45 | 85.99 | 90.18 | 0.51 | 0.45 | 10.09 | 0.93 |
| 2006 | 2787.17 | 7254 | 405 | 81.05 | 82.07 | 78.56 | 82.81 | 0.59 | 0.60 | 17.33 | 1.02 |
| 2007 | 3191.35 | 8082 | 405 | 90.85 | 91.26 | 89.95 | 92.26 | 1.11 | 1.39 | 7.36 | 0.41 |
| 2008 | 3070.50 | 7797 | 436 | 87.85 | 88.31 | 85.22 | 88.76 | 0.31 | 0.28 | 11.41 | 0.46 |
| 2009 | 3414.88 | 8128 | 436 | 90.86 | 91.54 | 89.41 | 92.79 | 0.50 | 0.56 | 7.90 | 0.68 |
| 2010 | 3189.95 | 7574 | 436 | 84.38 | 85.22 | 83.52 | 86.46 | 0.83 | 0.72 | 14.07 | 0.84 |
| 2011 | 3480.32 | 8195 | 436 | 91.55 | 92.49 | 91.12 | 93.55 | 0.33 | 0.31 | 7.21 | 0.93 |
| 2012 | 3476.42 | 8121 | 436 | 90.40 | 91.96 | 90.77 | 92.45 | 0.35 | 1.10 | 6.94 | 1.56 |
| 2013 | 3581.83 | 8274 | 436 | 93.27 | 94.22 | 93.78 | 94.45 | 0.11 | 0.10 | 5.68 | 0.95 |
| 2014 | 3392.49 | 7842 | 436 | 88.41 | 89.18 | 88.82 | 89.52 | 0.16 | 1.86 | 8.96 | 0.76 |
| 2015 | 3561.23 | 8296 | 436 | 93.39 | 94.40 | 93.24 | 94.70 | 0.01 | 0.10 | 5.50 | 1.02 |
| 2016 | 3535.75 | 8268 | 436 | 92.59 | 93.67 | 92.32 | 94.13 | 0.50 | 1.15 | 5.18 | 1.08 |
| 2017 | 3543.32 | 8280 | 436 | 93.20 | 94.16 | 92.77 | 94.52 | 0.15 | 0.41 | 5.43 | 0.95 |
| 2018 | 3271.12 | 7642 | 436 | 85.31 | 86.66 | 85.65 | 87.24 | 0.38 | 0.48 | 12.86 | 1.35 |
| 2019 | 3398.93 | 7922 | 436 | 88.65 | 89.77 | 88.99 | 90.43 | 0.18 | 3.26 | 6.97 | 1.12 |
| 2020 | 3332.80 | 8112 | 469 | 85.26 | 85.77 | 86.47 | 92.35 | 0.11 | 0.79 | 13.44 | 0.50 |
| 2021 | 3747.56 | 8155 | 469 | 91.05 | 92.35 | 91.22 | 93.09 | 0.73 | 2.44 | 5.20 | 1.30 |
| 2022 | 3800.50 | 8249 | 469 | 92.41 | 93.74 | 92.50 | 94.17 | 0.03 | 0.03 | 6.23 | 1.33 |
| 2023 | 3848.01 | 8327 | 469 | 93.46 | 94.63 | 93.66 | 95.06 | 0.09 | 0.23 | 5.13 | 1.18 |

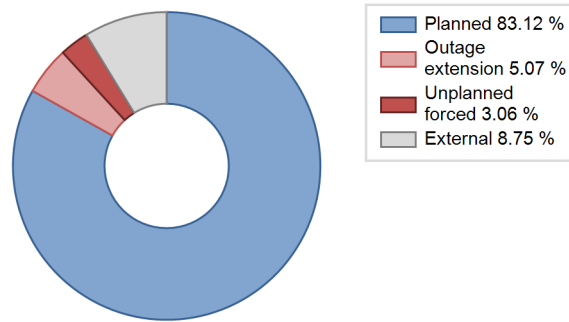
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2000 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 62 | |
| C. Inspection, maintenance or repair combined with refuelling | 420 | | | 746 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 67 | | |
| L. Human factor related | | | | | 4 | |
| Z. Other | | 13 | | | 1 | |
| Subtotal | 420 | 13 | | 813 | 67 | |
| Total | | 433 | | | 880 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2000 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 9 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 6 |
| 15. Reactor Cooling Systems | | 25 |
| 16. Steam generation systems | | 8 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 1 |
| 33. Circulating Water System | | 1 |
| 41. Main Generator Systems | | 3 |
| 42. Electrical Power Supply Systems | | 3 |
| Total | | 63 |

Highlights (2023)

MOCHOVCE 2 unit was operated at full power in base load mode in 2023. Throughout the year there were no reactor scram and no unplanned full outage. Annual value of the unplanned energy losses of 9.6 GWh was mainly due to the extension of the general overhaul with refueling. Planned energy losses of 210.9 GWh included the general overhaul with refueling in September, supporting services recertifications and losses due to cooling tower refurbishment between January and March. Other factors affecting energy generation were limitations due to environmental conditions and site heating. During the year the unit provided supporting services for grid adjustment.

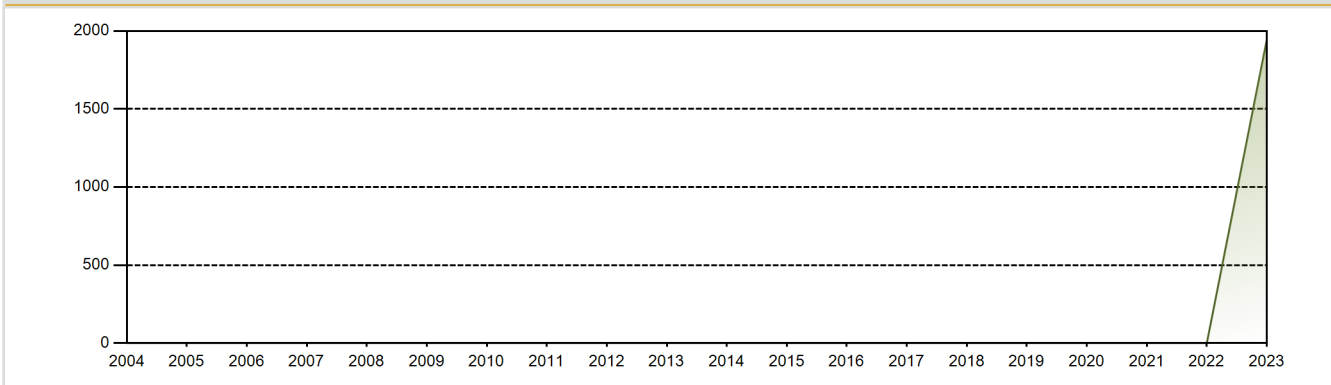
2023 Operating Experience

| SK-10 | | MOCHOVCE-3 | | SLOVAKIA | | | | | | | | |
|--|---|--|-------------------|------------|------|-----|-----|-----|-----|-----|-----|-----|
| Status at end of year | : Operational | | | | | | | | | | | |
| Operator | : SE (SLOVENSKÉ ELEKTRÁRNE, A.S.) | | | | | | | | | | | |
| Owner | : SE (SLOVENSKÉ ELEKTRÁRNE, A.S.) | | | | | | | | | | | |
| Reactor Supplier | : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS) | | | | | | | | | | | |
| Turbine Supplier | : ŠKODA (ŠKODA CONCERN NUCLEAR POWER PLANT WORKS) | | | | | | | | | | | |
| Reactor Unit Details | | | Key Dates | | | | | | | | | |
| Reactor type and model | : PWR / VVER V-213 | Construction Date | : | 1987-01-27 | | | | | | | | |
| Thermal power | : 1375 MWth | Grid Date | : | 2023-01-31 | | | | | | | | |
| Gross electrical power | : 471 MWe | Commercial Date | : | | | | | | | | | |
| Reference unit power (net) | : 440 MWe | Age at end of year | : | 0 years | | | | | | | | |
| Design Characteristics | | | | | | | | | | | | |
| Primary Systems | | | Secondary systems | | | | | | | | | |
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : | 12.23 | | | | | | | | |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : | 267.8 | | | | | | | | |
| Refuelling type | : OFF-line | Number of SG | : | 6 | | | | | | | | |
| Moderator material | : H2O | Containment type | : | - | | | | | | | | |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : | - | | | | | | | | |
| Refuelling frequency [month] | : 12 | Secondary systems | | | | | | | | | | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : | 2 | | | | | | | | |
| Average discharge burnup [MWd/t] | : 31000 | Turbine speed [rpm] | : | 3000 | | | | | | | | |
| Active core diameter [m] | : 2.88 | Number of LP cylinders per turbine | : | - | | | | | | | | |
| Active core height/length [m] | : 2.5 | HP cylinder inlet steam pressure [MPa] | : | 4.4 | | | | | | | | |
| Number of fissile fuel assemblies/bundles | : 349 | Output voltage [kV] | : | - | | | | | | | | |
| Fuel linear heat generation rate [kW/m] | : - | Primary means of condenser cooling | : | - | | | | | | | | |
| Number of control rod assemblies | : - | Number of main condensate pumps | : | - | | | | | | | | |
| Number of external reactor coolant loops | : 6 | Number of FW pumps for full power operation | : | - | | | | | | | | |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : | - | | | | | | | | |
| | | Non-electrical applications | | | none | | | | | | | |
| Annual Production Results (2023) | | | | | | | | | | | | |
| Net Energy Production | : 1945.27 GW(e).h | Forced Loss Rate (FLR) | : | 0 % | | | | | | | | |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : | 0 % | | | | | | | | |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : | 0 % | | | | | | | | |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : | 0 % | | | | | | | | |
| Operating Factor (OF) | : 0 % | Total off-line time | : | 624 hours | | | | | | | | |
| Annual Summary | | | | | | | | | | | | |
| No data found | | | | | | | | | | | | |
| <div style="border: 1px solid black; height: 100px; width: 100%;"></div> | | | | | | | | | | | | |
| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

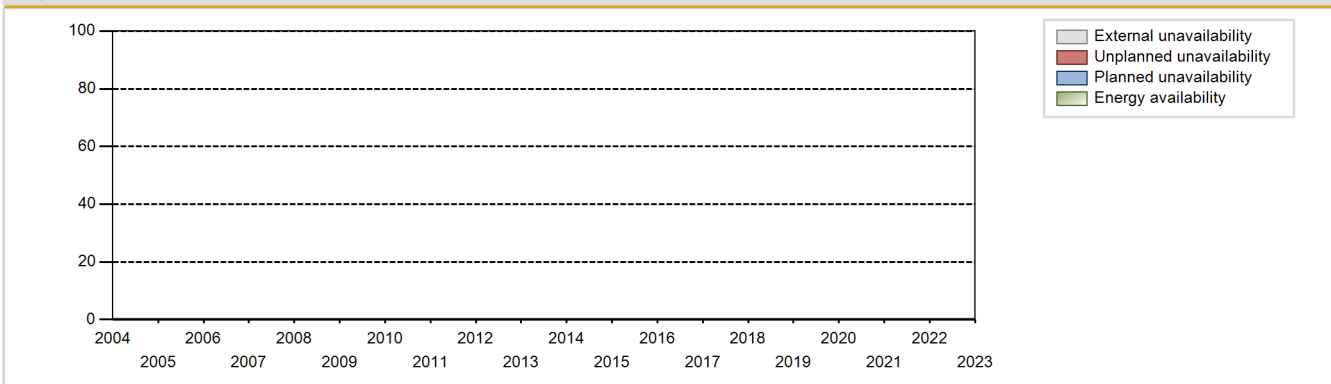
| | | | |
|---|-------------------|---|-------|
| Lifetime energy generation | : 1945.27 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0 % |
| Cumulative Energy Availability Factor (EAF) | : 0 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0 % |
| Cumulative Unit Capability Factor (UCF) | : 0 % | Cumulative Planned Unavailability Factor (PUF) | : 0 % |
| Cumulative Load Factor (LF) | : 0 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 0 % | | |

Electricity Production (net) [GWh]

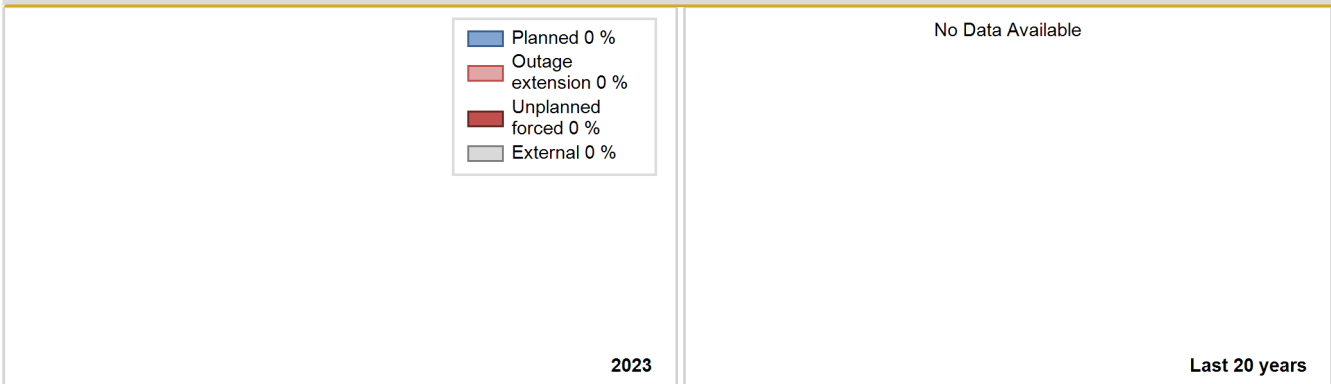


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | | |
|------|---------------|---------------------|---------------------------|---|---------|--------|--------|---------|---------|---------|---------|--|
| | | | | EAF [%] | UCF [%] | LF [%] | OF [%] | FLR [%] | UCL [%] | PUF [%] | XUF [%] | |
| | | | | | | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1 to 2023 | | |
|--------------|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| Subtotal | | | | | | |
| Total | | 0 | | | 0 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1 to 2023 |
|--------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| Total | | |

Highlights (2023)

| Date | Activity |
|------------------|-----------------------------|
| 13.1.2023 | Beggining of power start-up |
| 31.1.2023 | First TG32 synchronisation |
| 4.2.2023 | First TG31 synchronisation |
| 18.3.2023 | Reactor power achieved 55% |
| 22.9.2023 | Reactor power achieved 100% |
| 8.10.-14.10.2023 | 144 hours trial run test |

2023 Operating Experience

SI-1

KRSKO

SLOVENIA

Status at end of year : **Operational**
 Operator : NEK (Nuklearna elektrarna Krško)
 Owner : GEN (GEN Energija, d.o.o)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 2LP
 Thermal power : 1994 MWth
 Gross electrical power : 727 MWe
 Reference unit power (net) : 688 MWe

Key Dates

Construction Date : 1975-03-30
 Grid Date : 1981-10-02
 Commercial Date : 1983-01-01
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.8
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 46
 Average discharge burnup [MWd/t] : 44029
 Active core diameter [m] : 2.46
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 17.62
 Number of control rod assemblies : 33
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 325.2
 Number of SG : 2
 Containment type : Double
 Containment design pressure [MPa] : 0.309

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 2
 HP cylinder inlet steam pressure [MPa] : 6.13
 Output voltage [kV] : 21
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

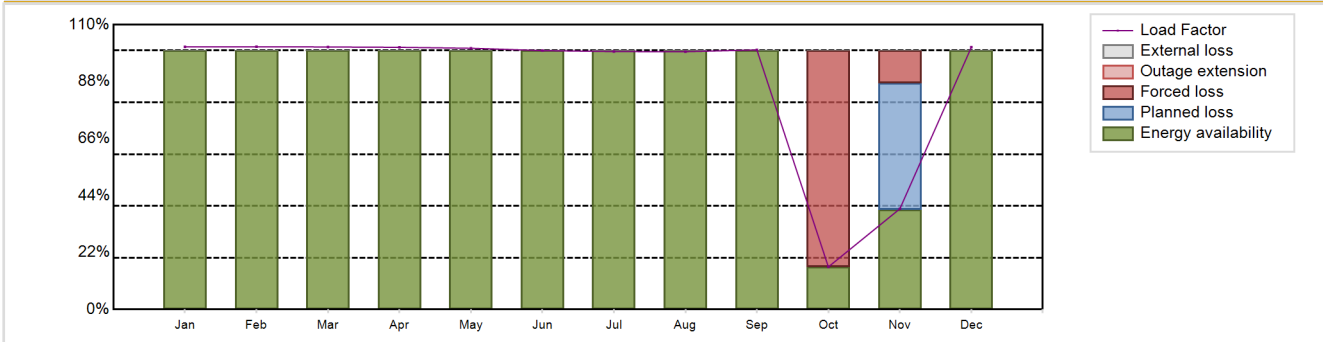
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 5332.49 GW(e).h
 Energy Availability Factor (EAF) : 87.83 %
 Unit Capability Factor (UCF) : 87.83 %
 Load Factor (LF) : 88.48 %
 Operating Factor (OF) : 87.82 %
 Forced Loss Rate (FLR) : 8.49 %
 Unplanned Capability Loss Factor (UCL) : 8.14 %
 Planned Unavailability Factor (PUF) : 4.02 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1067 hours

Annual Summary

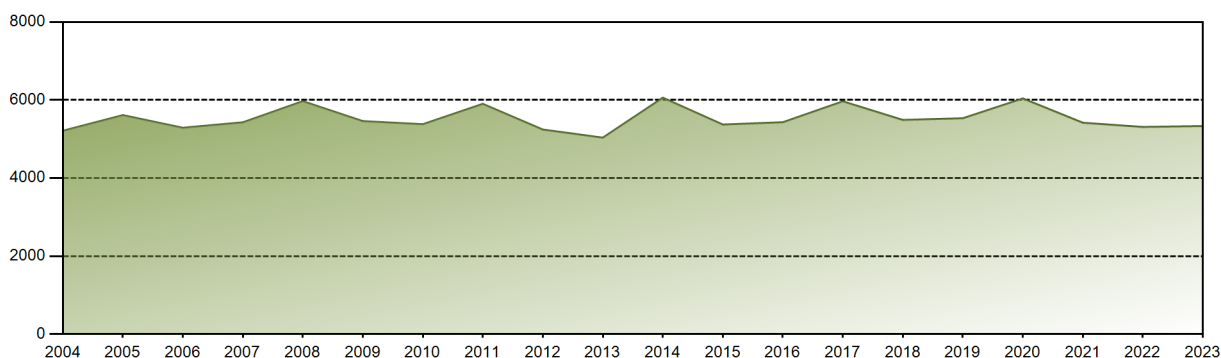


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 519.39 | 469.21 | 518.40 | 501.67 | 516.50 | 495.36 | 510.03 | 509.74 | 496.62 | 84.38 | 192.62 | 518.58 | 5332.49 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 16.38 | 38.48 | 100.00 | 87.83 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 16.38 | 38.48 | 100.00 | 87.83 |
| LF [%] | 101.47 | 101.49 | 101.41 | 101.27 | 100.90 | 100.00 | 99.64 | 99.58 | 100.25 | 16.46 | 38.89 | 101.31 | 88.48 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 16.24 | 38.47 | 100.00 | 87.82 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 83.62 | 24.61 | 0.00 | 8.49 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 83.62 | 12.56 | 0.00 | 8.14 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 48.95 | 0.00 | 4.02 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 205358.65 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.52 % |
| Cumulative Energy Availability Factor (EAF) | : 86.52 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.67 % |
| Cumulative Unit Capability Factor (UCF) | : 87.55 % | Cumulative Planned Unavailability Factor (PUF) | : 10.78 % |
| Cumulative Load Factor (LF) | : 86.09 % | Cumulative Externally cause unavailability (XUF) | : 1.02 % |
| Cumulative Operating Factor (OF) | : 87.9 % | | |

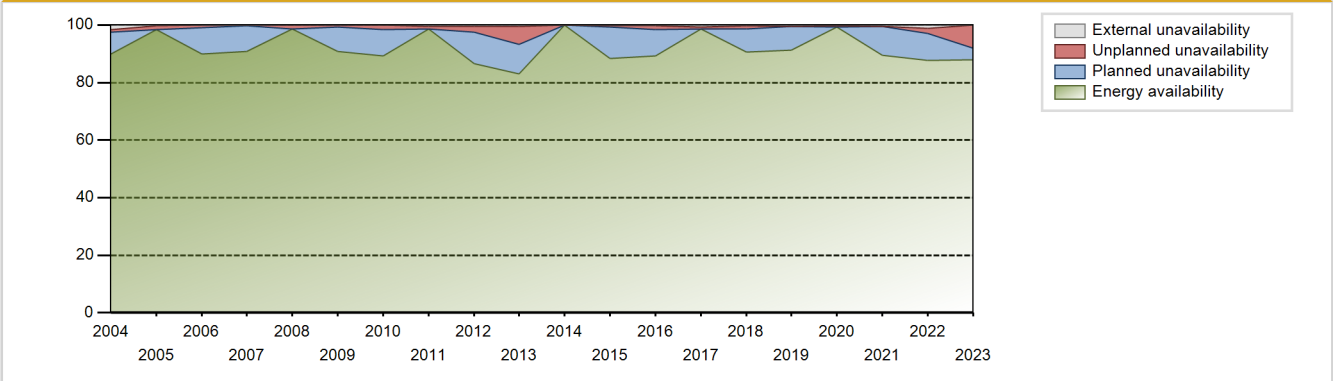
Electricity Production (net) [GWh]



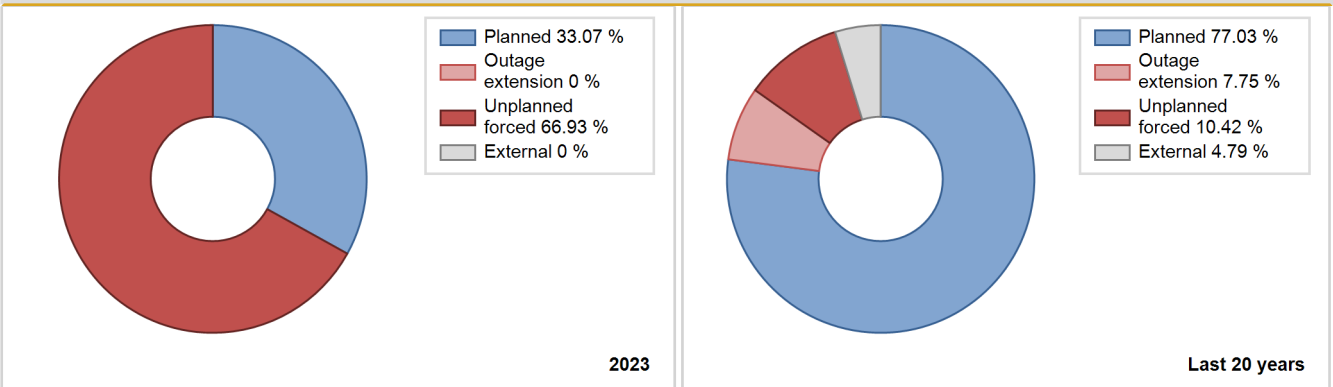
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 3724.10 | 6255 | 632 | 69.63 | 69.63 | 67.27 | 71.40 | 5.54 | 4.08 | 26.29 | 0.00 |
| 1984 | 4207.60 | 7073 | 632 | 79.80 | 79.80 | 75.79 | 80.52 | 5.16 | 4.34 | 15.86 | 0.00 |
| 1985 | 3845.27 | 6421 | 632 | 72.06 | 72.06 | 69.46 | 73.30 | 8.22 | 6.46 | 21.48 | 0.00 |
| 1986 | 3821.99 | 6561 | 620 | 73.74 | 74.83 | 70.37 | 74.90 | 2.64 | 2.03 | 23.14 | 1.10 |
| 1987 | 4278.82 | 7287 | 620 | 83.54 | 83.54 | 78.78 | 83.18 | 1.90 | 1.62 | 14.84 | 0.00 |
| 1988 | 3935.75 | 6866 | 620 | 76.94 | 77.03 | 72.27 | 78.16 | 6.58 | 5.43 | 17.54 | 0.09 |
| 1989 | 4453.95 | 7500 | 620 | 85.18 | 85.46 | 82.01 | 85.62 | 1.38 | 1.20 | 13.34 | 0.27 |
| 1990 | 4386.77 | 7592 | 620 | 85.38 | 87.10 | 80.77 | 86.67 | 0.17 | 0.15 | 12.75 | 1.72 |
| 1991 | 4718.22 | 8133 | 632 | 88.67 | 94.63 | 85.22 | 92.84 | 0.09 | 0.09 | 5.28 | 5.96 |
| 1992 | 3767.25 | 6699 | 632 | 68.60 | 73.98 | 67.86 | 76.26 | 2.41 | 1.83 | 24.19 | 5.38 |
| 1993 | 3762.77 | 6493 | 620 | 69.28 | 72.53 | 69.28 | 74.12 | 6.46 | 5.01 | 22.46 | 3.26 |
| 1994 | 4403.53 | 7402 | 620 | 81.08 | 82.10 | 81.08 | 84.50 | 0.80 | 0.66 | 17.25 | 1.02 |
| 1995 | 4568.50 | 7606 | 620 | 84.07 | 85.09 | 84.12 | 86.83 | 2.21 | 1.92 | 12.99 | 1.02 |
| 1996 | 4361.62 | 7143 | 620 | 79.64 | 79.64 | 80.09 | 81.32 | 0.27 | 0.22 | 20.14 | 0.00 |
| 1997 | 4793.98 | 7824 | 620 | 87.76 | 88.27 | 88.27 | 89.32 | 2.28 | 2.06 | 9.66 | 0.51 |
| 1998 | 4793.60 | 7913 | 620 | 88.01 | 89.54 | 88.26 | 90.33 | 0.05 | 0.05 | 10.42 | 1.53 |
| 1999 | 4492.38 | 7480 | 620 | 82.45 | 84.73 | 82.71 | 85.39 | 1.17 | 1.00 | 14.27 | 2.28 |
| 2000 | 4548.79 | 7295 | 676 | 80.49 | 82.56 | 80.10 | 83.05 | 0.00 | 0.00 | 17.43 | 2.08 |
| 2001 | 5036.28 | 7790 | 656 | 86.22 | 88.45 | 87.64 | 88.93 | 0.00 | 0.00 | 11.55 | 2.23 |
| 2002 | 5308.75 | 8111 | 676 | 91.09 | 91.99 | 89.65 | 92.59 | 0.86 | 0.80 | 7.20 | 0.91 |
| 2003 | 4963.34 | 8084 | 676 | 86.19 | 91.60 | 83.82 | 92.28 | 0.87 | 0.81 | 7.59 | 5.42 |
| 2004 | 5212.18 | 8081 | 676 | 89.88 | 91.41 | 87.78 | 92.00 | 0.40 | 0.88 | 7.71 | 1.53 |
| 2005 | 5613.65 | 8664 | 656 | 98.32 | 98.55 | 97.69 | 98.90 | 1.45 | 1.45 | 0.00 | 0.22 |
| 2006 | 5289.47 | 7883 | 666 | 89.92 | 90.06 | 91.34 | 89.99 | 0.00 | 0.83 | 9.11 | 0.14 |
| 2007 | 5428.19 | 7989 | 666 | 90.90 | 91.01 | 93.04 | 91.20 | 0.12 | 0.11 | 8.89 | 0.11 |
| 2008 | 5972.03 | 8660 | 666 | 98.59 | 98.59 | 102.08 | 98.59 | 1.41 | 1.41 | 0.00 | 0.00 |
| 2009 | 5459.72 | 7992 | 666 | 90.75 | 90.75 | 93.58 | 91.23 | 0.03 | 0.60 | 8.65 | 0.00 |
| 2010 | 5380.71 | 7876 | 666 | 89.33 | 89.33 | 92.23 | 89.91 | 0.00 | 1.52 | 9.15 | 0.00 |
| 2011 | 5902.24 | 8600 | 688 | 98.64 | 99.20 | 97.93 | 98.17 | 0.77 | 0.77 | 0.03 | 0.55 |
| 2012 | 5243.68 | 7697 | 688 | 86.48 | 87.00 | 86.77 | 87.63 | 0.72 | 1.96 | 11.04 | 0.52 |
| 2013 | 5036.47 | 7391 | 688 | 83.04 | 83.47 | 83.57 | 84.37 | 2.79 | 6.28 | 10.25 | 0.43 |
| 2014 | 6060.82 | 8760 | 688 | 99.95 | 100.00 | 100.56 | 100.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| 2015 | 5371.66 | 7826 | 688 | 88.47 | 88.78 | 89.13 | 89.34 | 0.00 | 0.31 | 10.91 | 0.31 |
| 2016 | 5431.27 | 7923 | 688 | 89.25 | 89.62 | 89.87 | 90.20 | 0.00 | 1.15 | 9.23 | 0.36 |
| 2017 | 5967.83 | 8708 | 688 | 98.52 | 99.19 | 99.01 | 99.40 | 0.81 | 0.81 | 0.00 | 0.67 |
| 2018 | 5489.91 | 8010 | 688 | 90.57 | 90.92 | 91.09 | 91.44 | 0.20 | 0.98 | 8.09 | 0.35 |
| 2019 | 5532.98 | 8081 | 688 | 91.28 | 91.72 | 91.81 | 92.25 | 0.00 | 0.00 | 8.28 | 0.44 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|------|------|
| 2020 | 6040.85 | 8748 | 688 | 99.34 | 99.51 | 99.96 | 99.59 | 0.49 | 0.49 | 0.00 | 0.17 |
| 2021 | 5418.64 | 7940 | 688 | 89.57 | 90.15 | 89.91 | 90.64 | 0.00 | 0.00 | 9.85 | 0.58 |
| 2022 | 5310.70 | 7849 | 688 | 87.80 | 89.06 | 88.12 | 89.60 | 0.00 | 1.62 | 9.32 | 1.27 |
| 2023 | 5332.49 | 7693 | 688 | 87.83 | 87.83 | 88.48 | 87.82 | 8.49 | 8.14 | 4.02 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 713 | | | 142 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 773 | | |
| D. Inspection, maintenance or repair without refuelling | 352 | | | 128 | | |
| E. Testing of plant systems or components | | | | 37 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 56 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 1 | |
| Subtotal | 352 | 713 | | 994 | 145 | 4 |
| Total | | 1065 | | | 1143 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 14 |
| 12. Reactor I&C Systems | | 3 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | 713 | 27 |
| 16. Steam generation systems | | 10 |
| 21. Fuel Handling and Storage Facilities | | 2 |
| 31. Turbine and auxiliaries | | 27 |
| 32. Feedwater and Main Steam System | | 33 |
| 33. Circulating Water System | | 3 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 6 |
| 42. Electrical Power Supply Systems | | 13 |
| Total | 713 | 142 |

Highlights (2023)

There were no automatic or manual reactor scrams during the year 2023. As a highlights of the operation during the year 2023 it should be emphasized unplanned shutdown of the plant due to leak on safety injection pipeline.

2023 Operating Experience

ZA-1

KOEBERG-1

SOUTH AFRICA

Status at end of year : **Operational**
 Operator : ESKOM (ESKOM)
 Owner : ESKOM (ESKOM)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : AA (ALSTHOM ATLANTIQUE)



Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2775 MWth
 Gross electrical power : 964 MWe
 Reference unit power (net) : 924 MWe

Key Dates

Construction Date : 1976-07-01
 Grid Date : 1984-04-04
 Commercial Date : 1984-07-21
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.9
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 46000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.6
 Number of control rod assemblies : 32
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 314.9
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.5
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

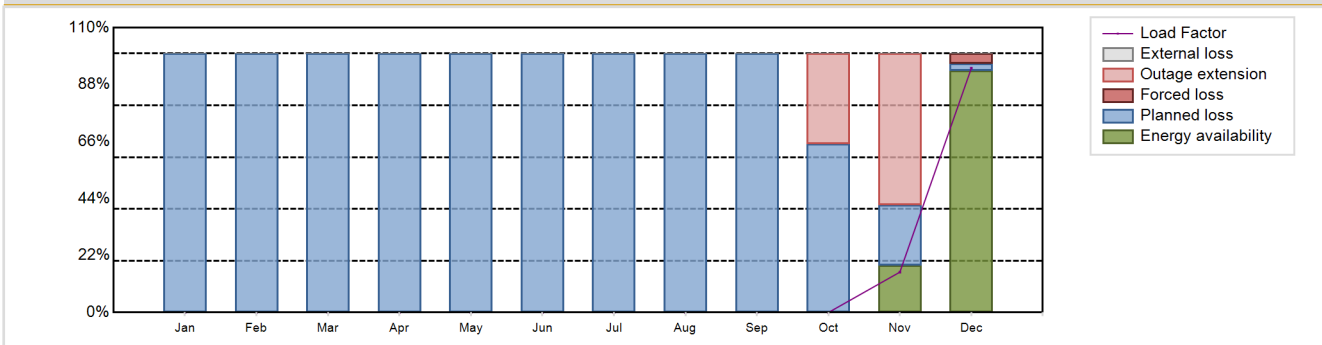
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 752.77 GW(e).h
 Energy Availability Factor (EAF) : 9.44 %
 Unit Capability Factor (UCF) : 9.44 %
 Load Factor (LF) : 9.3 %
 Operating Factor (OF) : 11.88 %

Forced Loss Rate (FLR) : 3.38 %
 Unplanned Capability Loss Factor (UCL) : 8.1 %
 Planned Unavailability Factor (PUF) : 82.46 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 7719 hours

Annual Summary

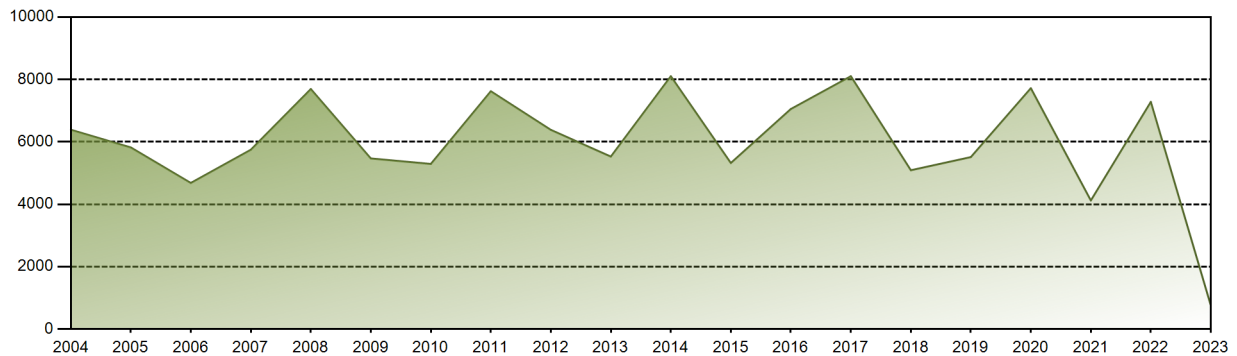


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|
| GW(e)-h | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 103.84 | 648.93 | 752.77 |
| EAF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.28 | 93.43 | 9.44 |
| UCF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.28 | 93.43 | 9.44 |
| LF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.61 | 94.40 | 9.30 |
| OF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 41.53 | 99.73 | 11.88 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.00 | 3.38 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.97 | 58.44 | 3.89 | 8.10 |
| PUF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 65.03 | 23.27 | 2.68 | 82.46 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 224092.7 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.67 % |
| Cumulative Energy Availability Factor (EAF) | : 72.21 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.41 % |
| Cumulative Unit Capability Factor (UCF) | : 75.31 % | Cumulative Planned Unavailability Factor (PUF) | : 17.28 % |
| Cumulative Load Factor (LF) | : 70.51 % | Cumulative Externally cause unavailability (XUF) | : 3.1 % |
| Cumulative Operating Factor (OF) | : 76.36 % | | |

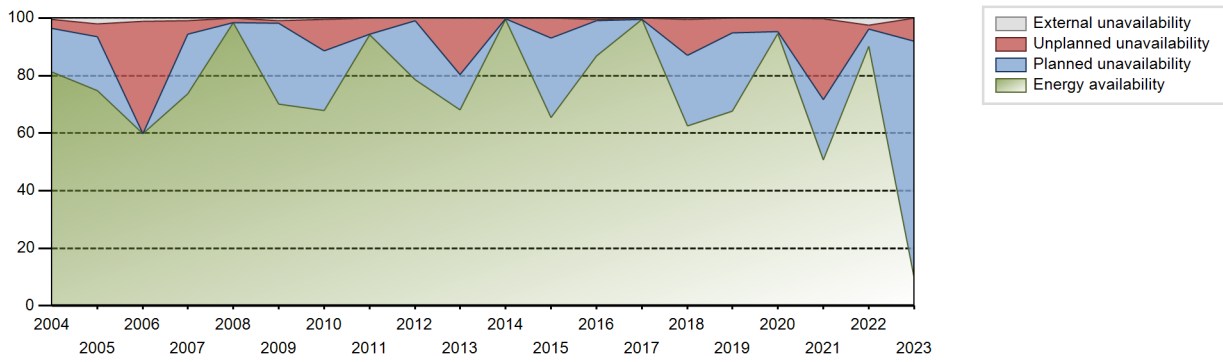
Electricity Production (net) [GWh]



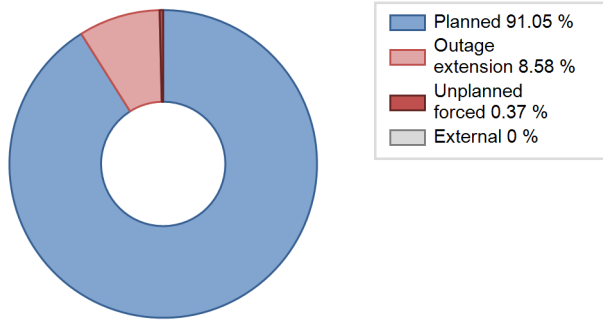
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 3949.53 | 5063 | 920 | 91.26 | 91.46 | 86.35 | 95.26 | 8.50 | 8.50 | 0.03 | 0.20 |
| 1985 | 4004.30 | 4986 | 920 | 53.49 | 53.49 | 49.69 | 56.92 | 45.38 | 44.45 | 2.06 | 0.00 |
| 1986 | 3418.99 | 4575 | 922 | 53.58 | 53.58 | 42.33 | 52.23 | 14.53 | 9.11 | 37.31 | 0.00 |
| 1987 | 2864.54 | 4337 | 920 | 61.60 | 61.60 | 35.54 | 49.51 | 1.96 | 1.23 | 37.17 | 0.00 |
| 1988 | 5964.44 | 6791 | 920 | 76.03 | 76.03 | 73.81 | 77.31 | 5.42 | 4.36 | 19.61 | 0.00 |
| 1989 | 4498.08 | 5655 | 922 | 63.21 | 63.21 | 55.24 | 64.03 | 8.46 | 5.84 | 30.95 | 0.00 |
| 1990 | 3852.07 | 5360 | 920 | 52.72 | 61.72 | 47.80 | 61.19 | 2.85 | 1.81 | 36.47 | 8.99 |
| 1991 | 5976.84 | 6886 | 920 | 74.56 | 76.34 | 74.16 | 78.61 | 6.48 | 5.29 | 18.37 | 1.78 |
| 1992 | 3992.53 | 5697 | 920 | 50.32 | 63.62 | 49.40 | 64.86 | 8.83 | 6.16 | 30.22 | 13.29 |
| 1993 | 4097.94 | 6010 | 920 | 50.52 | 66.41 | 50.85 | 68.61 | 9.43 | 6.92 | 26.68 | 15.88 |
| 1994 | 5933.92 | 8422 | 920 | 74.86 | 95.64 | 73.63 | 96.14 | 3.87 | 3.85 | 0.51 | 20.79 |
| 1995 | 4576.86 | 5853 | 920 | 56.81 | 65.70 | 56.75 | 66.82 | 13.12 | 9.92 | 24.38 | 8.88 |
| 1996 | 5672.79 | 7260 | 920 | 70.37 | 81.82 | 70.20 | 82.65 | 1.73 | 1.44 | 16.74 | 11.46 |
| 1997 | 6610.69 | 7676 | 920 | 82.31 | 87.37 | 82.03 | 87.63 | 3.07 | 2.77 | 9.86 | 5.06 |
| 1998 | 7248.29 | 8552 | 920 | 90.11 | 97.63 | 89.94 | 97.63 | 2.37 | 2.37 | 0.00 | 7.52 |
| 1999 | 7051.70 | 7848 | 920 | 83.28 | 88.07 | 87.50 | 89.59 | 3.96 | 3.64 | 8.29 | 4.79 |
| 2000 | 5629.15 | 7250 | 920 | 70.21 | 73.36 | 69.79 | 82.70 | 15.82 | 13.79 | 12.85 | 3.16 |
| 2001 | 6042.50 | 7303 | 920 | 77.13 | 83.02 | 74.98 | 83.37 | 1.64 | 1.38 | 15.60 | 5.89 |
| 2002 | 7328.60 | 8417 | 900 | 93.07 | 95.19 | 92.96 | 96.08 | 3.67 | 3.62 | 1.19 | 2.12 |
| 2003 | 6413.36 | 7398 | 900 | 81.94 | 84.12 | 81.35 | 84.45 | 2.88 | 2.50 | 13.39 | 2.18 |
| 2004 | 6388.00 | 7358 | 900 | 81.13 | 81.65 | 80.80 | 83.77 | 2.53 | 3.07 | 15.28 | 0.51 |
| 2005 | 5821.02 | 6726 | 900 | 74.69 | 76.76 | 73.83 | 76.78 | 3.84 | 4.33 | 18.90 | 2.07 |
| 2006 | 4682.78 | 5435 | 900 | 59.76 | 60.99 | 59.40 | 62.04 | 39.01 | 39.01 | 0.00 | 1.23 |
| 2007 | 5747.01 | 6609 | 900 | 73.57 | 74.40 | 72.89 | 75.45 | 2.13 | 4.74 | 20.85 | 0.83 |
| 2008 | 7691.88 | 8689 | 900 | 98.33 | 98.33 | 97.30 | 98.92 | 1.67 | 1.67 | 0.00 | 0.00 |
| 2009 | 5467.97 | 6307 | 900 | 70.10 | 71.12 | 69.36 | 72.00 | 0.05 | 0.71 | 28.17 | 1.02 |
| 2010 | 5291.74 | 6085 | 900 | 67.83 | 68.37 | 67.12 | 69.46 | 12.55 | 10.81 | 20.82 | 0.55 |
| 2011 | 7622.37 | 8315 | 930 | 94.27 | 94.28 | 94.05 | 94.92 | 5.67 | 5.67 | 0.05 | 0.02 |
| 2012 | 6384.83 | 6975 | 930 | 78.47 | 78.58 | 78.16 | 79.41 | 1.12 | 0.89 | 20.53 | 0.11 |
| 2013 | 5527.64 | 6084 | 930 | 68.15 | 68.15 | 67.85 | 69.45 | 20.99 | 19.60 | 12.25 | 0.00 |
| 2014 | 8102.87 | 8760 | 930 | 99.60 | 99.62 | 99.46 | 100.00 | 0.23 | 0.23 | 0.15 | 0.02 |
| 2015 | 5321.75 | 5860 | 930 | 65.47 | 65.50 | 65.32 | 66.89 | 3.61 | 6.89 | 27.61 | 0.03 |
| 2016 | 7051.38 | 7759 | 930 | 86.77 | 87.20 | 86.32 | 88.33 | 0.39 | 0.40 | 12.40 | 0.43 |
| 2017 | 8103.47 | 8760 | 930 | 99.49 | 99.49 | 99.47 | 100.00 | 0.50 | 0.50 | 0.01 | 0.00 |
| 2018 | 5090.34 | 5838 | 930 | 62.50 | 62.99 | 62.48 | 66.64 | 7.46 | 12.40 | 24.61 | 0.48 |
| 2019 | 5510.90 | 6049 | 930 | 67.74 | 67.83 | 67.64 | 69.05 | 5.53 | 5.05 | 27.12 | 0.09 |
| 2020 | 7719.38 | 8572 | 930 | 94.52 | 94.60 | 94.49 | 97.59 | 3.28 | 4.65 | 0.76 | 0.08 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2021 | 4120.92 | 4664 | 924 | 50.74 | 51.06 | 50.69 | 53.24 | 20.81 | 28.10 | 20.84 | 0.33 |
| 2022 | 7280.79 | 8236 | 924 | 90.11 | 92.63 | 89.95 | 94.02 | 1.47 | 1.38 | 5.98 | 2.52 |
| 2023 | 752.77 | 1041 | 924 | 9.44 | 9.44 | 9.30 | 11.88 | 3.38 | 8.10 | 82.46 | 0.00 |

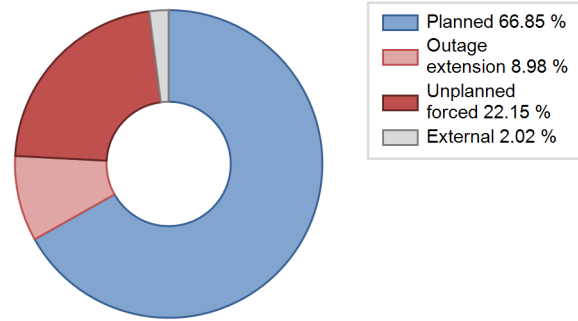
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 372 | |
| C. Inspection, maintenance or repair combined with refuelling | 7036 | | | 1347 | 11 | |
| D. Inspection, maintenance or repair without refuelling | | | | 125 | | |
| E. Testing of plant systems or components | 2 | | | 3 | 10 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 43 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 41 | | |
| Z. Other | | 681 | | | 52 | |
| Subtotal | 7038 | 681 | | 1516 | 488 | 0 |
| Total | | 7719 | | | 2004 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 49 |
| 12. Reactor I&C Systems | | 20 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 67 |
| 16. Steam generation systems | | 21 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 48 |
| 32. Feedwater and Main Steam System | | 36 |
| 33. Circulating Water System | | 5 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 110 |
| 42. Electrical Power Supply Systems | | 39 |
| Total | | 399 |

2023 Operating Experience

ZA-2

KOEBERG-2

SOUTH AFRICA

Status at end of year : **Operational**
 Operator : ESKOM (ESKOM)
 Owner : ESKOM (ESKOM)
 Reactor Supplier : FRAM (FRAMATOME)
 Turbine Supplier : AA (ALSTHOM ATLANTIQUE)



Reactor Unit Details

Reactor type and model : PWR / CP1
 Thermal power : 2775 MWth
 Gross electrical power : 970 MWe
 Reference unit power (net) : 930 MWe

Key Dates

Construction Date : 1976-07-01
 Grid Date : 1985-07-25
 Commercial Date : 1985-11-09
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.9
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 46000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.6
 Number of control rod assemblies : 32
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 314.9
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 5.5
 Output voltage [kV] : 24
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

Non-electrical applications

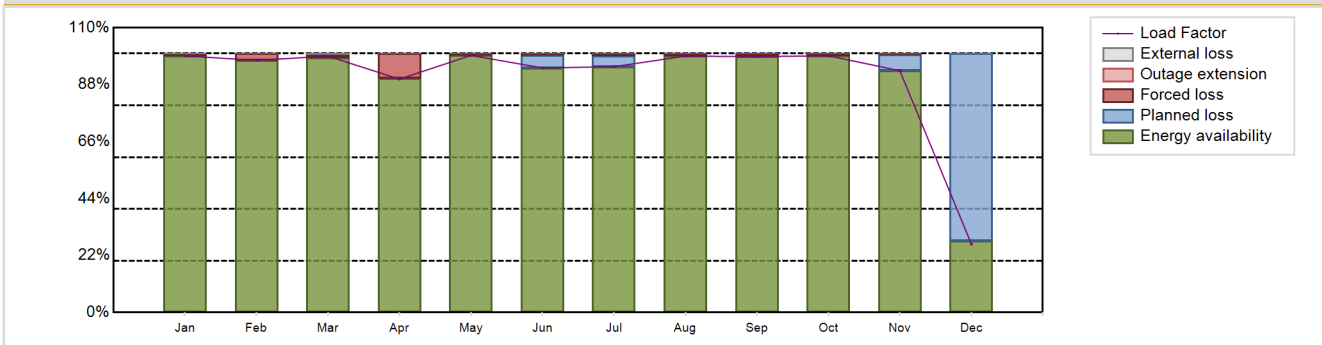
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7401.06 GW(e).h
 Energy Availability Factor (EAF) : 90.92 %
 Unit Capability Factor (UCF) : 90.95 %
 Load Factor (LF) : 90.85 %
 Operating Factor (OF) : 93.64 %

Forced Loss Rate (FLR) : 1.75 %
 Unplanned Capability Loss Factor (UCL) : 1.62 %
 Planned Unavailability Factor (PUF) : 7.42 %
 Externally cause unavailability (XUF) : 0.03 %
 Total off-line time : 557 hours

Annual Summary

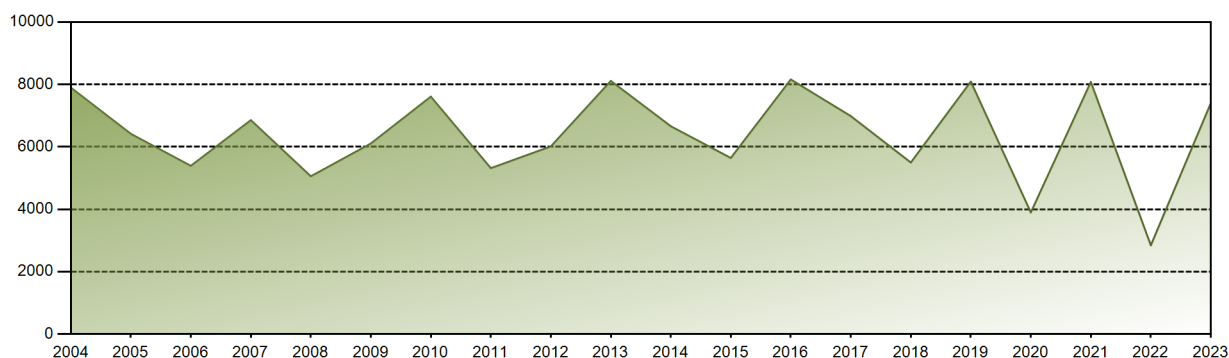


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 685.66 | 608.74 | 685.04 | 603.60 | 687.01 | 632.64 | 656.94 | 685.16 | 661.77 | 686.07 | 625.37 | 183.08 | 7401.06 |
| EAF [%] | 99.15 | 97.45 | 98.47 | 90.34 | 99.29 | 94.48 | 94.94 | 99.02 | 98.83 | 99.15 | 93.39 | 27.60 | 90.92 |
| UCF [%] | 99.21 | 97.45 | 98.79 | 90.34 | 99.29 | 94.48 | 94.94 | 99.02 | 98.83 | 99.15 | 93.39 | 27.60 | 90.95 |
| LF [%] | 99.09 | 97.40 | 99.01 | 90.14 | 99.29 | 94.48 | 94.94 | 99.02 | 98.83 | 99.15 | 93.39 | 26.46 | 90.85 |
| OF [%] | 100.00 | 98.07 | 100.00 | 94.31 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 32.39 | 93.64 |
| FLR [%] | 0.79 | 2.55 | 1.21 | 9.66 | 0.71 | 0.74 | 0.82 | 0.98 | 1.17 | 0.85 | 0.34 | 0.00 | 1.75 |
| UCL [%] | 0.79 | 2.55 | 1.21 | 9.66 | 0.71 | 0.70 | 0.78 | 0.98 | 1.17 | 0.85 | 0.32 | 0.00 | 1.62 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.82 | 4.27 | 0.00 | 0.00 | 0.00 | 6.29 | 72.40 | 7.42 |
| XUF [%] | 0.06 | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 223888.09 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.62 % |
| Cumulative Energy Availability Factor (EAF) | : 73.6 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.88 % |
| Cumulative Unit Capability Factor (UCF) | : 79.18 % | Cumulative Planned Unavailability Factor (PUF) | : 14.94 % |
| Cumulative Load Factor (LF) | : 72.67 % | Cumulative Externally cause unavailability (XUF) | : 5.58 % |
| Cumulative Operating Factor (OF) | : 79.08 % | | |

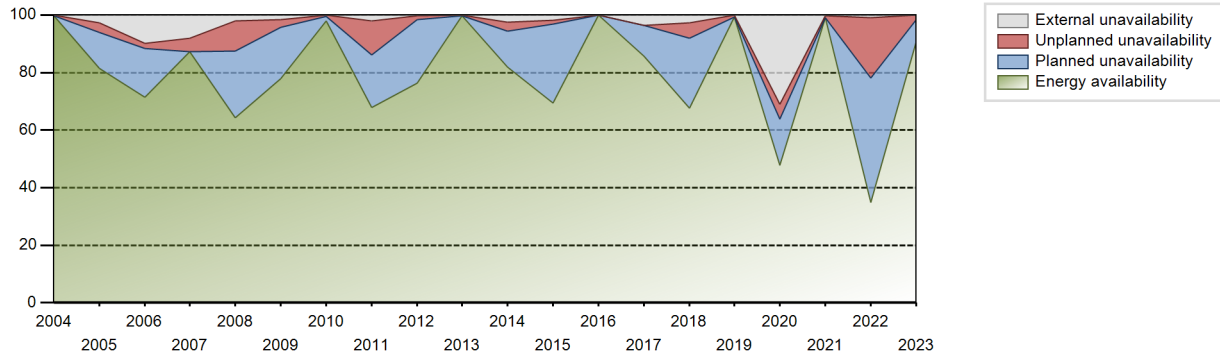
Electricity Production (net) [GWh]



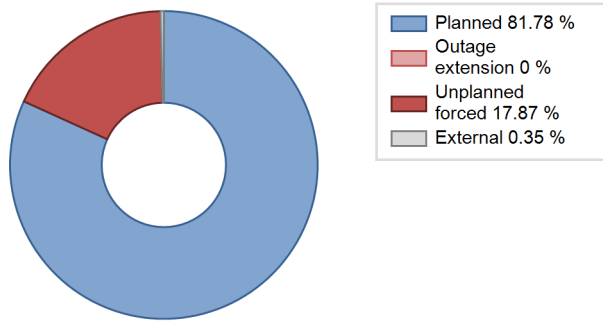
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 1389.80 | 2006 | 920 | 37.18 | 37.18 | 35.91 | 37.91 | 0.05 | 0.02 | 62.80 | 0.00 |
| 1986 | 5408.99 | 5969 | 922 | 67.32 | 67.38 | 66.97 | 68.14 | 32.00 | 31.70 | 0.91 | 0.06 |
| 1987 | 3352.78 | 4193 | 920 | 48.63 | 48.63 | 41.60 | 47.87 | 15.41 | 8.86 | 42.51 | 0.00 |
| 1988 | 4552.69 | 5626 | 920 | 63.07 | 63.07 | 56.34 | 64.05 | 14.74 | 10.91 | 26.02 | 0.00 |
| 1989 | 6620.21 | 8115 | 922 | 89.24 | 89.24 | 81.30 | 91.88 | 4.13 | 3.84 | 6.92 | 0.00 |
| 1990 | 4614.34 | 5933 | 920 | 58.39 | 64.80 | 57.26 | 67.73 | 2.46 | 1.63 | 33.57 | 6.41 |
| 1991 | 3191.94 | 5067 | 920 | 40.27 | 56.29 | 39.61 | 57.84 | 1.63 | 0.93 | 42.78 | 16.02 |
| 1992 | 5308.06 | 8439 | 920 | 66.26 | 94.89 | 65.68 | 96.07 | 4.87 | 4.86 | 0.25 | 28.63 |
| 1993 | 3212.30 | 4654 | 920 | 40.36 | 52.62 | 39.86 | 53.13 | 18.51 | 11.95 | 35.43 | 12.26 |
| 1994 | 3755.92 | 5944 | 920 | 49.45 | 69.19 | 46.60 | 67.85 | 9.80 | 7.52 | 23.30 | 19.73 |
| 1995 | 6710.53 | 8640 | 920 | 83.21 | 98.60 | 83.27 | 98.63 | 1.40 | 1.40 | 0.00 | 15.39 |
| 1996 | 6084.93 | 7177 | 920 | 75.78 | 81.46 | 75.30 | 81.71 | 3.71 | 3.13 | 15.41 | 5.68 |
| 1997 | 6016.36 | 7409 | 920 | 75.20 | 83.77 | 74.65 | 84.58 | 5.73 | 5.09 | 11.14 | 8.57 |
| 1998 | 6333.04 | 7194 | 920 | 78.97 | 81.31 | 78.58 | 82.12 | 8.14 | 7.21 | 11.48 | 2.35 |
| 1999 | 6413.89 | 7509 | 920 | 75.71 | 86.19 | 79.58 | 85.72 | 3.45 | 3.08 | 10.74 | 10.48 |
| 2000 | 7365.91 | 8687 | 920 | 91.23 | 98.06 | 91.15 | 98.90 | 1.23 | 1.22 | 0.72 | 6.83 |
| 2001 | 4662.84 | 5461 | 920 | 60.08 | 66.55 | 57.86 | 62.34 | 23.64 | 20.61 | 12.84 | 6.47 |
| 2002 | 4688.80 | 5439 | 900 | 59.59 | 60.58 | 59.47 | 62.09 | 9.17 | 21.90 | 17.52 | 0.99 |
| 2003 | 6255.50 | 7150 | 900 | 79.41 | 82.92 | 79.34 | 81.62 | 3.33 | 2.98 | 14.10 | 3.51 |
| 2004 | 7896.70 | 8784 | 900 | 99.78 | 99.81 | 99.89 | 100.00 | 0.19 | 0.19 | 0.00 | 0.02 |
| 2005 | 6416.81 | 7330 | 900 | 81.55 | 84.17 | 81.39 | 83.68 | 1.63 | 3.50 | 12.33 | 2.62 |
| 2006 | 5391.37 | 7003 | 900 | 71.44 | 81.26 | 68.38 | 79.94 | 0.73 | 1.78 | 16.96 | 9.82 |
| 2007 | 6853.86 | 8422 | 900 | 87.29 | 95.31 | 86.93 | 96.14 | 4.69 | 4.69 | 0.00 | 8.02 |
| 2008 | 5055.87 | 5960 | 900 | 64.20 | 66.24 | 63.95 | 67.85 | 12.77 | 10.38 | 23.38 | 2.04 |
| 2009 | 6105.80 | 7079 | 900 | 77.86 | 79.40 | 77.45 | 80.81 | 3.41 | 2.81 | 17.79 | 1.54 |
| 2010 | 7608.20 | 8565 | 900 | 98.03 | 98.06 | 96.50 | 97.77 | 0.35 | 0.35 | 1.59 | 0.03 |
| 2011 | 5316.17 | 6254 | 900 | 67.96 | 70.12 | 67.43 | 71.39 | 13.51 | 11.78 | 18.11 | 2.16 |
| 2012 | 6012.70 | 6911 | 930 | 76.28 | 76.43 | 75.84 | 78.68 | 1.84 | 1.47 | 22.10 | 0.15 |
| 2013 | 8112.97 | 8760 | 930 | 99.81 | 99.81 | 99.58 | 100.00 | 0.19 | 0.19 | 0.00 | 0.00 |
| 2014 | 6659.83 | 7462 | 930 | 82.01 | 84.47 | 81.75 | 85.18 | 0.11 | 3.13 | 12.40 | 2.46 |
| 2015 | 5643.39 | 6328 | 930 | 69.35 | 71.08 | 69.27 | 72.24 | 1.10 | 1.38 | 27.54 | 1.73 |
| 2016 | 8158.09 | 8784 | 930 | 99.99 | 100.00 | 99.86 | 100.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 2017 | 6983.82 | 7878 | 930 | 85.65 | 89.18 | 85.72 | 89.93 | 0.16 | 0.14 | 10.67 | 3.54 |
| 2018 | 5496.77 | 6320 | 930 | 67.54 | 70.28 | 67.47 | 72.15 | 2.60 | 5.20 | 24.51 | 2.74 |
| 2019 | 8091.67 | 8760 | 930 | 99.35 | 99.40 | 99.32 | 100.00 | 0.59 | 0.59 | 0.01 | 0.05 |
| 2020 | 3896.22 | 4667 | 930 | 47.72 | 78.86 | 47.69 | 53.13 | 1.25 | 5.10 | 16.05 | 31.14 |
| 2021 | 8077.98 | 8760 | 930 | 99.15 | 99.47 | 99.16 | 100.00 | 0.53 | 0.53 | 0.00 | 0.32 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| 2022 | 2842.90 | 3239 | 930 | 34.90 | 35.73 | 34.90 | 36.97 | 18.89 | 21.12 | 43.15 | 0.83 |
| 2023 | 7401.06 | 8203 | 930 | 90.92 | 90.95 | 90.85 | 93.64 | 1.75 | 1.62 | 7.42 | 0.03 |

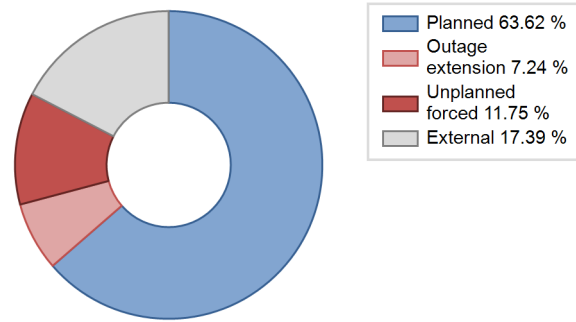
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 49 | | | 404 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1179 | 26 | |
| D. Inspection, maintenance or repair without refuelling | | | | 38 | | |
| E. Testing of plant systems or components | | | | 35 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | 503 | | | 13 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 23 |
| L. Human factor related | | | | | 38 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 0 |
| Z. Other | | | | | 33 | 64 |
| Subtotal | 503 | 49 | | 1265 | 503 | 87 |
| Total | | 552 | | | 1855 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 25 |
| 12. Reactor I&C Systems | | 28 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 50 |
| 15. Reactor Cooling Systems | | 11 |
| 16. Steam generation systems | | 37 |
| 31. Turbine and auxiliaries | 8 | 26 |
| 32. Feedwater and Main Steam System | 41 | 23 |
| 33. Circulating Water System | | 3 |
| 34. Miscellaneous Systems | | 34 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 61 |
| 42. Electrical Power Supply Systems | | 127 |
| Total | 49 | 427 |

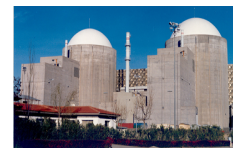
2023 Operating Experience

ES-6

ALMARAZ-1

SPAIN

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : CNAT (CENTRALES NUCLEARES ALMARAZ-TRILLO (ID/UFG/ENDESA/HC/NUCLENOR)) |
| Owner | : ID/EN/GN (Iberdrola, Endesa, Gas Natural) |
| Reactor Supplier | : WH (WESTINGHOUSE ELECTRIC CORPORATION) |
| Turbine Supplier | : WH (WESTINGHOUSE ELECTRIC CORPORATION) |



| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP | Construction Date | : 1973-07-03 |
| Thermal power | : 2947 MWth | Grid Date | : 1981-05-01 |
| Gross electrical power | : 1049 MWe | Commercial Date | : 1983-09-01 |
| Reference unit power (net) | : 1011 MWe | Age at end of year | : 42 years |

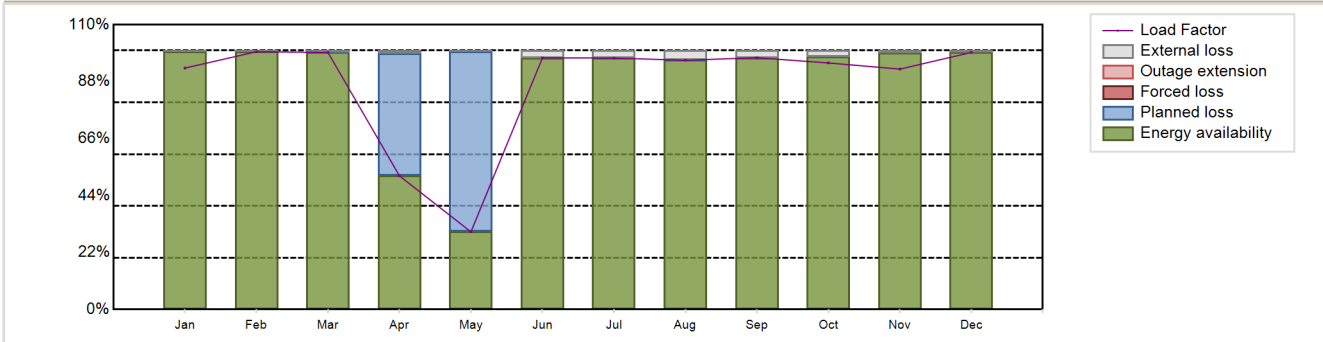
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|-----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.8 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 325 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 4.60 | Containment design pressure [MPa] | : 3.5 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 58000 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.65 | HP cylinder inlet steam pressure [MPa] | : 6.9 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.3 | Primary means of condenser cooling | : Lake (once-through) |
| Number of control rod assemblies | : 48 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : NA |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 7735.09 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 88.58 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 90.18 % | Planned Unavailability Factor (PUF) | : 9.82 % |
| Load Factor (LF) | : 87.34 % | Externally cause unavailability (XUF) | : 1.61 % |
| Operating Factor (OF) | : 90.73 % | Total off-line time | : 812 hours |

Annual Summary

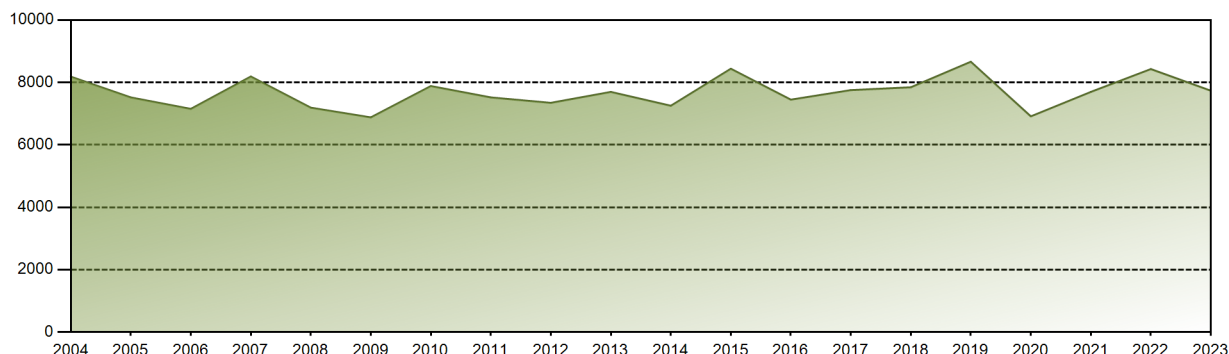


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 701.46 | 676.47 | 745.68 | 375.74 | 225.69 | 707.46 | 730.59 | 724.09 | 707.94 | 717.27 | 675.92 | 746.80 | 7735.09 |
| EAF [%] | 99.51 | 99.57 | 99.27 | 51.62 | 30.01 | 97.19 | 97.13 | 96.27 | 97.26 | 97.53 | 99.07 | 99.28 | 88.58 |
| UCF [%] | 100.00 | 100.00 | 99.97 | 52.68 | 30.30 | 100.00 | 100.00 | 99.92 | 100.00 | 100.00 | 100.00 | 100.00 | 90.18 |
| LF [%] | 93.26 | 99.57 | 99.27 | 51.62 | 30.01 | 97.19 | 97.13 | 96.27 | 97.26 | 95.23 | 92.86 | 99.28 | 87.34 |
| OF [%] | 100.00 | 100.00 | 100.00 | 53.33 | 36.02 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.73 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.03 | 47.32 | 69.70 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 9.82 |
| XUF [%] | 0.49 | 0.43 | 0.71 | 1.06 | 0.29 | 2.81 | 2.87 | 3.66 | 2.74 | 2.47 | 0.93 | 0.72 | 1.61 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 295370.82 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.22 % |
| Cumulative Energy Availability Factor (EAF) | : 86.3 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.1 % |
| Cumulative Unit Capability Factor (UCF) | : 87.41 % | Cumulative Planned Unavailability Factor (PUF) | : 10.49 % |
| Cumulative Load Factor (LF) | : 86.31 % | Cumulative Externally cause unavailability (XUF) | : 1.11 % |
| Cumulative Operating Factor (OF) | : 88.81 % | | |

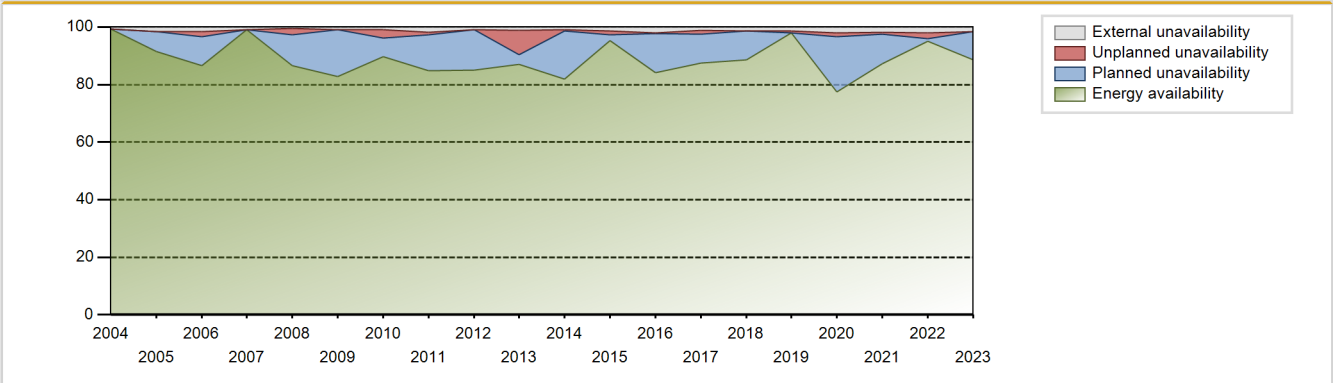
Electricity Production (net) [GWh]



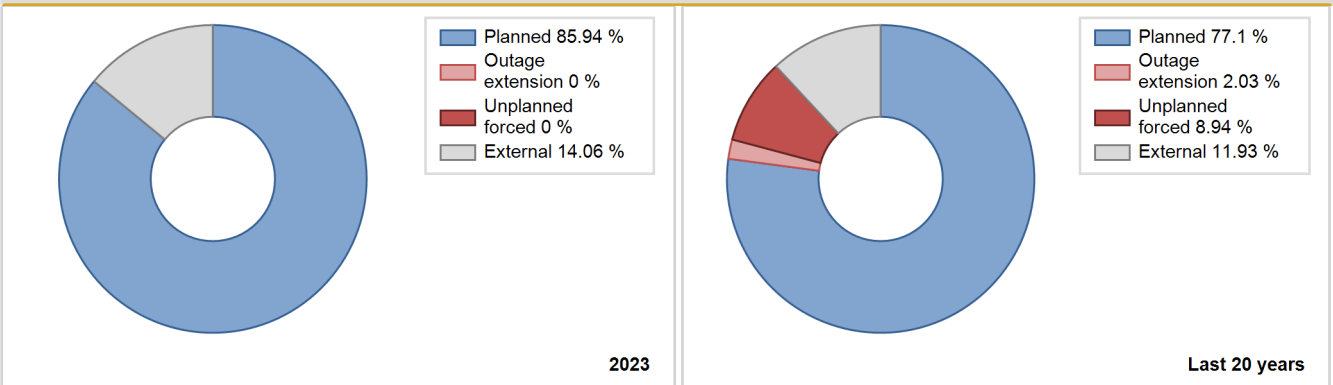
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 3713.90 | 5925 | 930 | 78.42 | 78.42 | 78.40 | 88.67 | 1.07 | 0.85 | 20.73 | 0.00 |
| 1984 | 4820.50 | 6062 | 893 | 65.03 | 65.03 | 61.45 | 69.01 | 6.16 | 4.27 | 30.71 | 0.00 |
| 1985 | 4825.17 | 5705 | 900 | 61.63 | 61.63 | 61.20 | 65.13 | 7.22 | 4.80 | 33.57 | 0.00 |
| 1986 | 5425.02 | 6418 | 900 | 69.29 | 69.29 | 68.81 | 73.26 | 10.45 | 8.08 | 22.63 | 0.00 |
| 1987 | 7193.69 | 8346 | 900 | 92.54 | 92.54 | 91.24 | 95.27 | 2.97 | 2.83 | 4.63 | 0.00 |
| 1988 | 5879.59 | 6899 | 900 | 74.60 | 74.60 | 74.37 | 78.54 | 15.76 | 13.96 | 11.45 | 0.00 |
| 1989 | 6562.18 | 7640 | 895 | 83.20 | 83.20 | 83.70 | 87.21 | 1.90 | 1.61 | 15.19 | 0.00 |
| 1990 | 6460.66 | 7451 | 895 | 82.22 | 82.22 | 82.40 | 85.06 | 1.63 | 1.36 | 16.42 | 0.00 |
| 1991 | 7481.71 | 8589 | 895 | 96.20 | 96.20 | 95.43 | 98.05 | 2.72 | 2.69 | 1.11 | 0.00 |
| 1992 | 6379.06 | 7387 | 895 | 80.76 | 80.76 | 81.14 | 84.10 | 1.88 | 1.55 | 17.68 | 0.00 |
| 1993 | 6530.85 | 7663 | 895 | 83.19 | 85.05 | 83.30 | 87.48 | 4.26 | 3.78 | 11.17 | 1.86 |
| 1994 | 7448.60 | 8495 | 895 | 95.05 | 95.92 | 95.01 | 96.97 | 3.38 | 3.36 | 0.73 | 0.86 |
| 1995 | 6588.46 | 7709 | 895 | 83.74 | 86.23 | 84.03 | 88.00 | 3.41 | 3.05 | 10.73 | 2.49 |
| 1996 | 5904.30 | 6789 | 895 | 72.53 | 73.77 | 75.10 | 77.29 | 2.81 | 2.13 | 24.09 | 1.24 |
| 1997 | 6642.83 | 7371 | 895 | 79.57 | 82.95 | 84.73 | 84.14 | 3.20 | 2.75 | 14.30 | 3.38 |
| 1998 | 8032.46 | 8760 | 944 | 97.12 | 98.81 | 97.13 | 100.00 | 1.19 | 1.19 | 0.00 | 1.69 |
| 1999 | 6988.63 | 7613 | 927 | 84.68 | 85.40 | 86.06 | 86.91 | 2.93 | 2.58 | 12.01 | 0.73 |
| 2000 | 7471.57 | 8014 | 927 | 90.32 | 91.08 | 91.76 | 91.23 | 1.08 | 0.99 | 7.93 | 0.76 |
| 2001 | 8151.39 | 8749 | 927 | 99.02 | 99.59 | 100.38 | 99.87 | 0.41 | 0.41 | 0.00 | 0.56 |
| 2002 | 7427.99 | 8100 | 944 | 90.38 | 92.21 | 89.82 | 92.47 | 0.66 | 0.61 | 7.17 | 1.83 |
| 2003 | 7499.11 | 8233 | 944 | 91.59 | 93.76 | 90.68 | 93.98 | 0.00 | 0.00 | 6.24 | 2.17 |
| 2004 | 8185.69 | 8784 | 944 | 99.23 | 99.90 | 98.72 | 100.00 | 0.10 | 0.10 | 0.01 | 0.67 |
| 2005 | 7519.43 | 8180 | 944 | 91.45 | 93.06 | 90.93 | 93.38 | 0.03 | 0.03 | 6.92 | 1.61 |
| 2006 | 7152.42 | 7831 | 944 | 86.54 | 88.07 | 86.49 | 89.39 | 1.96 | 1.76 | 10.17 | 1.54 |
| 2007 | 8189.80 | 8760 | 944 | 98.98 | 99.93 | 99.04 | 100.00 | 0.07 | 0.07 | 0.00 | 0.95 |
| 2008 | 7190.76 | 7725 | 944 | 86.61 | 87.16 | 86.72 | 87.94 | 0.10 | 2.08 | 10.77 | 0.55 |
| 2009 | 6880.10 | 7336 | 944 | 82.85 | 83.73 | 83.20 | 83.74 | 0.00 | 0.00 | 16.27 | 0.88 |
| 2010 | 7884.25 | 8147 | 1008 | 89.67 | 90.50 | 89.70 | 93.00 | 3.31 | 3.10 | 6.40 | 0.82 |
| 2011 | 7519.49 | 7814 | 1011 | 84.91 | 86.77 | 84.90 | 89.20 | 0.94 | 0.82 | 12.41 | 1.86 |
| 2012 | 7346.07 | 7405 | 1004 | 85.00 | 85.90 | 83.30 | 84.30 | 0.00 | 0.00 | 14.10 | 0.90 |
| 2013 | 7695.84 | 7882 | 1011 | 87.08 | 88.34 | 86.90 | 89.98 | 8.65 | 8.36 | 3.30 | 1.26 |
| 2014 | 7252.45 | 7351 | 1011 | 81.86 | 82.70 | 81.89 | 83.92 | 0.56 | 0.47 | 16.83 | 0.84 |
| 2015 | 8438.61 | 8613 | 1011 | 95.28 | 96.61 | 95.28 | 98.32 | 1.43 | 1.41 | 1.98 | 1.33 |
| 2016 | 7447.79 | 7622 | 1011 | 84.08 | 86.06 | 83.87 | 86.77 | 0.43 | 0.37 | 13.57 | 1.98 |
| 2017 | 7753.93 | 7885 | 1011 | 87.55 | 88.77 | 87.55 | 90.01 | 1.44 | 1.29 | 9.94 | 1.22 |
| 2018 | 7844.02 | 7934 | 1011 | 88.69 | 89.96 | 88.57 | 90.57 | 0.04 | 0.03 | 10.01 | 1.27 |
| 2019 | 8662.82 | 8760 | 1011 | 98.05 | 99.42 | 97.81 | 100.00 | 0.57 | 0.57 | 0.01 | 1.37 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2020 | 6913.13 | 7065 | 1011 | 77.54 | 79.58 | 77.85 | 80.43 | 1.66 | 1.34 | 19.08 | 2.04 |
| 2021 | 7695.62 | 7800 | 1011 | 87.16 | 89.02 | 86.89 | 89.04 | 0.00 | 0.68 | 10.30 | 1.86 |
| 2022 | 8427.99 | 8564 | 1011 | 95.16 | 97.30 | 95.16 | 97.76 | 0.02 | 1.94 | 0.77 | 2.13 |
| 2023 | 7735.09 | 7948 | 1011 | 88.58 | 90.18 | 87.34 | 90.73 | 0.00 | 0.00 | 9.82 | 1.61 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 122 | |
| C. Inspection, maintenance or repair combined with refuelling | 813 | | | 793 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 147 | | |
| E. Testing of plant systems or components | | | | 43 | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| L. Human factor related | | | | | 3 | |
| Z. Other | | | | | 1 | |
| Subtotal | 813 | | | 983 | 126 | 4 |
| Total | | 813 | | | 1113 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1983 to 2023 | |
|--|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 12 |
| 13. Reactor Auxiliary Systems | | | | 26 |
| 15. Reactor Cooling Systems | | | | 15 |
| 16. Steam generation systems | | | | 4 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 0 |
| 31. Turbine and auxiliaries | | | | 4 |
| 32. Feedwater and Main Steam System | | | | 17 |
| 33. Circulating Water System | | | | 1 |
| 41. Main Generator Systems | | | | 23 |
| 42. Electrical Power Supply Systems | | | | 19 |
| Total | | | | 121 |

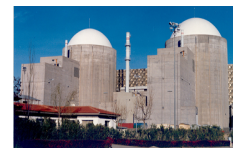
2023 Operating Experience

ES-7

ALMARAZ-2

SPAIN

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : CNAT (CENTRALES NUCLEARES ALMARAZ-TRILLO (ID/UFG/ENDESA/HC/NUCLENOR)) |
| Owner | : ID/EN/GN (Iberdrola, Endesa, Gas Natural) |
| Reactor Supplier | : WH (WESTINGHOUSE ELECTRIC CORPORATION) |
| Turbine Supplier | : WH (WESTINGHOUSE ELECTRIC CORPORATION) |



Reactor Unit Details

| | |
|----------------------------|----------------|
| Reactor type and model | : PWR / WH 3LP |
| Thermal power | : 2947 MWth |
| Gross electrical power | : 1044 MWe |
| Reference unit power (net) | : 1006 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 1973-07-03 |
| Grid Date | : 1983-10-08 |
| Commercial Date | : 1984-07-01 |
| Age at end of year | : 40 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : 4.60 |
| Refuelling frequency [month] | : 18 |
| Part of the core refuelled [%] | : 33 |
| Average discharge burnup [MWd/t] | : 58000 |
| Active core diameter [m] | : 3.04 |
| Active core height/length [m] | : 3.65 |
| Number of fissile fuel assemblies/bundles | : 157 |
| Fuel linear heat generation rate [kW/m] | : 17.3 |
| Number of control rod assemblies | : 48 |
| Number of external reactor coolant loops | : 3 |
| Coolant type | : H2O |

| | |
|-----------------------------------|----------|
| Operating coolant pressure [MPa] | : 15.8 |
| Reactor outlet temperature [°C] | : 325 |
| Number of SG | : 3 |
| Containment type | : Single |
| Containment design pressure [MPa] | : 3.5 |

Secondary systems

| | |
|--|-----------------------|
| Number of turbine-generators per unit/reactor | : 1 |
| Turbine speed [rpm] | : 1500 |
| Number of LP cylinders per turbine | : - |
| HP cylinder inlet steam pressure [MPa] | : 6.9 |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : Lake (once-through) |
| Number of main condensate pumps | : - |
| Number of FW pumps for full power operation | : - |
| Number of on-site safety related diesel generators | : NA |

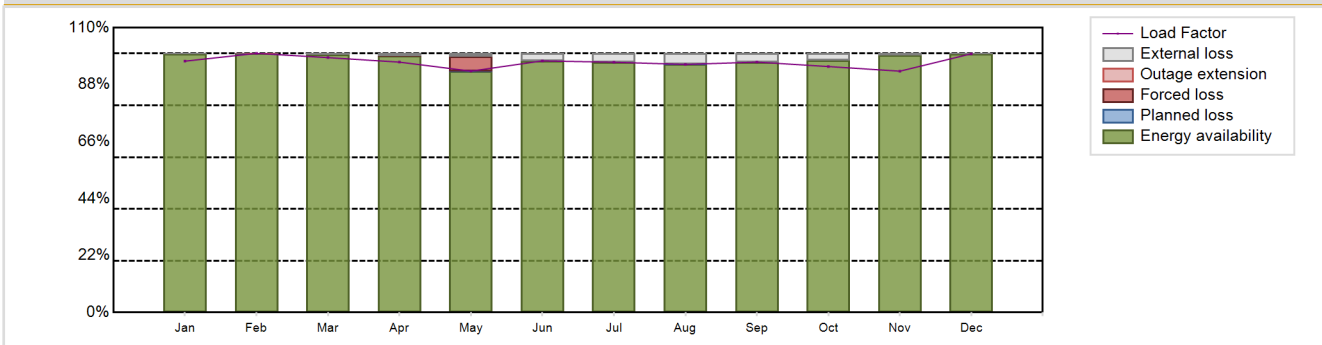
Non-electrical applications

| | |
|--|--------|
| | : none |
|--|--------|

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|------------|
| Net Energy Production | : 8517.29 GW(e).h | Forced Loss Rate (FLR) | : 0.48 % |
| Energy Availability Factor (EAF) | : 97.91 % | Unplanned Capability Loss Factor (UCL) | : 0.48 % |
| Unit Capability Factor (UCF) | : 99.51 % | Planned Unavailability Factor (PUF) | : 0.01 % |
| Load Factor (LF) | : 96.65 % | Externally cause unavailability (XUF) | : 1.6 % |
| Operating Factor (OF) | : 99.77 % | Total off-line time | : 20 hours |

Annual Summary

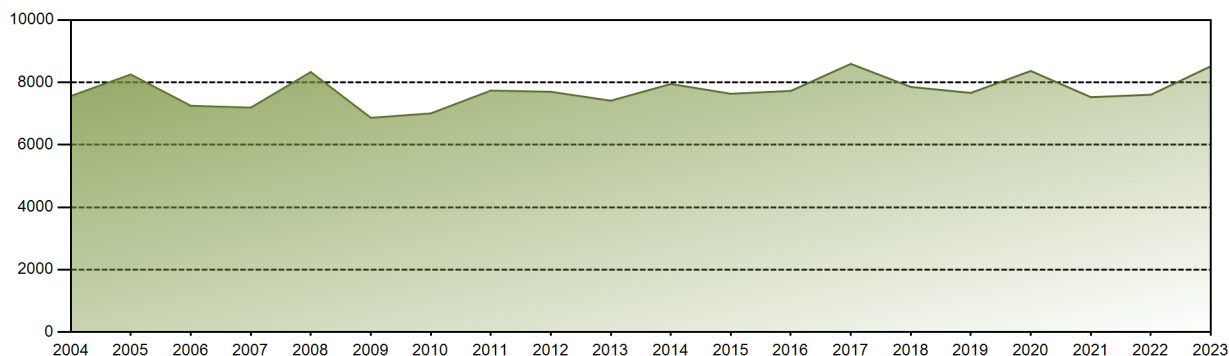


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 726.56 | 676.60 | 735.84 | 700.45 | 697.81 | 703.89 | 723.42 | 717.24 | 700.51 | 711.97 | 675.13 | 747.86 | 8517.29 |
| EAF [%] | 99.80 | 100.08 | 99.60 | 99.19 | 93.23 | 97.18 | 96.65 | 95.83 | 96.71 | 97.49 | 99.47 | 99.92 | 97.91 |
| UCF [%] | 100.00 | 99.98 | 100.00 | 99.99 | 94.28 | 100.00 | 100.00 | 99.97 | 100.00 | 100.00 | 100.00 | 100.00 | 99.51 |
| LF [%] | 97.07 | 100.08 | 98.45 | 96.70 | 93.23 | 97.18 | 96.65 | 95.83 | 96.71 | 95.00 | 93.21 | 99.92 | 96.65 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 97.31 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.77 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.01 | 5.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.01 | 5.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 |
| PUF [%] | 0.00 | 0.02 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| XUF [%] | 0.20 | -0.10 | 0.40 | 0.81 | 1.05 | 2.82 | 3.35 | 4.14 | 3.29 | 2.51 | 0.53 | 0.08 | 1.60 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 292624.81 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.14 % |
| Cumulative Energy Availability Factor (EAF) | : 87.86 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.3 % |
| Cumulative Unit Capability Factor (UCF) | : 89 % | Cumulative Planned Unavailability Factor (PUF) | : 8.7 % |
| Cumulative Load Factor (LF) | : 87.89 % | Cumulative Externally cause unavailability (XUF) | : 1.14 % |
| Cumulative Operating Factor (OF) | : 90.43 % | | |

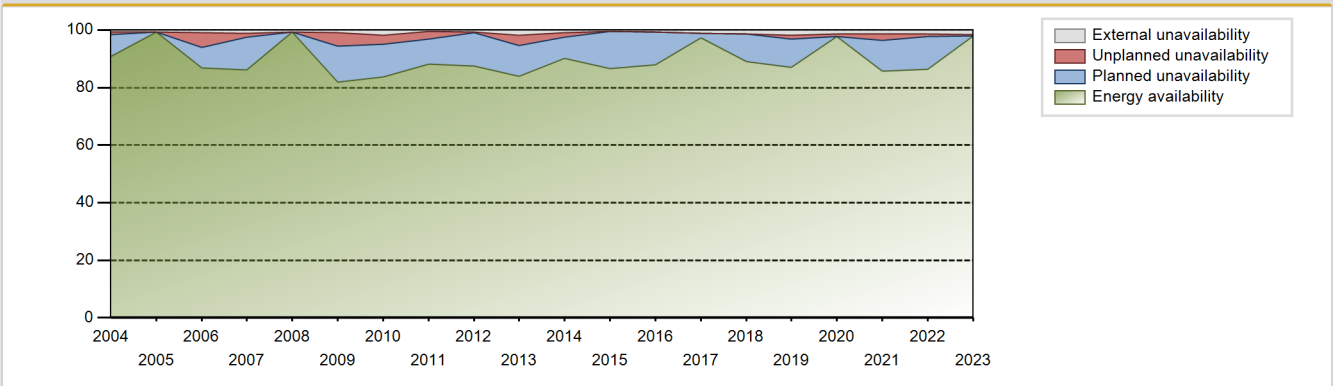
Electricity Production (net) [GWh]



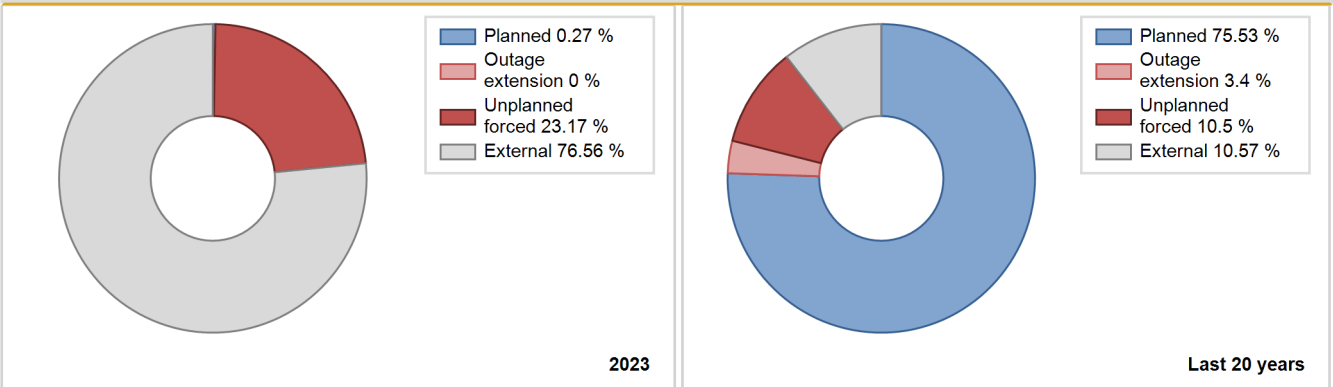
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 6012.94 | 7502 | 893 | 86.01 | 86.01 | 81.25 | 90.31 | 6.46 | 5.94 | 8.05 | 0.00 |
| 1985 | 6236.07 | 7297 | 900 | 79.84 | 79.84 | 79.10 | 83.30 | 2.74 | 2.25 | 17.91 | 0.00 |
| 1986 | 5825.18 | 7136 | 900 | 75.23 | 75.23 | 73.89 | 81.46 | 4.46 | 3.51 | 21.26 | 0.00 |
| 1987 | 6402.53 | 7351 | 900 | 81.78 | 81.78 | 81.21 | 83.92 | 2.13 | 1.78 | 16.45 | 0.00 |
| 1988 | 6809.37 | 7838 | 900 | 86.26 | 86.26 | 86.13 | 89.23 | 2.06 | 1.81 | 11.93 | 0.00 |
| 1989 | 6545.67 | 7638 | 895 | 82.83 | 82.83 | 83.49 | 87.19 | 5.23 | 4.57 | 12.60 | 0.00 |
| 1990 | 7649.30 | 8652 | 895 | 97.39 | 97.39 | 97.57 | 98.77 | 1.08 | 1.06 | 1.54 | 0.00 |
| 1991 | 6812.87 | 7712 | 895 | 85.35 | 85.35 | 86.90 | 88.04 | 2.01 | 1.75 | 12.90 | 0.00 |
| 1992 | 6892.72 | 7997 | 895 | 87.33 | 87.33 | 87.67 | 91.04 | 0.66 | 0.58 | 12.09 | 0.00 |
| 1993 | 7710.14 | 8760 | 895 | 98.54 | 98.99 | 98.34 | 100.00 | 0.94 | 0.94 | 0.07 | 0.45 |
| 1994 | 6384.58 | 7562 | 895 | 80.89 | 84.25 | 81.43 | 86.32 | 1.56 | 1.34 | 14.42 | 3.35 |
| 1995 | 6814.74 | 7952 | 895 | 86.18 | 89.05 | 86.92 | 90.78 | 1.22 | 1.10 | 9.85 | 2.87 |
| 1996 | 7273.32 | 8108 | 895 | 91.50 | 91.64 | 92.52 | 92.30 | 8.16 | 8.15 | 0.22 | 0.13 |
| 1997 | 6042.50 | 6811 | 895 | 72.56 | 76.60 | 77.07 | 77.75 | 3.68 | 2.93 | 20.47 | 4.04 |
| 1998 | 5892.43 | 6810 | 953 | 70.16 | 75.90 | 70.58 | 77.74 | 13.09 | 11.43 | 12.67 | 5.75 |
| 1999 | 8126.64 | 8743 | 936 | 97.41 | 98.04 | 99.11 | 99.81 | 1.96 | 1.96 | 0.00 | 0.63 |
| 2000 | 7401.83 | 8160 | 936 | 88.45 | 90.58 | 90.03 | 92.90 | 1.69 | 1.56 | 7.86 | 2.13 |
| 2001 | 7601.46 | 8189 | 936 | 91.33 | 92.08 | 92.71 | 93.48 | 1.56 | 1.46 | 6.45 | 0.75 |
| 2002 | 8154.94 | 8760 | 953 | 98.10 | 98.84 | 97.68 | 100.00 | 1.14 | 1.14 | 0.01 | 0.75 |
| 2003 | 6627.94 | 7391 | 953 | 79.90 | 81.88 | 79.39 | 84.37 | 4.75 | 10.80 | 7.32 | 1.97 |
| 2004 | 7563.17 | 8083 | 953 | 90.93 | 91.63 | 90.35 | 92.02 | 1.00 | 0.92 | 7.45 | 0.69 |
| 2005 | 8253.32 | 8760 | 956 | 99.24 | 99.96 | 98.55 | 100.00 | 0.03 | 0.03 | 0.00 | 0.73 |
| 2006 | 7250.11 | 7747 | 956 | 86.78 | 87.71 | 86.56 | 88.43 | 5.41 | 5.02 | 7.27 | 0.93 |
| 2007 | 7191.67 | 7668 | 956 | 86.04 | 87.11 | 85.88 | 87.53 | 0.00 | 1.38 | 11.51 | 1.07 |
| 2008 | 8331.69 | 8784 | 956 | 99.22 | 99.98 | 99.22 | 100.00 | 0.02 | 0.02 | 0.00 | 0.76 |
| 2009 | 6864.58 | 7367 | 956 | 82.01 | 82.91 | 81.97 | 84.10 | 2.19 | 4.60 | 12.49 | 0.90 |
| 2010 | 7007.03 | 7572 | 956 | 83.79 | 85.50 | 83.67 | 86.44 | 3.74 | 3.32 | 11.18 | 1.71 |
| 2011 | 7737.28 | 7991 | 1006 | 88.07 | 88.58 | 88.17 | 91.22 | 2.84 | 2.59 | 8.83 | 0.51 |
| 2012 | 7698.78 | 7730 | 1006 | 87.55 | 88.16 | 87.12 | 88.00 | 0.00 | 0.22 | 11.63 | 0.61 |
| 2013 | 7412.90 | 7557 | 1006 | 84.00 | 85.90 | 84.12 | 86.27 | 3.94 | 3.52 | 10.58 | 1.90 |
| 2014 | 7949.00 | 8054 | 1006 | 90.18 | 91.06 | 90.20 | 91.94 | 1.78 | 1.65 | 7.29 | 0.88 |
| 2015 | 7635.93 | 7709 | 1006 | 86.58 | 87.06 | 86.65 | 88.00 | 0.00 | 0.00 | 12.94 | 0.47 |
| 2016 | 7726.48 | 7827 | 1006 | 87.88 | 88.56 | 87.44 | 89.11 | 0.00 | 0.00 | 11.44 | 0.68 |
| 2017 | 8593.49 | 8656 | 1006 | 97.36 | 98.47 | 97.51 | 98.81 | 0.00 | 0.00 | 1.53 | 1.11 |
| 2018 | 7854.88 | 7969 | 1006 | 88.97 | 90.40 | 89.13 | 90.97 | 0.00 | 0.00 | 9.60 | 1.43 |
| 2019 | 7662.81 | 7824 | 1006 | 86.95 | 88.66 | 86.95 | 89.32 | 0.00 | 1.36 | 9.98 | 1.70 |
| 2020 | 8366.41 | 8741 | 1006 | 97.82 | 99.22 | 94.68 | 99.51 | 0.77 | 0.77 | 0.01 | 1.40 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 7527.14 | 7722 | 1006 | 85.65 | 86.92 | 85.41 | 88.15 | 1.22 | 2.33 | 10.75 | 1.27 |
| 2022 | 7604.97 | 7764 | 1006 | 86.31 | 87.77 | 86.30 | 88.63 | 0.71 | 0.79 | 11.44 | 1.46 |
| 2023 | 8517.29 | 8740 | 1006 | 97.91 | 99.51 | 96.65 | 99.77 | 0.48 | 0.48 | 0.01 | 1.60 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 20 | | | 121 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 683 | 5 | |
| D. Inspection, maintenance or repair without refuelling | | | | 16 | | |
| E. Testing of plant systems or components | | | | 27 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 6 | |
| Z. Other | | | | | 11 | |
| Subtotal | | 20 | | 726 | 143 | 2 |
| Total | | 20 | | | 871 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 11 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 15 |
| 16. Steam generation systems | | 20 |
| 21. Fuel Handling and Storage Facilities | | 0 |
| 31. Turbine and auxiliaries | | 22 |
| 32. Feedwater and Main Steam System | 20 | 21 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 15 |
| 42. Electrical Power Supply Systems | | 23 |
| Total | 20 | 134 |

2023 Operating Experience

ES-8

ASCO-1

SPAIN

Status at end of year : **Operational**
 Operator : ANAV (ASOCIACIÓN NUCLEAR ASCÓ-VANDELLÓS A.I.E. (ENDESA/ID))
 Owner : ENDESA (ENDESA, S.A.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 3LP
 Thermal power : 2941 MWth
 Gross electrical power : 1033 MWe
 Reference unit power (net) : 995 MWe

Key Dates

Construction Date : 1974-05-16
 Grid Date : 1983-08-13
 Commercial Date : 1984-12-10
 Age at end of year : 40 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 28
 Average discharge burnup [MWd/t] : 50500
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.65
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.92
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.72
 Reactor outlet temperature [°C] : 326.7
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 3.86

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.6
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

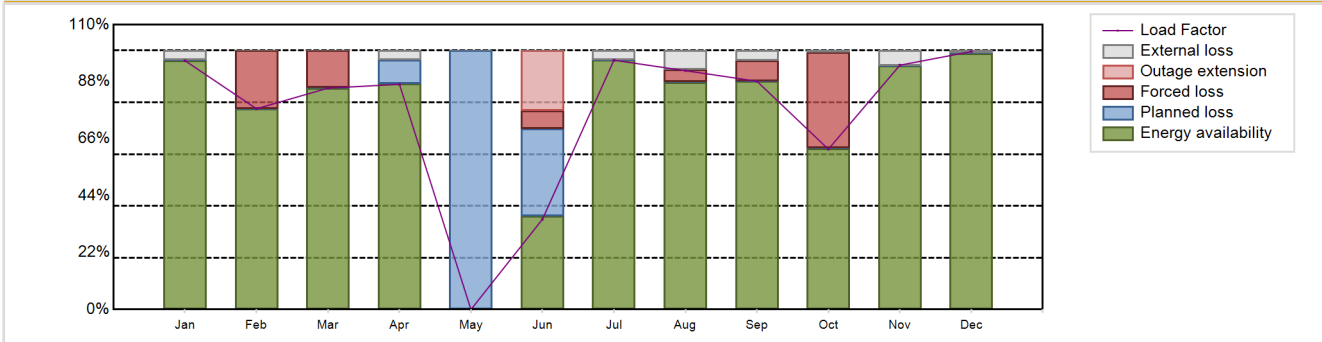
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6634.81 GW(e).h
 Energy Availability Factor (EAF) : 75.78 %
 Unit Capability Factor (UCF) : 78.26 %
 Load Factor (LF) : 76.12 %
 Operating Factor (OF) : 80.19 %
 Forced Loss Rate (FLR) : 8.94 %
 Unplanned Capability Loss Factor (UCL) : 9.59 %
 Planned Unavailability Factor (PUF) : 12.15 %
 Externally cause unavailability (XUF) : 2.48 %
 Total off-line time : 1735 hours

Annual Summary

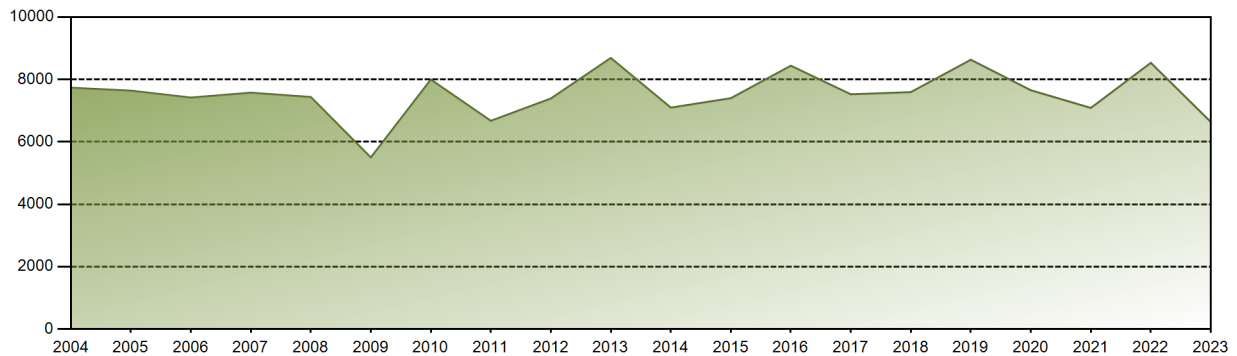


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 711.44 | 518.47 | 632.15 | 623.11 | 0.00 | 249.74 | 712.80 | 682.84 | 631.76 | 459.04 | 675.97 | 737.49 | 6634.81 |
| EAF [%] | 96.10 | 77.55 | 85.50 | 87.23 | 0.00 | 35.96 | 96.29 | 87.58 | 88.19 | 62.23 | 94.10 | 98.93 | 75.78 |
| UCF [%] | 99.83 | 77.55 | 85.50 | 90.84 | 0.00 | 35.96 | 99.84 | 94.99 | 92.02 | 62.96 | 99.86 | 99.87 | 78.26 |
| LF [%] | 96.10 | 77.54 | 85.51 | 86.98 | 0.00 | 34.86 | 96.29 | 92.24 | 88.19 | 61.93 | 94.36 | 99.62 | 76.12 |
| OF [%] | 100.00 | 76.34 | 84.12 | 93.33 | 0.00 | 50.14 | 100.00 | 100.00 | 90.97 | 67.52 | 100.00 | 100.00 | 80.19 |
| FLR [%] | 0.00 | 22.37 | 14.40 | 0.00 | 0.00 | 16.06 | 0.00 | 4.68 | 7.86 | 36.98 | 0.00 | 0.00 | 8.94 |
| UCL [%] | 0.00 | 22.35 | 14.38 | 0.00 | 0.00 | 30.07 | 0.00 | 4.66 | 7.85 | 36.95 | 0.00 | 0.00 | 9.59 |
| PUF [%] | 0.17 | 0.10 | 0.12 | 9.16 | 100.00 | 33.97 | 0.16 | 0.35 | 0.13 | 0.09 | 0.14 | 0.13 | 12.15 |
| XUF [%] | 3.73 | 0.00 | 0.00 | 3.61 | 0.00 | 0.00 | 3.56 | 7.41 | 3.84 | 0.74 | 5.76 | 0.94 | 2.48 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 284973.25 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.67 % |
| Cumulative Energy Availability Factor (EAF) | : 85.54 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.42 % |
| Cumulative Unit Capability Factor (UCF) | : 86.26 % | Cumulative Planned Unavailability Factor (PUF) | : 10.32 % |
| Cumulative Load Factor (LF) | : 84.97 % | Cumulative Externally cause unavailability (XUF) | : 0.73 % |
| Cumulative Operating Factor (OF) | : 87.86 % | | |

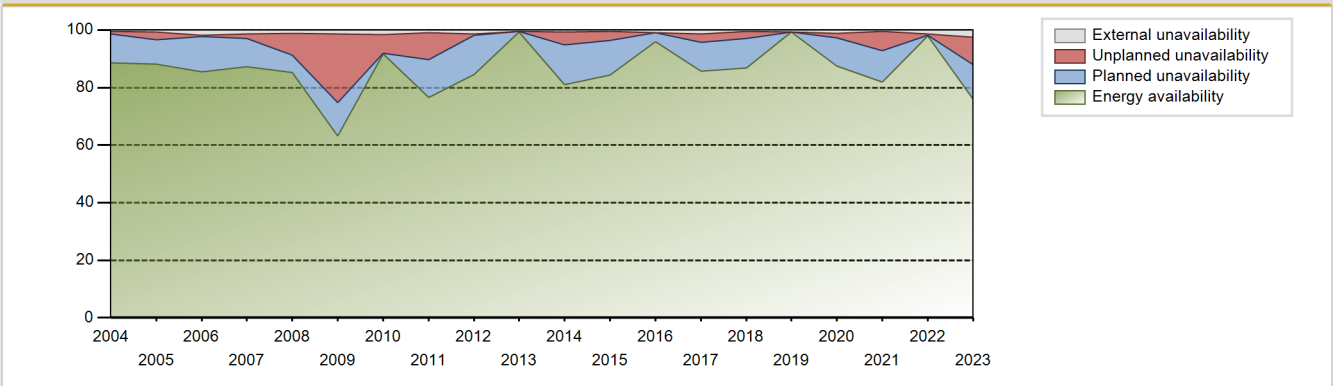
Electricity Production (net) [GWh]



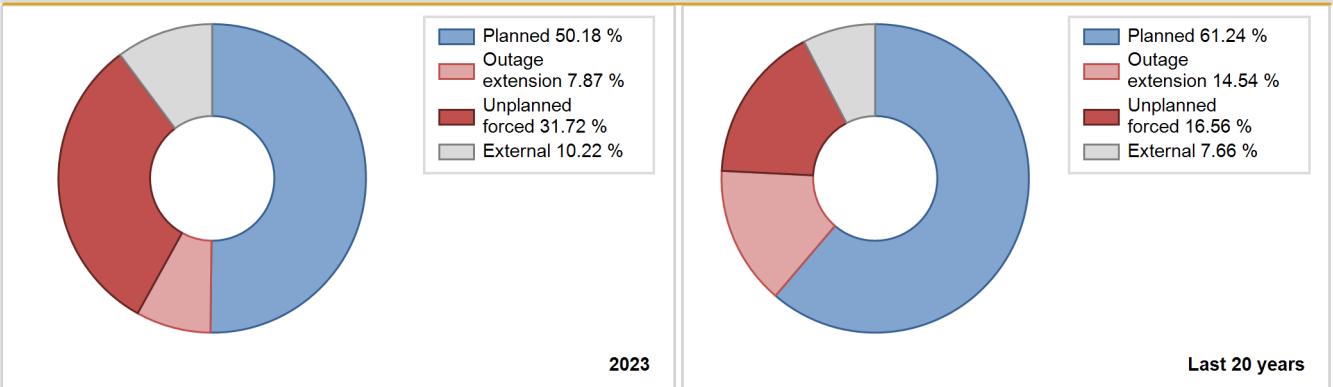
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 4038.42 | 5771 | 887 | 20.02 | 20.02 | 15.76 | 21.64 | 67.19 | 41.00 | 38.98 | 0.00 |
| 1985 | 4429.40 | 5342 | 898 | 60.32 | 60.32 | 56.31 | 60.98 | 6.75 | 4.37 | 35.31 | 0.00 |
| 1986 | 5129.00 | 6208 | 898 | 68.16 | 68.16 | 65.20 | 70.87 | 2.29 | 1.60 | 30.24 | 0.00 |
| 1987 | 6392.00 | 7569 | 898 | 83.70 | 84.27 | 81.26 | 86.40 | 2.22 | 1.91 | 13.82 | 0.57 |
| 1988 | 6669.00 | 7599 | 898 | 84.11 | 84.11 | 84.55 | 86.51 | 6.85 | 6.19 | 9.70 | 0.00 |
| 1989 | 6750.00 | 7771 | 930 | 86.03 | 86.05 | 82.85 | 88.71 | 2.79 | 2.47 | 11.48 | 0.03 |
| 1990 | 6642.00 | 7699 | 930 | 84.54 | 84.54 | 81.53 | 87.89 | 2.21 | 1.91 | 13.55 | 0.00 |
| 1991 | 6836.00 | 7810 | 930 | 87.03 | 87.16 | 83.91 | 89.16 | 1.58 | 1.40 | 11.44 | 0.13 |
| 1992 | 6875.00 | 7898 | 887 | 86.51 | 86.51 | 88.24 | 89.91 | 1.66 | 1.46 | 12.03 | 0.00 |
| 1993 | 6599.00 | 7401 | 930 | 83.19 | 83.33 | 81.00 | 84.49 | 5.59 | 4.94 | 11.73 | 0.14 |
| 1994 | 6868.00 | 7758 | 930 | 86.85 | 87.13 | 84.30 | 88.56 | 1.43 | 1.26 | 11.60 | 0.29 |
| 1995 | 5708.00 | 6387 | 900 | 70.37 | 70.75 | 72.40 | 72.91 | 1.90 | 1.37 | 27.88 | 0.38 |
| 1996 | 7972.00 | 8755 | 947 | 99.04 | 99.04 | 95.84 | 99.67 | 0.86 | 0.85 | 0.10 | 0.00 |
| 1997 | 6411.00 | 7198 | 915 | 77.58 | 80.50 | 79.98 | 82.17 | 9.99 | 8.93 | 10.57 | 2.92 |
| 1998 | 7349.00 | 7943 | 949 | 89.13 | 89.28 | 88.40 | 90.67 | 3.21 | 2.96 | 7.75 | 0.16 |
| 1999 | 8147.00 | 8741 | 945 | 98.74 | 98.96 | 98.42 | 99.78 | 1.00 | 1.00 | 0.03 | 0.23 |
| 2000 | 7681.00 | 8008 | 991 | 89.50 | 89.81 | 89.27 | 91.17 | 1.23 | 1.12 | 9.07 | 0.31 |
| 2001 | 7798.00 | 8056 | 991 | 89.81 | 90.30 | 89.83 | 91.96 | 0.58 | 0.52 | 9.18 | 0.48 |
| 2002 | 8397.00 | 8737 | 998 | 97.60 | 98.24 | 96.05 | 99.74 | 0.43 | 0.43 | 1.33 | 0.64 |
| 2003 | 7581.11 | 7900 | 995 | 87.32 | 88.04 | 86.89 | 90.18 | 0.12 | 0.10 | 11.85 | 0.73 |
| 2004 | 7734.27 | 7949 | 995 | 88.62 | 89.16 | 88.49 | 90.49 | 0.36 | 0.78 | 10.05 | 0.55 |
| 2005 | 7640.50 | 8548 | 995 | 88.24 | 88.99 | 87.66 | 97.58 | 2.98 | 2.73 | 8.28 | 0.76 |
| 2006 | 7418.37 | 7971 | 995 | 85.38 | 87.09 | 85.10 | 90.98 | 0.32 | 0.52 | 12.39 | 1.71 |
| 2007 | 7574.76 | 7876 | 995 | 87.36 | 88.63 | 86.90 | 89.91 | 0.73 | 1.72 | 9.65 | 1.27 |
| 2008 | 7436.29 | 7768 | 995 | 85.23 | 86.34 | 85.08 | 88.43 | 0.61 | 7.65 | 6.00 | 1.12 |
| 2009 | 5499.76 | 5758 | 995 | 63.10 | 64.43 | 63.10 | 65.73 | 22.82 | 23.92 | 11.65 | 1.33 |
| 2010 | 7996.12 | 8231 | 995 | 91.74 | 93.31 | 91.74 | 93.96 | 6.45 | 6.43 | 0.25 | 1.58 |
| 2011 | 6674.51 | 6946 | 995 | 76.58 | 77.45 | 76.58 | 79.29 | 0.43 | 9.31 | 13.24 | 0.88 |
| 2012 | 7388.22 | 7666 | 995 | 84.51 | 85.97 | 84.53 | 87.27 | 0.41 | 0.35 | 13.67 | 1.46 |
| 2013 | 8687.39 | 8760 | 995 | 99.33 | 99.87 | 99.67 | 100.00 | 0.00 | 0.00 | 0.13 | 0.54 |
| 2014 | 7096.39 | 7226 | 995 | 80.98 | 81.69 | 81.42 | 82.49 | 0.00 | 4.48 | 13.82 | 0.72 |
| 2015 | 7397.93 | 7725 | 995 | 84.36 | 84.82 | 84.88 | 88.18 | 2.13 | 3.24 | 11.93 | 0.46 |
| 2016 | 8439.80 | 8560 | 995 | 95.91 | 96.83 | 96.56 | 97.45 | 0.05 | 0.05 | 3.12 | 0.91 |
| 2017 | 7522.94 | 7689 | 995 | 85.67 | 86.95 | 86.31 | 87.77 | 1.05 | 2.92 | 10.13 | 1.27 |
| 2018 | 7592.83 | 7718 | 995 | 86.76 | 87.18 | 87.11 | 88.11 | 0.00 | 2.44 | 10.38 | 0.42 |
| 2019 | 8630.08 | 8760 | 995 | 99.25 | 99.87 | 99.01 | 100.00 | 0.00 | 0.00 | 0.13 | 0.62 |
| 2020 | 7654.10 | 7848 | 995 | 87.57 | 88.75 | 87.57 | 89.34 | 1.03 | 1.64 | 9.61 | 1.18 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 7085.78 | 7324 | 995 | 81.94 | 82.35 | 81.29 | 83.61 | 3.18 | 6.81 | 10.84 | 0.41 |
| 2022 | 8532.56 | 8715 | 995 | 98.05 | 99.34 | 97.89 | 99.49 | 0.53 | 0.53 | 0.13 | 1.29 |
| 2023 | 6634.81 | 7025 | 995 | 75.78 | 78.26 | 76.12 | 80.19 | 8.94 | 9.59 | 12.15 | 2.48 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 584 | | | 265 | |
| C. Inspection, maintenance or repair combined with refuelling | 984 | | | 777 | 36 | |
| D. Inspection, maintenance or repair without refuelling | | | | 31 | | |
| E. Testing of plant systems or components | | | | 43 | 5 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 4 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 6 |
| Z. Other | | 167 | | | 10 | |
| Subtotal | 984 | 751 | | 851 | 320 | 11 |
| Total | | 1735 | | | 1182 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 5 |
| 12. Reactor I&C Systems | | 3 |
| 13. Reactor Auxiliary Systems | 65 | 2 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 10 |
| 16. Steam generation systems | | 13 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | 167 | 48 |
| 31. Turbine and auxiliaries | | 57 |
| 32. Feedwater and Main Steam System | | 17 |
| 33. Circulating Water System | | 4 |
| 34. Miscellaneous Systems | | 3 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | 242 | 76 |
| 42. Electrical Power Supply Systems | 277 | 72 |
| Total | 751 | 312 |

Highlights (2023)

In 2023 Ascó I NPP produced 6632.61 net GWh slightly lower than expected net 8716.20 GWh. These were the main events affecting the operation:

- On February 22nd, outage for intervention in Motor 1 Diesel Generator A
 - On April 29th, starts refuelling
 - On May, continues refuelling
 - On June, continues refuelling
 - On September 1st, controlled shutdown for intervention in the BRR pump
 - On October 19th, alternator cooling system repair
- Due to these incidents, the load factor was 76,69 %.

2023 Operating Experience

ES-9

ASCO-2

SPAIN

Status at end of year : **Operational**
 Operator : ANAV (ASOCIACIÓN NUCLEAR ASCÓ-VANDELLÓS A.I.E. (ENDESA/ID))
 Owner : EN/ID (ENDESA, IBERDROLA)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP | Construction Date | : 1975-03-07 |
| Thermal power | : 2941 MWth | Grid Date | : 1985-10-23 |
| Gross electrical power | : 1027 MWe | Commercial Date | : 1986-03-31 |
| Reference unit power (net) | : 997 MWe | Age at end of year | : 38 years |

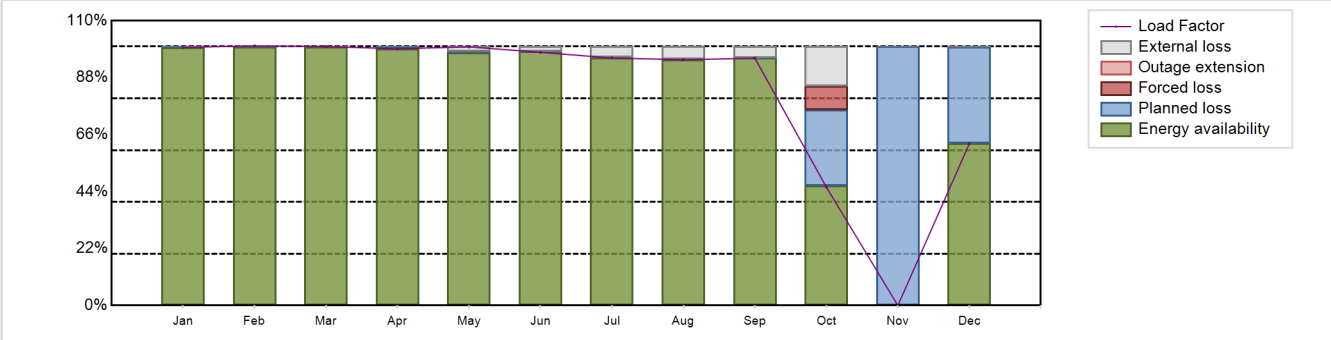
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|------------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.72 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 327 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 3.86 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 50500 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.65 | HP cylinder inlet steam pressure [MPa] | : 6.6 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 18.92 | Primary means of condenser cooling | : River (once-through) |
| Number of control rod assemblies | : 48 | Number of main condensate pumps | : 4 |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 2 |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 7209.27 GW(e).h | Forced Loss Rate (FLR) | : 0.92 % |
| Energy Availability Factor (EAF) | : 82.38 % | Unplanned Capability Loss Factor (UCL) | : 0.79 % |
| Unit Capability Factor (UCF) | : 85.13 % | Planned Unavailability Factor (PUF) | : 14.08 % |
| Load Factor (LF) | : 82.55 % | Externally cause unavailability (XUF) | : 2.75 % |
| Operating Factor (OF) | : 85.86 % | Total off-line time | : 1239 hours |

Annual Summary

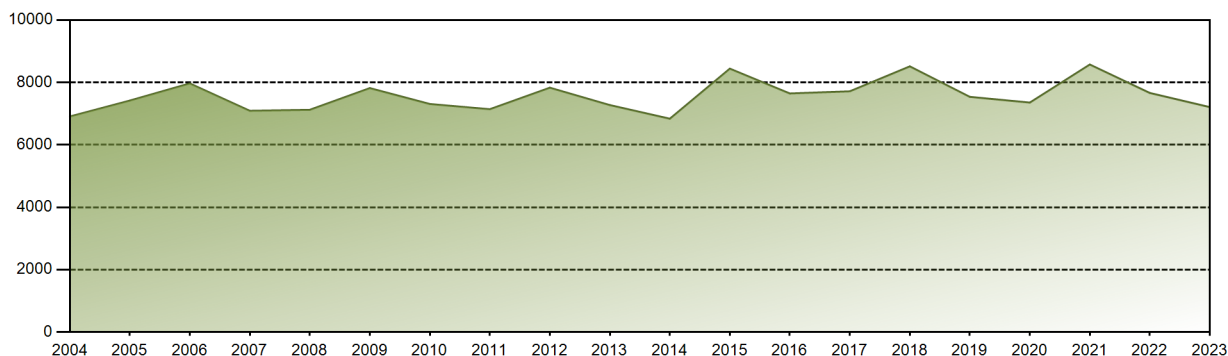


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|---------|
| GW(e)-h | 739.40 | 671.91 | 740.91 | 711.67 | 741.01 | 701.90 | 709.10 | 704.10 | 685.72 | 339.70 | 0.00 | 463.83 | 7209.27 |
| EAF [%] | 99.68 | 99.87 | 99.87 | 99.14 | 97.75 | 98.06 | 95.60 | 94.92 | 95.53 | 46.15 | 0.01 | 62.53 | 82.38 |
| UCF [%] | 99.68 | 99.87 | 99.87 | 99.14 | 99.59 | 99.96 | 99.82 | 99.83 | 99.82 | 61.45 | 0.01 | 62.65 | 85.13 |
| LF [%] | 99.68 | 100.29 | 100.02 | 99.14 | 99.90 | 97.78 | 95.60 | 94.92 | 95.53 | 45.73 | 0.00 | 62.53 | 82.55 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 62.28 | 0.00 | 68.01 | 85.86 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.10 | 0.00 | 0.00 | 0.92 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.26 | 0.00 | 0.00 | 0.79 |
| PUF [%] | 0.32 | 0.13 | 0.13 | 0.86 | 0.41 | 0.04 | 0.18 | 0.17 | 0.18 | 29.29 | 99.99 | 37.35 | 14.08 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 1.84 | 1.90 | 4.22 | 4.90 | 4.29 | 15.30 | 0.00 | 0.12 | 2.75 |

Historical Summary

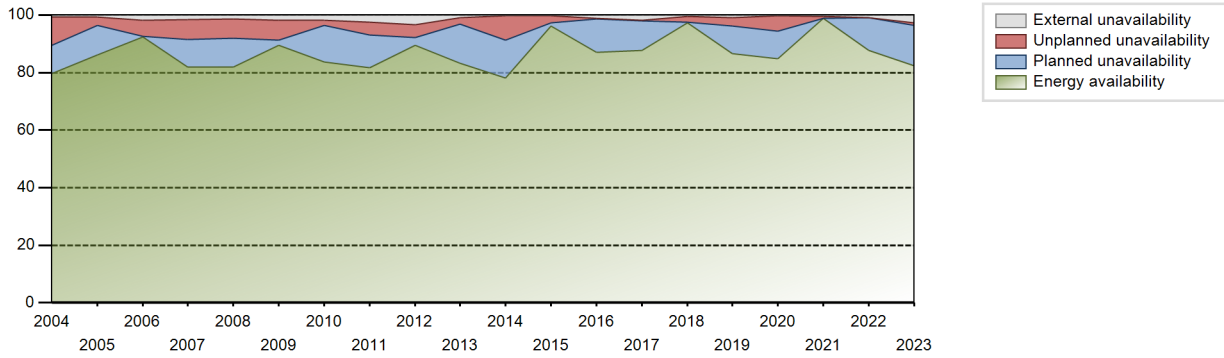
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 279242.37 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.53 % |
| Cumulative Energy Availability Factor (EAF) | : 87.45 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.99 % |
| Cumulative Unit Capability Factor (UCF) | : 88.45 % | Cumulative Planned Unavailability Factor (PUF) | : 8.56 % |
| Cumulative Load Factor (LF) | : 86.7 % | Cumulative Externally cause unavailability (XUF) | : 1 % |
| Cumulative Operating Factor (OF) | : 89.77 % | | |

Electricity Production (net) [GWh]

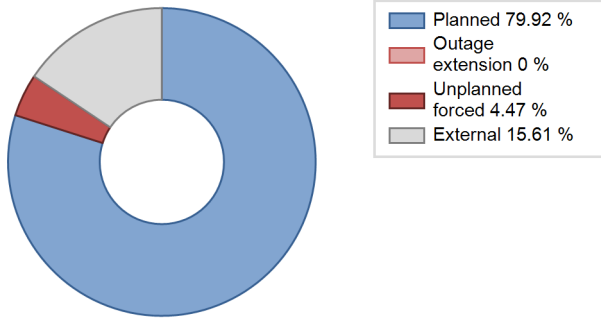


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 5368.00 | 6639 | 898 | 77.72 | 77.72 | 74.11 | 78.65 | 21.50 | 21.28 | 1.00 | 0.00 |
| 1987 | 5954.00 | 7035 | 898 | 77.27 | 78.13 | 75.69 | 80.31 | 3.63 | 2.94 | 18.93 | 0.86 |
| 1988 | 6865.00 | 7874 | 898 | 86.76 | 88.23 | 87.03 | 89.64 | 1.86 | 1.67 | 10.10 | 1.47 |
| 1989 | 6732.00 | 7729 | 930 | 85.70 | 86.30 | 82.63 | 88.23 | 1.79 | 1.57 | 12.13 | 0.60 |
| 1990 | 6933.00 | 7916 | 930 | 90.42 | 90.42 | 85.10 | 90.37 | 0.73 | 0.66 | 8.92 | 0.00 |
| 1991 | 6820.00 | 7799 | 930 | 86.49 | 86.69 | 83.71 | 89.03 | 0.76 | 0.67 | 12.64 | 0.20 |
| 1992 | 7077.00 | 8042 | 953 | 89.92 | 89.92 | 84.54 | 91.55 | 0.99 | 0.90 | 9.17 | 0.00 |
| 1993 | 7052.00 | 7897 | 930 | 88.61 | 90.02 | 86.56 | 90.15 | 1.20 | 1.09 | 8.89 | 1.41 |
| 1994 | 7085.00 | 7962 | 930 | 89.47 | 89.77 | 86.97 | 90.89 | 1.56 | 1.43 | 8.81 | 0.29 |
| 1995 | 6977.00 | 7674 | 900 | 86.25 | 86.39 | 88.50 | 87.60 | 1.04 | 0.91 | 12.70 | 0.13 |
| 1996 | 6011.00 | 6825 | 963 | 75.14 | 75.61 | 71.06 | 77.70 | 3.95 | 3.11 | 21.28 | 0.47 |
| 1997 | 7916.00 | 8725 | 900 | 96.18 | 98.17 | 100.42 | 99.61 | 1.24 | 1.23 | 0.60 | 1.99 |
| 1998 | 7399.00 | 8050 | 946 | 89.88 | 90.57 | 89.28 | 91.89 | 1.27 | 1.16 | 8.26 | 0.69 |
| 1999 | 7215.00 | 7854 | 946 | 86.42 | 87.17 | 87.06 | 89.66 | 3.04 | 2.73 | 10.10 | 0.75 |
| 2000 | 8451.00 | 8734 | 983 | 98.63 | 98.63 | 97.87 | 99.43 | 0.59 | 0.59 | 0.78 | 0.00 |
| 2001 | 7829.00 | 8102 | 983 | 90.55 | 90.97 | 90.92 | 92.49 | 0.48 | 0.44 | 8.59 | 0.42 |
| 2002 | 7780.00 | 8127 | 997 | 89.40 | 90.78 | 89.08 | 92.77 | 0.50 | 0.45 | 8.77 | 1.38 |
| 2003 | 8521.20 | 8738 | 997 | 98.73 | 99.59 | 97.57 | 99.75 | 0.27 | 0.27 | 0.14 | 0.86 |
| 2004 | 6909.28 | 7287 | 997 | 79.62 | 80.24 | 78.89 | 82.96 | 10.36 | 9.83 | 9.93 | 0.62 |
| 2005 | 7418.88 | 7779 | 997 | 86.10 | 86.75 | 84.95 | 88.80 | 2.29 | 3.03 | 10.22 | 0.65 |
| 2006 | 7968.75 | 8335 | 997 | 92.42 | 94.34 | 91.24 | 95.15 | 5.52 | 5.51 | 0.16 | 1.92 |
| 2007 | 7091.43 | 7532 | 997 | 81.94 | 83.58 | 81.20 | 85.98 | 5.19 | 6.77 | 9.64 | 1.65 |
| 2008 | 7123.62 | 7413 | 997 | 81.98 | 83.28 | 81.34 | 84.39 | 0.03 | 6.84 | 9.88 | 1.30 |
| 2009 | 7818.32 | 8082 | 997 | 89.52 | 91.34 | 89.52 | 92.26 | 6.95 | 6.82 | 1.84 | 1.82 |
| 2010 | 7309.13 | 7583 | 997 | 83.69 | 85.62 | 83.69 | 86.56 | 0.03 | 1.68 | 12.70 | 1.93 |
| 2011 | 7142.24 | 7560 | 997 | 81.78 | 84.19 | 81.78 | 86.30 | 1.55 | 4.57 | 11.25 | 2.41 |
| 2012 | 7831.53 | 8327 | 997 | 89.43 | 92.80 | 89.43 | 94.80 | 1.14 | 4.47 | 2.73 | 3.37 |
| 2013 | 7274.22 | 7499 | 997 | 83.27 | 84.30 | 83.29 | 85.61 | 2.16 | 2.16 | 13.55 | 1.02 |
| 2014 | 6837.37 | 7010 | 997 | 78.03 | 78.37 | 78.29 | 80.02 | 9.18 | 8.43 | 13.20 | 0.33 |
| 2015 | 8442.11 | 8656 | 997 | 96.27 | 96.47 | 96.66 | 98.81 | 2.62 | 2.59 | 0.94 | 0.20 |
| 2016 | 7646.24 | 7852 | 997 | 87.14 | 88.26 | 87.31 | 89.39 | 0.00 | 0.23 | 11.51 | 1.13 |
| 2017 | 7716.07 | 7917 | 997 | 87.78 | 89.52 | 88.35 | 90.38 | 0.00 | 0.31 | 10.18 | 1.74 |
| 2018 | 8514.79 | 8582 | 997 | 97.30 | 97.73 | 97.49 | 97.97 | 2.15 | 2.14 | 0.13 | 0.43 |
| 2019 | 7537.35 | 7783 | 997 | 86.54 | 87.35 | 86.30 | 88.85 | 1.31 | 2.90 | 9.74 | 0.82 |
| 2020 | 7354.45 | 7546 | 997 | 84.81 | 85.09 | 83.98 | 85.91 | 1.83 | 5.34 | 9.57 | 0.28 |
| 2021 | 8574.34 | 8701 | 997 | 98.77 | 99.20 | 98.18 | 99.33 | 0.67 | 0.67 | 0.13 | 0.42 |
| 2022 | 7662.31 | 7833 | 997 | 87.73 | 88.70 | 87.73 | 89.42 | 0.00 | 0.00 | 11.30 | 0.97 |

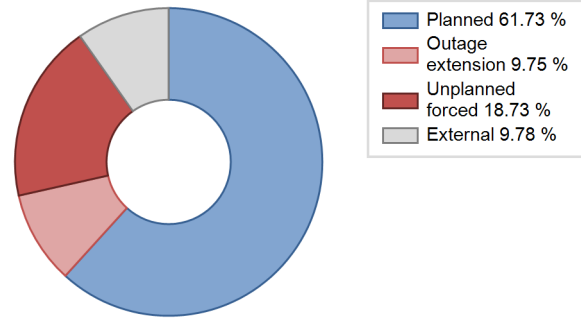
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 69 | | | 184 | |
| C. Inspection, maintenance or repair combined with refuelling | 1170 | | | 661 | 39 | |
| D. Inspection, maintenance or repair without refuelling | | | | 28 | | |
| E. Testing of plant systems or components | | | | 14 | 7 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 13 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| L. Human factor related | | | | | 3 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 7 | | |
| Z. Other | | | | 3 | 7 | |
| Subtotal | 1170 | 69 | | 726 | 240 | 6 |
| Total | | 1239 | | | 972 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 5 |
| 13. Reactor Auxiliary Systems | | 21 |
| 14. Safety Systems | | 0 |
| 15. Reactor Cooling Systems | | 16 |
| 16. Steam generation systems | | 11 |
| 21. Fuel Handling and Storage Facilities | | 49 |
| 31. Turbine and auxiliaries | | 12 |
| 32. Feedwater and Main Steam System | | 52 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | | 6 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | 69 | 10 |
| 42. Electrical Power Supply Systems | | 47 |
| Total | 69 | 240 |

Highlights (2023)

In 2023 Ascó II NPP produced 7209.27 net GWh slightly lower than expected net 8733.72 GWh. These were the main events affecting the operation:

- On October 23rd, refuelling
- On November, continue refuelling
- On December, 10th, finish refuelling

Due to these incidents, the load factor was 83,64%.

2023 Operating Experience

ES-10

COFRENTES

SPAIN

Status at end of year : **Operational**
 Operator : ID (IBERDROLA, S.A.)
 Owner : ID (IBERDROLA, S.A.)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-6 (Mark 3) | Construction Date | : 1975-09-09 |
| Thermal power | : 3237 MWth | Grid Date | : 1984-10-14 |
| Gross electrical power | : 1102 MWe | Commercial Date | : 1985-03-11 |
| Reference unit power (net) | : 1064 MWe | Age at end of year | : 39 years |

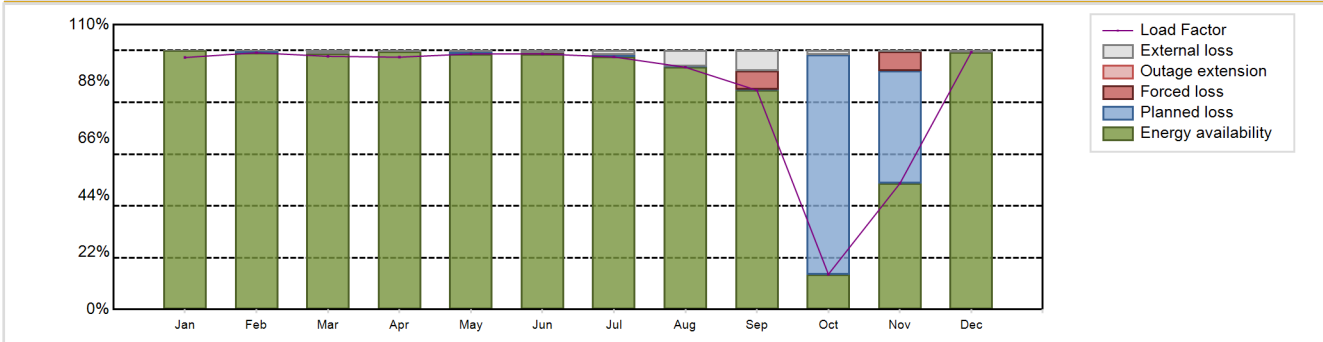
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 7.26 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 288 |
| Refuelling type | : OFF-line | Number of SG | : NA |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : 4 | Containment design pressure [MPa] | : 0.103 |
| Refuelling frequency [month] | : 24 | Secondary systems | |
| Part of the core refuelled [%] | : 41 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 40000 | Turbine speed [rpm] | : 1500 |
| Active core diameter [m] | : 4.29 | Number of LP cylinders per turbine | : 2 |
| Active core height/length [m] | : 3.81 | HP cylinder inlet steam pressure [MPa] | : 7.115 |
| Number of fissile fuel assemblies/bundles | : 624 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 20.03 | Primary means of condenser cooling | : Cooling Towers |
| Number of control rod assemblies | : 145 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 7965.62 GW(e).h | Forced Loss Rate (FLR) | : 1.38 % |
| Energy Availability Factor (EAF) | : 85.97 % | Unplanned Capability Loss Factor (UCL) | : 1.23 % |
| Unit Capability Factor (UCF) | : 87.72 % | Planned Unavailability Factor (PUF) | : 11.06 % |
| Load Factor (LF) | : 85.46 % | Externally cause unavailability (XUF) | : 1.75 % |
| Operating Factor (OF) | : 88.86 % | Total off-line time | : 976 hours |

Annual Summary

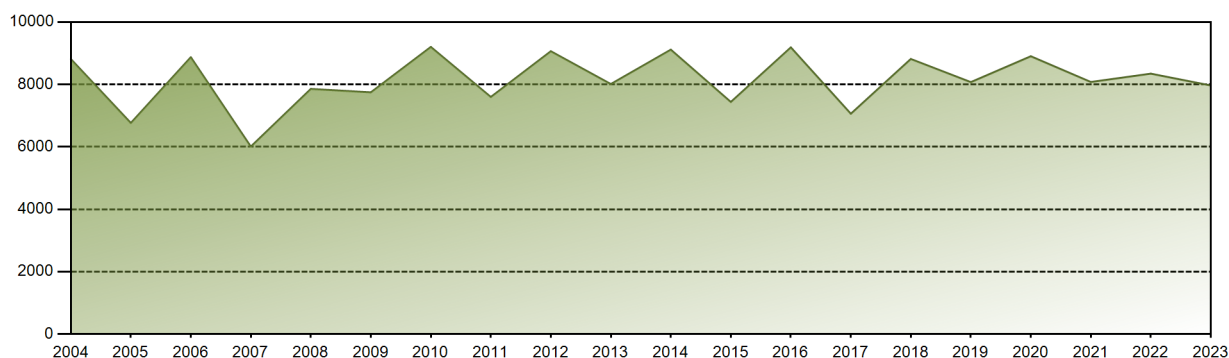


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 770.49 | 709.01 | 773.02 | 746.51 | 781.55 | 756.06 | 772.20 | 740.58 | 648.63 | 107.81 | 372.79 | 786.97 | 7965.62 |
| EAF [%] | 100.00 | 99.17 | 98.81 | 99.73 | 98.73 | 98.70 | 97.55 | 93.56 | 84.67 | 13.61 | 48.67 | 99.42 | 85.97 |
| UCF [%] | 100.00 | 99.17 | 100.00 | 100.00 | 99.14 | 99.53 | 99.21 | 99.58 | 92.57 | 15.23 | 49.08 | 100.00 | 87.72 |
| LF [%] | 97.33 | 99.16 | 97.78 | 97.45 | 98.73 | 98.69 | 97.55 | 93.55 | 84.67 | 13.60 | 48.66 | 99.41 | 85.46 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.00 | 16.11 | 56.25 | 100.00 | 88.86 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | 0.00 | 0.00 | 7.18 | 0.00 | 13.26 | 0.00 | 1.38 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | 0.00 | 0.00 | 7.16 | 0.00 | 7.50 | 0.00 | 1.23 |
| PUF [%] | 0.00 | 0.83 | 0.00 | 0.00 | 0.86 | 0.20 | 0.79 | 0.42 | 0.27 | 84.77 | 43.42 | 0.00 | 11.06 |
| XUF [%] | 0.00 | 0.01 | 1.19 | 0.27 | 0.40 | 0.84 | 1.66 | 6.02 | 7.90 | 1.63 | 0.41 | 0.58 | 1.75 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 303048.62 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.97 % |
| Cumulative Energy Availability Factor (EAF) | : 87.42 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.14 % |
| Cumulative Unit Capability Factor (UCF) | : 88.42 % | Cumulative Planned Unavailability Factor (PUF) | : 8.45 % |
| Cumulative Load Factor (LF) | : 87.33 % | Cumulative Externally cause unavailability (XUF) | : 0.99 % |
| Cumulative Operating Factor (OF) | : 90.21 % | | |

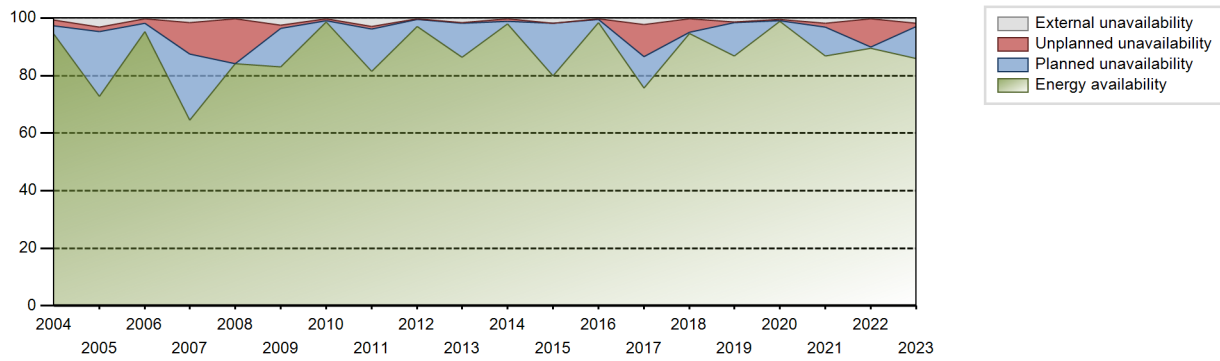
Electricity Production (net) [GWh]



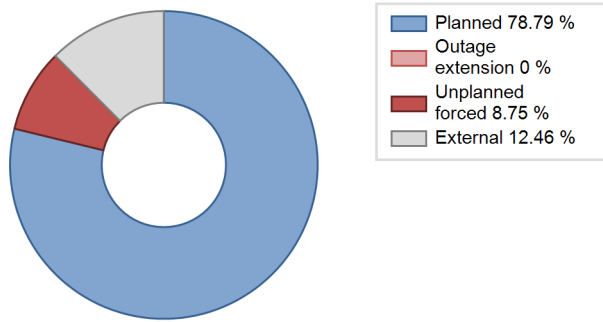
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 6142.48 | 7300 | 939 | 81.41 | 81.41 | 81.39 | 87.75 | 12.12 | 11.23 | 7.35 | 0.00 |
| 1986 | 6668.30 | 7487 | 939 | 81.07 | 81.96 | 81.07 | 85.47 | 2.10 | 1.75 | 16.29 | 0.89 |
| 1987 | 6883.08 | 7615 | 930 | 83.40 | 83.42 | 84.49 | 86.93 | 5.00 | 4.39 | 12.19 | 0.02 |
| 1988 | 7142.15 | 7850 | 930 | 85.51 | 85.74 | 87.43 | 89.37 | 2.18 | 1.91 | 12.35 | 0.23 |
| 1989 | 7052.24 | 7732 | 939 | 83.90 | 83.90 | 85.73 | 88.26 | 4.54 | 3.99 | 12.11 | 0.00 |
| 1990 | 7070.30 | 7560 | 939 | 85.10 | 85.10 | 85.95 | 86.30 | 4.12 | 3.66 | 11.24 | 0.00 |
| 1991 | 6999.63 | 7660 | 953 | 83.70 | 83.70 | 83.85 | 87.44 | 3.62 | 3.15 | 13.15 | 0.00 |
| 1992 | 7712.12 | 8376 | 939 | 91.87 | 91.87 | 93.50 | 95.36 | 3.17 | 3.01 | 5.12 | 0.00 |
| 1993 | 7016.23 | 7579 | 953 | 83.57 | 84.76 | 84.04 | 86.52 | 3.31 | 2.90 | 12.34 | 1.18 |
| 1994 | 6990.86 | 7553 | 953 | 83.55 | 85.06 | 83.74 | 86.22 | 1.05 | 0.90 | 14.04 | 1.51 |
| 1995 | 8186.97 | 8683 | 953 | 97.54 | 97.78 | 98.07 | 99.12 | 1.60 | 1.59 | 0.63 | 0.24 |
| 1996 | 7687.49 | 8215 | 953 | 90.88 | 91.90 | 91.83 | 93.52 | 1.09 | 1.01 | 7.08 | 1.02 |
| 1997 | 6893.65 | 7668 | 953 | 83.73 | 86.15 | 82.59 | 87.54 | 3.25 | 2.90 | 10.95 | 2.43 |
| 1998 | 8174.10 | 8546 | 993 | 96.56 | 96.56 | 93.97 | 97.56 | 2.86 | 2.85 | 0.59 | 0.00 |
| 1999 | 7491.64 | 8004 | 989 | 86.43 | 89.83 | 86.47 | 91.37 | 2.06 | 1.89 | 8.28 | 3.39 |
| 2000 | 7348.14 | 7808 | 989 | 84.59 | 86.87 | 84.58 | 88.89 | 1.76 | 1.56 | 11.57 | 2.28 |
| 2001 | 8278.15 | 8424 | 989 | 95.54 | 95.54 | 95.55 | 96.16 | 4.17 | 4.16 | 0.30 | 0.00 |
| 2002 | 7918.10 | 7875 | 1043 | 88.24 | 89.20 | 86.66 | 89.90 | 1.73 | 1.57 | 9.23 | 0.97 |
| 2003 | 8002.51 | 7742 | 1062 | 88.17 | 88.17 | 86.45 | 88.38 | 2.80 | 4.42 | 7.41 | 0.00 |
| 2004 | 8813.91 | 8457 | 1064 | 94.29 | 94.94 | 94.32 | 96.28 | 2.00 | 1.97 | 3.09 | 0.65 |
| 2005 | 6765.14 | 6768 | 1064 | 72.84 | 75.92 | 72.58 | 77.26 | 1.10 | 1.56 | 22.53 | 3.07 |
| 2006 | 8872.52 | 8492 | 1064 | 95.32 | 95.64 | 95.19 | 96.94 | 1.57 | 1.53 | 2.83 | 0.32 |
| 2007 | 6008.35 | 5898 | 1064 | 64.47 | 66.05 | 64.46 | 67.33 | 10.93 | 10.84 | 23.11 | 1.59 |
| 2008 | 7856.29 | 7643 | 1064 | 84.10 | 84.40 | 84.06 | 87.01 | 15.51 | 15.49 | 0.11 | 0.30 |
| 2009 | 7747.00 | 7618 | 1064 | 83.12 | 85.54 | 83.12 | 86.96 | 1.27 | 1.10 | 13.36 | 2.42 |
| 2010 | 9201.90 | 8760 | 1064 | 98.73 | 98.99 | 98.73 | 100.00 | 0.57 | 0.56 | 0.45 | 0.26 |
| 2011 | 7599.08 | 7564 | 1064 | 81.54 | 84.40 | 81.53 | 86.35 | 1.14 | 0.98 | 14.62 | 2.87 |
| 2012 | 9064.14 | 8686 | 1064 | 97.00 | 97.21 | 96.98 | 98.88 | 0.36 | 0.35 | 2.43 | 0.22 |
| 2013 | 8012.79 | 7800 | 1064 | 86.31 | 87.99 | 85.97 | 89.04 | 0.14 | 0.13 | 11.89 | 1.68 |
| 2014 | 9114.79 | 8760 | 1064 | 97.93 | 98.13 | 97.79 | 100.00 | 0.97 | 0.96 | 0.91 | 0.20 |
| 2015 | 7438.67 | 7325 | 1064 | 79.81 | 81.51 | 79.81 | 83.62 | 0.21 | 0.17 | 18.31 | 1.70 |
| 2016 | 9187.25 | 8784 | 1064 | 98.31 | 98.52 | 98.30 | 100.00 | 0.37 | 0.37 | 1.11 | 0.22 |
| 2017 | 7060.25 | 7030 | 1064 | 75.75 | 78.08 | 75.75 | 80.25 | 0.55 | 11.16 | 10.76 | 2.33 |
| 2018 | 8816.13 | 8436 | 1064 | 94.59 | 94.94 | 94.59 | 96.30 | 4.63 | 4.61 | 0.45 | 0.35 |
| 2019 | 8074.05 | 7854 | 1064 | 86.78 | 88.15 | 86.63 | 89.66 | 0.20 | 0.17 | 11.68 | 1.36 |
| 2020 | 8902.95 | 8784 | 1064 | 98.83 | 99.38 | 95.26 | 100.00 | 0.34 | 0.34 | 0.28 | 0.55 |
| 2021 | 8078.38 | 7887 | 1064 | 86.90 | 88.78 | 86.67 | 90.03 | 1.46 | 1.32 | 9.90 | 1.88 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 8344.99 | 7944 | 1064 | 89.54 | 89.78 | 89.53 | 90.68 | 9.94 | 9.91 | 0.31 | 0.24 |
| 2023 | 7965.62 | 7784 | 1064 | 85.97 | 87.72 | 85.46 | 88.86 | 1.38 | 1.23 | 11.06 | 1.75 |

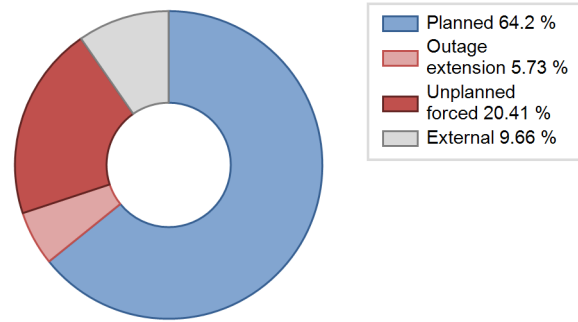
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 36 | | | 218 | |
| B. Refuelling without maintenance | | | | 5 | | |
| C. Inspection, maintenance or repair combined with refuelling | 911 | | | 588 | 2 | |
| D. Inspection, maintenance or repair without refuelling | | | | 15 | | |
| E. Testing of plant systems or components | | | | 14 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | 28 | | | 8 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| P. Fire | | | | | 15 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 7 | | |
| Z. Other | | | | | 9 | |
| Subtotal | 911 | 64 | | 629 | 252 | 3 |
| Total | | 975 | | | 884 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 46 |
| 12. Reactor I&C Systems | | 45 |
| 13. Reactor Auxiliary Systems | | 3 |
| 15. Reactor Cooling Systems | | 6 |
| 16. Steam generation systems | | 0 |
| 17. Safety I&C Systems (excluding reactor I&C) | 28 | 2 |
| 31. Turbine and auxiliaries | | 52 |
| 32. Feedwater and Main Steam System | 36 | 28 |
| 34. Miscellaneous Systems | | 1 |
| 41. Main Generator Systems | | 20 |
| 42. Electrical Power Supply Systems | | 38 |
| Total | 64 | 241 |

2023 Operating Experience

ES-11

TRILLO-1

SPAIN

Status at end of year : **Operational**
 Operator : CNAT (CENTRALES NUCLEARES ALMARAZ-TRILLO (ID/UFG/ENDESA/HC/NUCLENOR))
 Owner : ID/GN/HC (Iberdrola, Gas Natural, Hidroeléctrica del Cantábrico, Nuclenor)
 Reactor Supplier : KWU (KRAFTWERK UNION, AG)
 Turbine Supplier : KWU (KRAFTWERK UNION, AG)



Reactor Unit Details

Reactor type and model : PWR / PWR 3 loops
 Thermal power : 3010 MWth
 Gross electrical power : 1066 MWe
 Reference unit power (net) : 1003 MWe

Key Dates

Construction Date : 1979-08-17
 Grid Date : 1988-05-23
 Commercial Date : 1988-08-06
 Age at end of year : 35 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 4.20
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 22.6
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.44
 Active core height/length [m] : 3.4
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 20.71
 Number of control rod assemblies : 52
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 325.9
 Number of SG : 3
 Containment type : Double
 Containment design pressure [MPa] : 0.538

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.261
 Output voltage [kV] : 27
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 4

Non-electrical applications

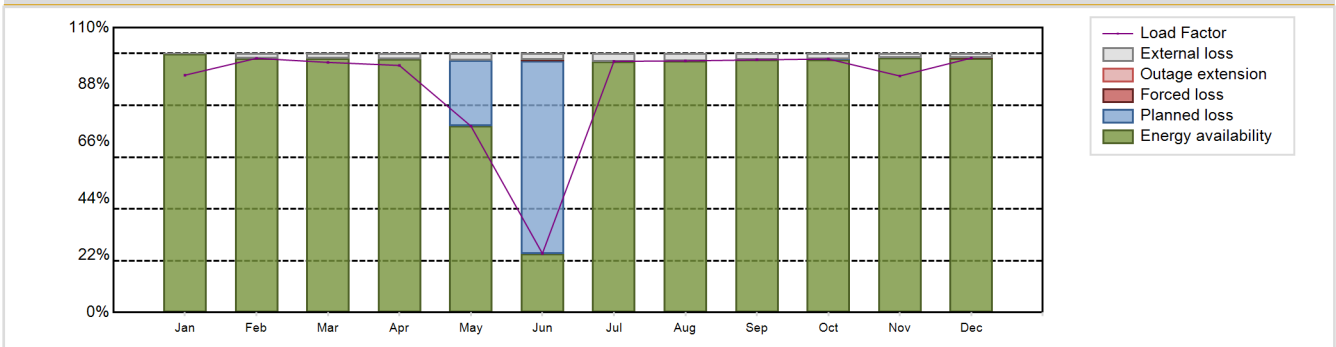
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7734.72 GW(e).h
 Energy Availability Factor (EAF) : 89.61 %
 Unit Capability Factor (UCF) : 91.68 %
 Load Factor (LF) : 88.03 %
 Operating Factor (OF) : 91.72 %

Forced Loss Rate (FLR) : 0.05 %
 Unplanned Capability Loss Factor (UCL) : 0.04 %
 Planned Unavailability Factor (PUF) : 8.28 %
 Externally cause unavailability (XUF) : 2.06 %
 Total off-line time : 725 hours

Annual Summary

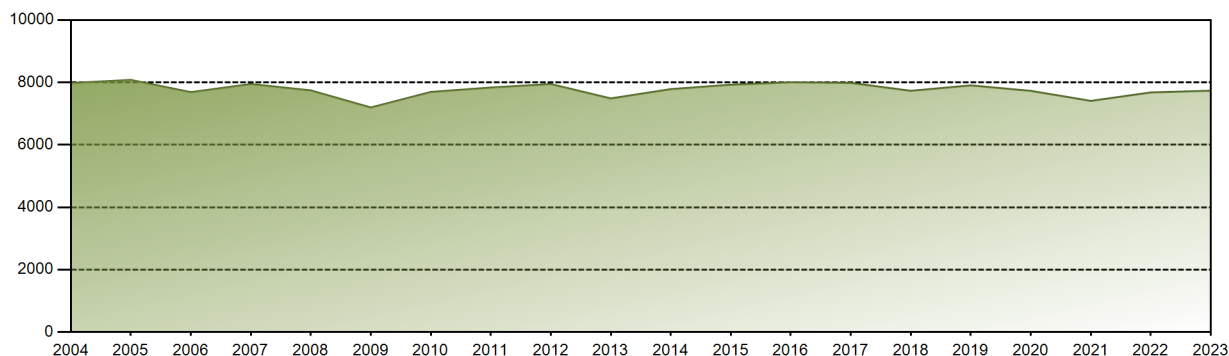


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 684.00 | 661.67 | 720.85 | 689.02 | 537.25 | 164.57 | 723.81 | 725.21 | 704.67 | 730.55 | 659.66 | 733.45 | 7734.72 |
| EAF [%] | 99.85 | 98.13 | 98.04 | 97.97 | 72.03 | 22.75 | 96.95 | 97.14 | 97.54 | 97.72 | 98.47 | 98.25 | 89.61 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 74.60 | 25.03 | 100.00 | 100.00 | 100.00 | 99.95 | 100.00 | 100.00 | 91.68 |
| LF [%] | 91.66 | 98.17 | 96.60 | 95.41 | 72.00 | 22.79 | 97.00 | 97.18 | 97.58 | 97.90 | 91.35 | 98.29 | 88.03 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 74.60 | 25.56 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.72 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 25.40 | 74.44 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 8.28 |
| XUF [%] | 0.15 | 1.87 | 1.96 | 2.03 | 2.56 | 2.28 | 3.05 | 2.86 | 2.46 | 2.23 | 1.53 | 1.75 | 2.06 |

Historical Summary

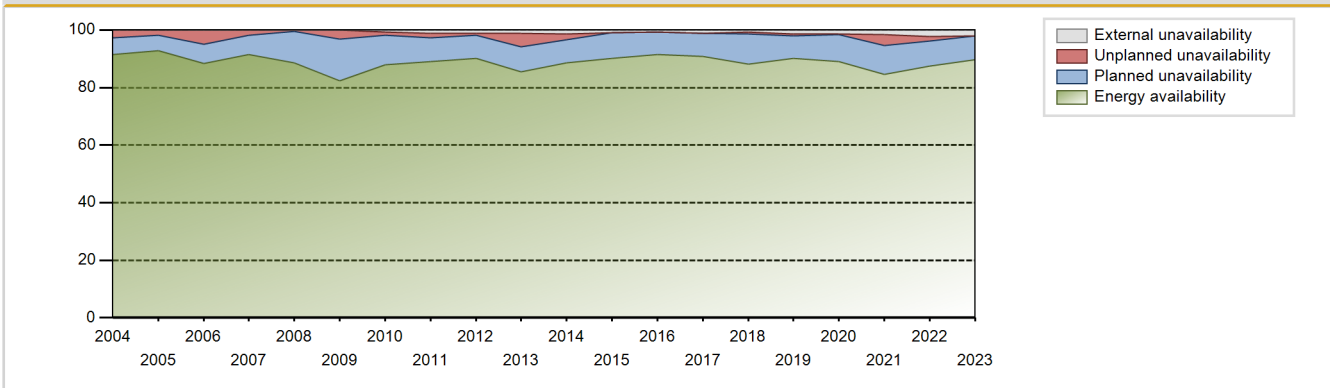
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 269989.29 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.38 % |
| Cumulative Energy Availability Factor (EAF) | : 87.32 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.53 % |
| Cumulative Unit Capability Factor (UCF) | : 87.93 % | Cumulative Planned Unavailability Factor (PUF) | : 9.54 % |
| Cumulative Load Factor (LF) | : 86.86 % | Cumulative Externally cause unavailability (XUF) | : 0.61 % |
| Cumulative Operating Factor (OF) | : 88.77 % | | |

Electricity Production (net) [GWh]

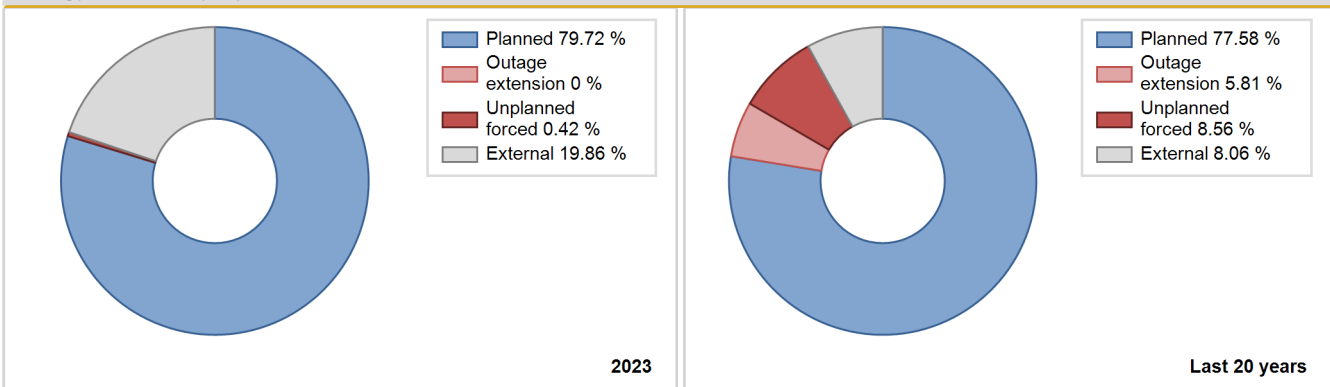


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 2896.23 | 3511 | 997 | 72.66 | 72.66 | 66.29 | 72.11 | 16.08 | 13.93 | 13.41 | 0.00 |
| 1989 | 7147.79 | 7665 | 974 | 83.77 | 83.79 | 83.77 | 87.50 | 1.38 | 1.17 | 15.04 | 0.02 |
| 1990 | 6372.44 | 7170 | 974 | 74.69 | 74.69 | 74.69 | 81.85 | 10.14 | 8.42 | 16.89 | 0.00 |
| 1991 | 6481.54 | 6891 | 974 | 75.97 | 75.97 | 75.97 | 78.66 | 5.72 | 4.61 | 19.43 | 0.00 |
| 1992 | 7938.46 | 8028 | 1000 | 90.37 | 90.37 | 90.37 | 91.39 | 2.05 | 1.89 | 7.74 | 0.00 |
| 1993 | 7395.86 | 7512 | 1000 | 84.43 | 84.43 | 84.43 | 85.75 | 3.95 | 3.47 | 12.10 | 0.00 |
| 1994 | 7927.69 | 8009 | 1000 | 90.99 | 90.99 | 90.50 | 91.43 | 0.29 | 0.27 | 8.74 | 0.00 |
| 1995 | 7472.62 | 7597 | 1000 | 85.78 | 86.43 | 85.30 | 86.72 | 0.08 | 0.07 | 13.51 | 0.64 |
| 1996 | 7626.31 | 7713 | 1000 | 87.34 | 87.37 | 86.82 | 87.81 | 1.25 | 1.11 | 11.52 | 0.03 |
| 1997 | 7765.45 | 8066 | 1000 | 89.30 | 91.85 | 88.65 | 92.08 | 0.17 | 0.15 | 7.99 | 2.55 |
| 1998 | 6589.73 | 6686 | 1000 | 75.77 | 76.10 | 75.23 | 76.32 | 23.89 | 23.88 | 0.02 | 0.33 |
| 1999 | 6828.82 | 6876 | 1000 | 78.01 | 78.03 | 77.95 | 78.48 | 3.34 | 2.69 | 19.28 | 0.02 |
| 2000 | 8206.49 | 8251 | 1000 | 93.62 | 93.68 | 93.41 | 93.92 | 0.32 | 0.30 | 6.02 | 0.06 |
| 2001 | 7907.41 | 7966 | 1000 | 90.63 | 90.66 | 90.27 | 90.94 | 2.42 | 2.25 | 7.09 | 0.03 |
| 2002 | 7827.00 | 7876 | 1000 | 89.61 | 89.65 | 89.34 | 89.90 | 0.01 | 0.01 | 10.34 | 0.04 |
| 2003 | 8114.66 | 8210 | 1003 | 93.10 | 93.10 | 92.46 | 93.71 | 1.36 | 1.84 | 5.07 | 0.00 |
| 2004 | 7980.12 | 8121 | 1003 | 91.50 | 91.50 | 90.57 | 92.44 | 2.04 | 2.82 | 5.68 | 0.00 |
| 2005 | 8080.62 | 8175 | 1003 | 92.94 | 92.94 | 91.97 | 93.32 | 0.28 | 1.74 | 5.32 | 0.00 |
| 2006 | 7687.80 | 7788 | 1003 | 88.45 | 88.59 | 87.50 | 88.90 | 1.53 | 4.92 | 6.50 | 0.14 |
| 2007 | 7948.88 | 8039 | 1003 | 91.44 | 91.50 | 90.47 | 91.77 | 0.33 | 1.86 | 6.64 | 0.05 |
| 2008 | 7743.95 | 7820 | 1003 | 88.53 | 88.66 | 87.90 | 89.03 | 0.36 | 0.32 | 11.02 | 0.13 |
| 2009 | 7197.10 | 7438 | 1003 | 82.38 | 82.48 | 81.91 | 84.91 | 3.56 | 3.05 | 14.47 | 0.09 |
| 2010 | 7695.50 | 7969 | 1003 | 87.85 | 88.54 | 87.59 | 90.97 | 0.92 | 1.01 | 10.44 | 0.70 |
| 2011 | 7835.70 | 7940 | 1003 | 89.14 | 90.38 | 89.18 | 90.64 | 1.50 | 1.52 | 8.10 | 1.24 |
| 2012 | 7948.78 | 8066 | 1003 | 90.26 | 91.33 | 90.22 | 91.83 | 0.14 | 0.68 | 7.99 | 1.07 |
| 2013 | 7487.11 | 7656 | 1003 | 85.43 | 86.56 | 85.21 | 87.40 | 3.47 | 4.81 | 8.63 | 1.12 |
| 2014 | 7785.49 | 7901 | 1003 | 88.65 | 89.96 | 88.61 | 90.19 | 0.00 | 2.13 | 7.90 | 1.31 |
| 2015 | 7926.99 | 8009 | 1003 | 90.24 | 91.21 | 90.22 | 91.43 | 0.00 | 0.00 | 8.79 | 0.97 |
| 2016 | 8004.55 | 8111 | 1003 | 91.44 | 92.23 | 90.85 | 92.34 | 0.00 | 0.00 | 7.77 | 0.80 |
| 2017 | 7983.09 | 8067 | 1003 | 90.86 | 91.90 | 90.86 | 92.09 | 0.09 | 0.08 | 8.02 | 1.04 |
| 2018 | 7732.00 | 7841 | 1003 | 88.12 | 88.79 | 88.00 | 89.51 | 0.65 | 0.65 | 10.56 | 0.67 |
| 2019 | 7905.28 | 8049 | 1003 | 90.23 | 91.61 | 89.97 | 91.88 | 0.01 | 0.59 | 7.80 | 1.38 |
| 2020 | 7729.61 | 7981 | 1003 | 89.12 | 90.39 | 87.73 | 90.86 | 0.29 | 0.26 | 9.35 | 1.26 |
| 2021 | 7408.21 | 7571 | 1003 | 84.57 | 86.25 | 84.32 | 86.43 | 4.19 | 3.77 | 9.98 | 1.68 |
| 2022 | 7679.74 | 7849 | 1003 | 87.37 | 89.54 | 87.41 | 89.60 | 1.74 | 1.59 | 8.88 | 2.17 |
| 2023 | 7734.72 | 8035 | 1003 | 89.61 | 91.68 | 88.03 | 91.72 | 0.05 | 0.04 | 8.28 | 2.06 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 119 | |
| C. Inspection, maintenance or repair combined with refuelling | 725 | | | 790 | 6 | |
| D. Inspection, maintenance or repair without refuelling | | | | 2 | | |
| P. Fire | | | | | 2 | |
| Subtotal | 725 | | | 792 | 127 | |
| Total | | 725 | | | 919 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 4 |
| 13. Reactor Auxiliary Systems | | 13 |
| 15. Reactor Cooling Systems | | 27 |
| 16. Steam generation systems | | 9 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 29 |
| 32. Feedwater and Main Steam System | | 13 |
| 33. Circulating Water System | | 0 |
| 34. Miscellaneous Systems | | 2 |
| 41. Main Generator Systems | | 8 |
| 42. Electrical Power Supply Systems | | 13 |
| Total | | 122 |

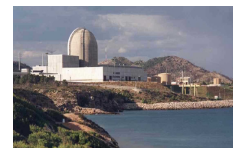
2023 Operating Experience

ES-16

VANDELLOS-2

SPAIN

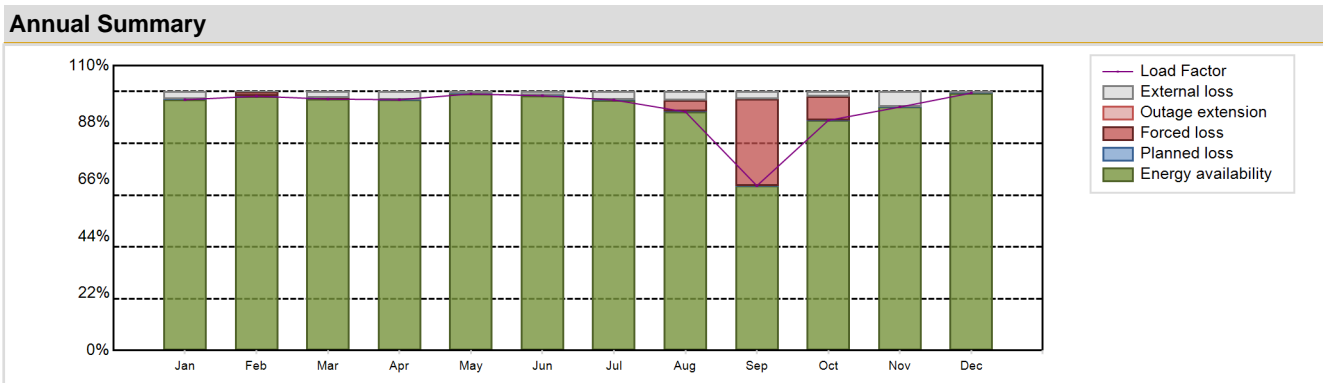
Status at end of year : **Operational**
 Operator : ANAV (ASOCIACIÓN NUCLEAR ASCÓ-VANDELLÓS A.I.E. (ENDESA/ID))
 Owner : EN/ID (ENDESA, IBERDROLA)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP | Construction Date | : 1980-12-29 |
| Thermal power | : 2941 MWth | Grid Date | : 1987-12-12 |
| Gross electrical power | : 1087 MWe | Commercial Date | : 1988-03-08 |
| Reference unit power (net) | : 1047 MWe | Age at end of year | : 36 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 328.3 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.38 |
| Average fuel enrichment [% of U235] | : 4.6 | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 50500 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 6.8 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : 21 |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.92 | Number of main condensate pumps | : 3 |
| Number of control rod assemblies | : 48 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 8573.98 GW(e).h | Forced Loss Rate (FLR) | : 4.02 % |
| Energy Availability Factor (EAF) | : 93.48 % | Unplanned Capability Loss Factor (UCL) | : 4.02 % |
| Unit Capability Factor (UCF) | : 95.84 % | Planned Unavailability Factor (PUF) | : 0.14 % |
| Load Factor (LF) | : 93.47 % | Externally cause unavailability (XUF) | : 2.36 % |
| Operating Factor (OF) | : 96.38 % | Total off-line time | : 317 hours |

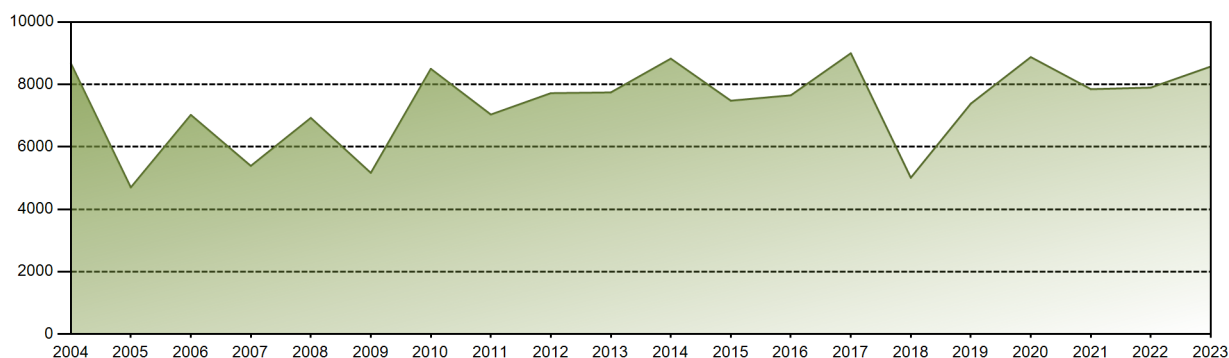


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 754.54 | 690.93 | 756.46 | 730.15 | 771.95 | 741.69 | 753.70 | 718.08 | 479.64 | 693.37 | 708.85 | 774.62 | 8573.98 |
| EAF [%] | 96.86 | 98.20 | 97.25 | 96.86 | 99.10 | 98.39 | 96.76 | 92.18 | 63.63 | 88.89 | 94.03 | 99.44 | 93.48 |
| UCF [%] | 99.85 | 98.41 | 99.54 | 99.85 | 99.84 | 99.86 | 99.85 | 95.55 | 66.57 | 90.75 | 99.85 | 99.87 | 95.84 |
| LF [%] | 96.86 | 98.20 | 97.11 | 96.86 | 99.10 | 98.39 | 96.76 | 92.18 | 63.63 | 88.89 | 94.03 | 99.44 | 93.47 |
| OF [%] | 100.00 | 100.00 | 99.87 | 100.00 | 100.00 | 100.00 | 100.00 | 97.45 | 65.83 | 93.15 | 100.00 | 100.00 | 96.38 |
| FLR [%] | 0.00 | 1.44 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 4.31 | 33.36 | 9.12 | 0.00 | 0.00 | 4.02 |
| UCL [%] | 0.00 | 1.43 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 4.31 | 33.33 | 9.11 | 0.00 | 0.00 | 4.02 |
| PUF [%] | 0.15 | 0.16 | 0.15 | 0.15 | 0.16 | 0.14 | 0.15 | 0.15 | 0.10 | 0.14 | 0.15 | 0.13 | 0.14 |
| XUF [%] | 2.99 | 0.21 | 2.30 | 2.99 | 0.74 | 1.47 | 3.09 | 3.37 | 2.95 | 1.86 | 5.82 | 0.42 | 2.36 |

Historical Summary

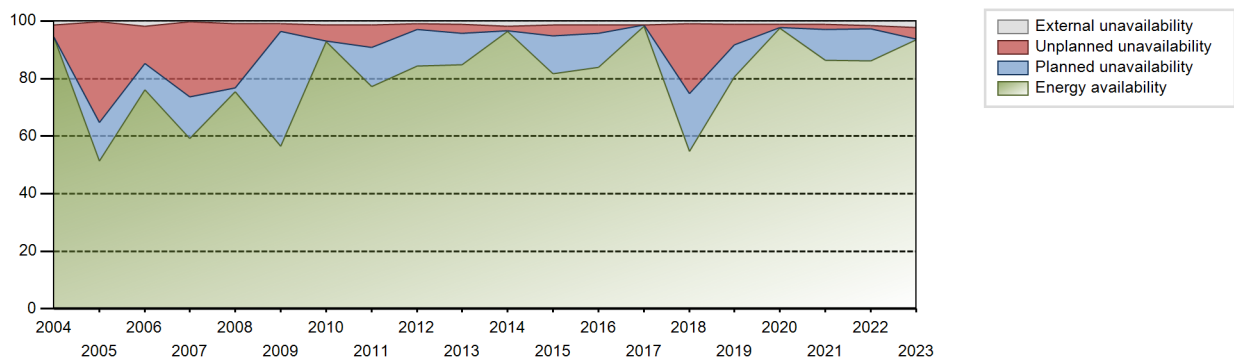
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 264323.92 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.69 % |
| Cumulative Energy Availability Factor (EAF) | : 82.86 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.73 % |
| Cumulative Unit Capability Factor (UCF) | : 83.89 % | Cumulative Planned Unavailability Factor (PUF) | : 9.38 % |
| Cumulative Load Factor (LF) | : 82.79 % | Cumulative Externally cause unavailability (XUF) | : 1.03 % |
| Cumulative Operating Factor (OF) | : 85.11 % | | |

Electricity Production (net) [GWh]

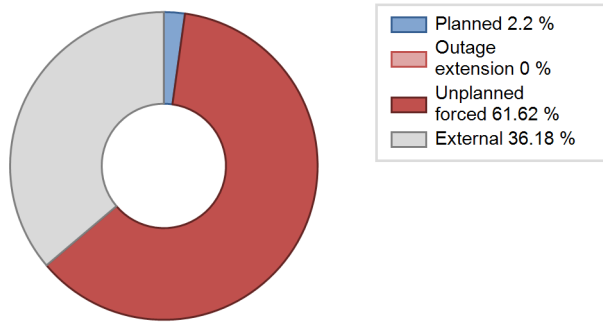


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 5101.90 | 6262 | 930 | 67.36 | 68.34 | 67.51 | 70.53 | 26.77 | 24.98 | 6.68 | 0.99 |
| 1989 | 5868.79 | 6357 | 943 | 70.58 | 70.62 | 71.04 | 72.57 | 22.13 | 20.07 | 9.31 | 0.04 |
| 1990 | 7334.29 | 7925 | 943 | 87.80 | 87.80 | 88.79 | 90.47 | 2.90 | 2.62 | 9.58 | 0.00 |
| 1991 | 7214.92 | 7825 | 953 | 86.31 | 88.49 | 86.42 | 89.33 | 2.06 | 1.86 | 9.65 | 2.18 |
| 1992 | 6718.20 | 7249 | 953 | 79.63 | 79.63 | 80.25 | 82.53 | 5.74 | 4.84 | 15.52 | 0.00 |
| 1993 | 6910.40 | 7377 | 961 | 82.41 | 84.33 | 82.09 | 84.21 | 7.95 | 7.28 | 8.39 | 1.92 |
| 1994 | 7208.44 | 7676 | 961 | 85.60 | 85.60 | 85.63 | 87.63 | 2.56 | 2.25 | 12.15 | 0.00 |
| 1995 | 7571.28 | 7957 | 961 | 89.48 | 89.48 | 89.94 | 90.83 | 0.59 | 0.53 | 9.98 | 0.00 |
| 1996 | 7511.43 | 7942 | 961 | 88.97 | 89.08 | 88.98 | 90.41 | 1.63 | 1.48 | 9.45 | 0.11 |
| 1997 | 7243.11 | 7961 | 961 | 85.51 | 88.66 | 86.05 | 90.89 | 1.25 | 1.12 | 10.22 | 3.16 |
| 1998 | 8359.01 | 8760 | 966 | 99.05 | 99.26 | 98.78 | 100.00 | 0.56 | 0.56 | 0.18 | 0.21 |
| 1999 | 7224.37 | 7430 | 1024 | 82.51 | 83.41 | 80.50 | 84.82 | 4.54 | 3.97 | 12.62 | 0.89 |
| 2000 | 7976.91 | 7852 | 1043 | 87.64 | 87.89 | 87.07 | 89.39 | 2.77 | 2.51 | 9.60 | 0.25 |
| 2001 | 9010.35 | 8727 | 1043 | 99.43 | 99.43 | 98.62 | 99.62 | 0.51 | 0.51 | 0.06 | 0.00 |
| 2002 | 8010.07 | 7881 | 1040 | 88.07 | 89.25 | 87.92 | 89.97 | 0.47 | 0.42 | 10.33 | 1.18 |
| 2003 | 8219.25 | 8067 | 1040 | 89.47 | 90.89 | 90.22 | 92.09 | 0.23 | 0.21 | 8.90 | 1.43 |
| 2004 | 8677.05 | 8429 | 1045 | 94.49 | 95.79 | 94.53 | 95.96 | 4.21 | 4.21 | 0.00 | 1.31 |
| 2005 | 4698.40 | 4657 | 1045 | 51.31 | 51.67 | 51.33 | 53.16 | 0.04 | 34.82 | 13.50 | 0.36 |
| 2006 | 7022.75 | 6882 | 1045 | 76.20 | 77.98 | 76.72 | 78.56 | 14.22 | 12.92 | 9.10 | 1.78 |
| 2007 | 5387.75 | 5313 | 1045 | 59.15 | 59.43 | 58.86 | 60.65 | 28.65 | 26.16 | 14.41 | 0.29 |
| 2008 | 6926.03 | 6922 | 1045 | 75.39 | 76.31 | 75.45 | 78.80 | 22.68 | 22.39 | 1.30 | 0.92 |
| 2009 | 5164.06 | 5241 | 1045 | 56.42 | 57.45 | 56.42 | 59.84 | 4.36 | 2.62 | 39.93 | 1.03 |
| 2010 | 8498.80 | 8293 | 1045 | 92.79 | 94.10 | 92.84 | 94.67 | 5.74 | 5.73 | 0.17 | 1.31 |
| 2011 | 7034.35 | 6894 | 1045 | 77.30 | 78.59 | 76.85 | 78.71 | 2.52 | 7.79 | 13.62 | 1.29 |
| 2012 | 7718.56 | 7549 | 1045 | 84.26 | 85.27 | 84.09 | 85.94 | 0.76 | 1.83 | 12.90 | 1.01 |
| 2013 | 7742.95 | 7676 | 1045 | 84.75 | 85.81 | 84.58 | 87.63 | 1.63 | 3.30 | 10.89 | 1.05 |
| 2014 | 8824.89 | 8663 | 1045 | 96.41 | 98.26 | 96.40 | 98.89 | 1.59 | 1.59 | 0.16 | 1.85 |
| 2015 | 7478.53 | 7353 | 1045 | 81.70 | 83.06 | 81.70 | 83.94 | 0.69 | 3.88 | 13.06 | 1.36 |
| 2016 | 7650.33 | 7568 | 1045 | 83.88 | 85.24 | 83.34 | 86.16 | 0.03 | 2.90 | 11.86 | 1.36 |
| 2017 | 8997.98 | 8760 | 1045 | 98.29 | 99.61 | 98.29 | 100.00 | 0.09 | 0.09 | 0.30 | 1.32 |
| 2018 | 5009.18 | 4947 | 1045 | 54.72 | 55.61 | 54.72 | 56.47 | 28.07 | 24.26 | 20.13 | 0.89 |
| 2019 | 7383.68 | 7293 | 1045 | 80.66 | 81.76 | 80.66 | 83.25 | 5.94 | 7.15 | 11.09 | 1.10 |
| 2020 | 8875.72 | 8784 | 1045 | 97.53 | 98.73 | 96.69 | 100.00 | 1.12 | 1.12 | 0.15 | 1.21 |
| 2021 | 7848.71 | 7758 | 1045 | 86.26 | 87.36 | 85.74 | 88.56 | 1.30 | 1.84 | 10.80 | 1.10 |
| 2022 | 7897.80 | 7759 | 1047 | 86.11 | 87.80 | 86.11 | 88.57 | 0.20 | 0.98 | 11.22 | 1.69 |
| 2023 | 8573.98 | 8444 | 1047 | 93.48 | 95.84 | 93.47 | 96.38 | 4.02 | 4.02 | 0.14 | 2.36 |

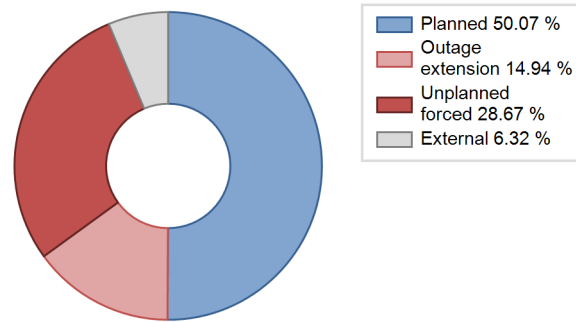
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 347 | | | 419 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 690 | 15 | |
| D. Inspection, maintenance or repair without refuelling | | | | 43 | | |
| E. Testing of plant systems or components | | | | 3 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | | 51 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 8 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 10 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 4 |
| Z. Other | | | | | 4 | |
| Subtotal | | 347 | | 736 | 500 | 13 |
| Total | | 347 | | | 1249 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 17 |
| 12. Reactor I&C Systems | | 53 |
| 13. Reactor Auxiliary Systems | | 88 |
| 15. Reactor Cooling Systems | | 91 |
| 16. Steam generation systems | | 1 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 14 |
| 32. Feedwater and Main Steam System | | 59 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | | 4 |
| 41. Main Generator Systems | 315 | 62 |
| 42. Electrical Power Supply Systems | 32 | 83 |
| Total | 347 | 480 |

2023 Operating Experience

SE-9

FORSMARK-1

SWEDEN

Status at end of year : **Operational**
 Operator : FKA (FORSMARK KRAFTGRUPP AB)
 Owner : FKA (FORSMARK KRAFTGRUPP AB)
 Reactor Supplier : ABB ATOM (ABB ATOM (formerly ASEA-ATOM))
 Turbine Supplier : STAL (STAL-LAVAL)



Reactor Unit Details

Reactor type and model : BWR / AA-III, BWR-2500
 Thermal power : 3075 MWth
 Gross electrical power : 1078 MWe
 Reference unit power (net) : 1040 MWe

Key Dates

Construction Date : 1973-06-01
 Grid Date : 1980-06-06
 Commercial Date : 1980-12-10
 Age at end of year : 43 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.60
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 17
 Average discharge burnup [MWd/t] : 48000
 Active core diameter [m] : 4.51
 Active core height/length [m] : 3.68
 Number of fissile fuel assemblies/bundles : 676
 Fuel linear heat generation rate [kW/m] : 16
 Number of control rod assemblies : 161
 Number of external reactor coolant loops : NA
 Coolant type : H2O

Operating coolant pressure [MPa] : 7
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : Single
 Containment design pressure [MPa] : 0.55

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.35
 Output voltage [kV] : 21.5
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 4

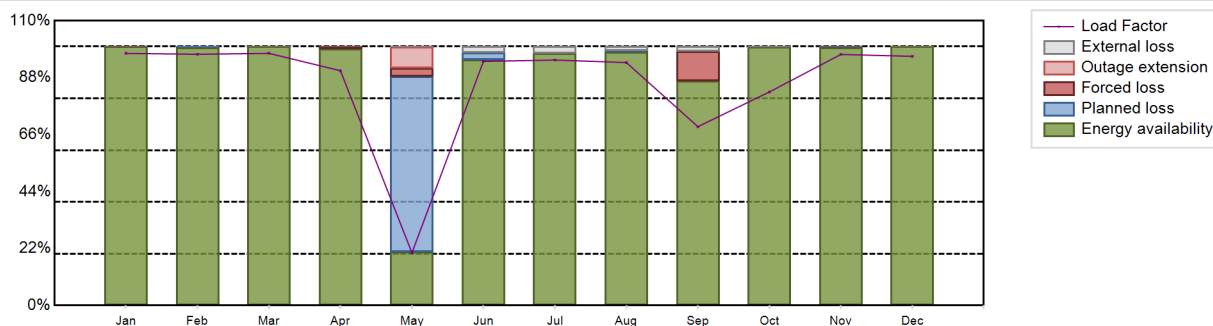
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7813.5 GW(e).h
 Energy Availability Factor (EAF) : 91.2 %
 Unit Capability Factor (UCF) : 91.92 %
 Load Factor (LF) : 85.76 %
 Operating Factor (OF) : 92.79 %
 Forced Loss Rate (FLR) : 1.39 %
 Unplanned Capability Loss Factor (UCL) : 2.01 %
 Planned Unavailability Factor (PUF) : 6.07 %
 Externally cause unavailability (XUF) : 0.72 %
 Total off-line time : 632 hours

Annual Summary

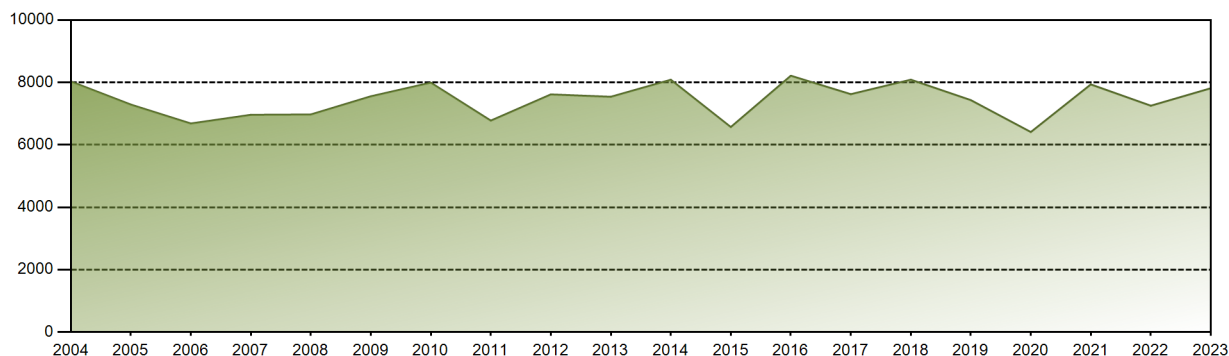


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 753.51 | 678.12 | 752.62 | 679.00 | 157.53 | 705.98 | 733.58 | 726.03 | 517.25 | 639.08 | 726.09 | 744.72 | 7813.50 |
| EAF [%] | 99.99 | 99.58 | 100.00 | 99.08 | 20.80 | 94.81 | 97.40 | 97.93 | 86.74 | 99.79 | 99.56 | 100.00 | 91.20 |
| UCF [%] | 99.99 | 99.58 | 100.00 | 99.08 | 20.84 | 97.19 | 100.00 | 99.55 | 88.52 | 100.00 | 99.56 | 100.00 | 91.92 |
| LF [%] | 97.38 | 97.03 | 97.40 | 90.68 | 20.36 | 94.28 | 94.81 | 93.83 | 69.08 | 82.48 | 96.97 | 96.25 | 85.76 |
| OF [%] | 100.00 | 100.00 | 100.00 | 96.67 | 27.15 | 100.00 | 100.00 | 100.00 | 90.83 | 100.00 | 100.00 | 100.00 | 92.79 |
| FLR [%] | 0.01 | 0.00 | 0.00 | 0.92 | 13.22 | 0.00 | 0.00 | 0.00 | 11.48 | 0.00 | 0.11 | 0.00 | 1.39 |
| UCL [%] | 0.01 | 0.00 | 0.00 | 0.92 | 11.51 | 0.00 | 0.00 | 0.00 | 11.48 | 0.00 | 0.11 | 0.00 | 2.01 |
| PUF [%] | 0.00 | 0.42 | 0.00 | 0.00 | 67.65 | 2.81 | 0.00 | 0.45 | 0.00 | 0.00 | 0.34 | 0.00 | 6.07 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 2.38 | 2.60 | 1.62 | 1.77 | 0.21 | 0.00 | 0.00 | 0.72 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 303249.26 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.76 % |
| Cumulative Energy Availability Factor (EAF) | : 84.68 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.61 % |
| Cumulative Unit Capability Factor (UCF) | : 86.64 % | Cumulative Planned Unavailability Factor (PUF) | : 9.75 % |
| Cumulative Load Factor (LF) | : 82.96 % | Cumulative Externally cause unavailability (XUF) | : 1.96 % |
| Cumulative Operating Factor (OF) | : 89.93 % | | |

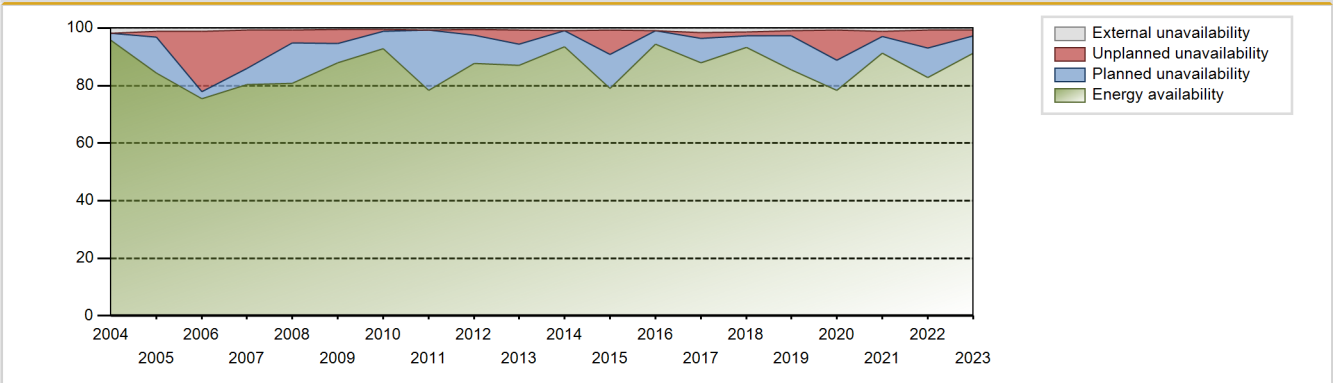
Electricity Production (net) [GWh]



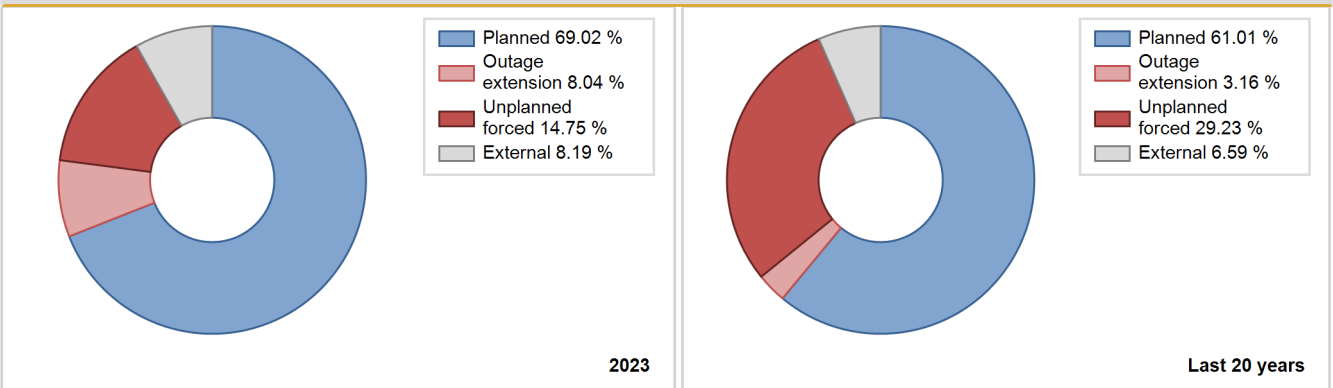
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | 2200.90 | 5016 | 928 | 100.00 | 100.00 | 100.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1981 | 6063.70 | 7305 | 900 | 76.91 | 76.91 | 76.91 | 83.39 | 8.70 | 7.33 | 15.76 | 0.00 |
| 1982 | 5548.10 | 7131 | 900 | 70.37 | 70.37 | 70.37 | 81.40 | 18.09 | 15.54 | 14.09 | 0.00 |
| 1983 | 5926.00 | 8095 | 900 | 75.17 | 75.17 | 75.16 | 92.41 | 15.95 | 14.26 | 10.57 | 0.00 |
| 1984 | 6461.80 | 8207 | 900 | 91.90 | 91.90 | 81.74 | 93.43 | 1.77 | 1.65 | 6.45 | 0.00 |
| 1985 | 5587.57 | 7773 | 900 | 79.42 | 79.42 | 70.87 | 88.73 | 1.82 | 1.48 | 19.10 | 0.00 |
| 1986 | 7317.15 | 8303 | 954 | 89.83 | 89.83 | 87.53 | 94.78 | 0.94 | 0.85 | 9.31 | 0.00 |
| 1987 | 6493.39 | 8291 | 970 | 79.45 | 79.45 | 76.42 | 94.65 | 0.29 | 0.23 | 20.32 | 0.00 |
| 1988 | 6852.84 | 7739 | 970 | 81.84 | 81.84 | 80.43 | 88.10 | 5.18 | 4.48 | 13.68 | 0.00 |
| 1989 | 6138.64 | 7907 | 969 | 85.46 | 85.46 | 72.30 | 90.26 | 2.53 | 2.22 | 12.32 | 0.00 |
| 1990 | 6257.49 | 7885 | 972 | 85.83 | 85.83 | 73.49 | 90.01 | 3.25 | 2.89 | 11.28 | 0.00 |
| 1991 | 7487.58 | 8122 | 968 | 88.26 | 90.58 | 88.30 | 92.72 | 0.11 | 0.10 | 9.32 | 2.32 |
| 1992 | 6833.64 | 8175 | 968 | 80.28 | 85.22 | 80.36 | 93.06 | 4.53 | 4.04 | 10.73 | 4.94 |
| 1993 | 7022.83 | 8010 | 968 | 82.73 | 91.93 | 82.81 | 91.43 | 1.46 | 1.36 | 6.70 | 9.20 |
| 1994 | 7398.21 | 8109 | 968 | 87.02 | 91.35 | 87.25 | 92.57 | 1.31 | 1.21 | 7.44 | 4.33 |
| 1995 | 7325.18 | 8173 | 968 | 86.19 | 91.29 | 86.39 | 93.30 | 2.45 | 2.29 | 6.42 | 5.11 |
| 1996 | 7311.38 | 8412 | 968 | 86.42 | 95.27 | 85.99 | 95.77 | 0.04 | 0.04 | 4.70 | 8.84 |
| 1997 | 5402.87 | 6255 | 968 | 64.57 | 64.57 | 63.54 | 71.21 | 0.55 | 0.36 | 35.08 | 0.00 |
| 1998 | 7307.70 | 8265 | 968 | 93.64 | 93.64 | 86.18 | 94.35 | 1.28 | 1.21 | 5.14 | 0.00 |
| 1999 | 7582.73 | 8420 | 968 | 96.29 | 96.69 | 89.42 | 96.12 | 0.04 | 0.04 | 3.27 | 0.40 |
| 2000 | 5730.82 | 7202 | 968 | 67.39 | 85.94 | 67.40 | 81.99 | 0.24 | 0.21 | 13.86 | 18.55 |
| 2001 | 7286.12 | 8482 | 968 | 86.25 | 94.77 | 85.92 | 96.83 | 0.84 | 0.80 | 4.43 | 8.51 |
| 2002 | 7143.77 | 7978 | 961 | 86.02 | 90.04 | 84.86 | 91.07 | 4.69 | 4.43 | 5.53 | 4.02 |
| 2003 | 7456.00 | 8093 | 961 | 88.49 | 88.49 | 88.56 | 92.38 | 0.52 | 1.36 | 10.15 | 0.00 |
| 2004 | 8032.28 | 8555 | 961 | 95.65 | 97.52 | 95.15 | 97.39 | 0.03 | 0.03 | 2.45 | 1.87 |
| 2005 | 7291.06 | 7648 | 1011 | 84.38 | 85.43 | 85.13 | 87.31 | 2.45 | 2.15 | 12.43 | 1.05 |
| 2006 | 6683.92 | 6806 | 995 | 75.43 | 76.50 | 75.47 | 77.69 | 21.61 | 21.09 | 2.40 | 1.07 |
| 2007 | 6961.43 | 7204 | 987 | 80.38 | 81.12 | 80.52 | 82.24 | 14.03 | 13.23 | 5.65 | 0.74 |
| 2008 | 6973.66 | 7442 | 978 | 80.76 | 81.41 | 81.10 | 84.71 | 3.25 | 4.51 | 14.07 | 0.65 |
| 2009 | 7555.38 | 8029 | 978 | 87.90 | 88.35 | 88.19 | 91.66 | 4.80 | 4.88 | 6.77 | 0.46 |
| 2010 | 7993.61 | 8283 | 978 | 92.83 | 93.38 | 93.30 | 94.55 | 0.09 | 0.49 | 6.13 | 0.55 |
| 2011 | 6776.59 | 7005 | 984 | 78.44 | 79.22 | 79.02 | 79.97 | 0.03 | 0.03 | 20.76 | 0.77 |
| 2012 | 7615.92 | 7938 | 984 | 87.69 | 88.16 | 88.11 | 90.37 | 2.25 | 2.03 | 9.80 | 0.48 |
| 2013 | 7539.63 | 7782 | 984 | 87.12 | 87.78 | 87.47 | 88.84 | 2.02 | 5.00 | 7.23 | 0.66 |
| 2014 | 8085.96 | 8307 | 984 | 93.54 | 94.41 | 93.81 | 94.83 | 0.05 | 0.05 | 5.54 | 0.87 |
| 2015 | 6570.19 | 7153 | 984 | 79.10 | 79.76 | 76.22 | 81.66 | 8.82 | 8.49 | 11.75 | 0.66 |
| 2016 | 8214.31 | 8421 | 984 | 94.49 | 95.40 | 95.04 | 95.87 | 0.04 | 0.04 | 4.56 | 0.91 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|-------|-------|-------|------|
| 2017 | 7623.46 | 7994 | 984 | 87.85 | 89.45 | 88.44 | 91.26 | 1.34 | 2.03 | 8.52 | 1.60 |
| 2018 | 8087.58 | 8448 | 986 | 93.30 | 94.76 | 93.70 | 96.44 | 1.36 | 1.30 | 3.94 | 1.46 |
| 2019 | 7432.93 | 7699 | 990 | 85.54 | 86.35 | 85.87 | 87.89 | 2.06 | 1.81 | 11.83 | 0.81 |
| 2020 | 6410.35 | 7652 | 990 | 78.29 | 79.04 | 73.71 | 87.11 | 11.72 | 10.49 | 10.46 | 0.76 |
| 2021 | 7935.93 | 8295 | 990 | 91.17 | 92.33 | 91.51 | 94.69 | 1.86 | 1.75 | 5.92 | 1.16 |
| 2022 | 7253.90 | 7775 | 1040 | 82.88 | 83.64 | 82.94 | 88.76 | 6.45 | 6.29 | 10.07 | 0.75 |
| 2023 | 7813.50 | 8128 | 1040 | 91.20 | 91.92 | 85.76 | 92.79 | 1.39 | 2.01 | 6.07 | 0.72 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|--|------------|------------|-----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 128 | | | 144 | |
| B. Refuelling without maintenance | | | | 8 | | |
| C. Inspection, maintenance or repair combined with refuelling | 480 | | | 665 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 1 | | |
| E. Testing of plant systems or components | | | | 3 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 23 | | |
| H. Nuclear regulatory requirements | | | | | 6 | |
| J. Grid limitation, failure or grid unavailability | | | 24 | | | 2 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 10 |
| L. Human factor related | | | | | 26 | |
| P. Fire | | | | | 0 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 5 | |
| Subtotal | 480 | 128 | 24 | 700 | 181 | 12 |
| Total | | 632 | | | 893 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1980 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 62 | 47 |
| 12. Reactor I&C Systems | | 13 |
| 13. Reactor Auxiliary Systems | | 17 |
| 14. Safety Systems | | 29 |
| 15. Reactor Cooling Systems | 66 | 11 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 8 |
| 32. Feedwater and Main Steam System | | 2 |
| 34. Miscellaneous Systems | | 1 |
| 41. Main Generator Systems | | 3 |
| 42. Electrical Power Supply Systems | | 41 |
| Total | 128 | 174 |

Highlights (2023)

Annual outage in May.

2023 Operating Experience

SE-11

FORSMARK-2

SWEDEN

Status at end of year : **Operational**
 Operator : FKA (FORSMARK KRAFTGRUPP AB)
 Owner : FKA (FORSMARK KRAFTGRUPP AB)
 Reactor Supplier : ABB ATOM (ABB ATOM (formerly ASEA-ATOM))
 Turbine Supplier : STAL (STAL-LAVAL)



Reactor Unit Details

Reactor type and model : BWR / AA-III, BWR-2500
 Thermal power : 3253 MWth
 Gross electrical power : 1160 MWe
 Reference unit power (net) : 1121 MWe

Key Dates

Construction Date : 1975-01-01
 Grid Date : 1981-01-26
 Commercial Date : 1981-07-07
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.60
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 20
 Average discharge burnup [MWd/t] : 48000
 Active core diameter [m] : 4.51
 Active core height/length [m] : 3.68
 Number of fissile fuel assemblies/bundles : 676
 Fuel linear heat generation rate [kW/m] : 19
 Number of control rod assemblies : 161
 Number of external reactor coolant loops : NA
 Coolant type : H2O

Operating coolant pressure [MPa] : 7
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : Single
 Containment design pressure [MPa] : 0.55

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.35
 Output voltage [kV] : 21.5
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 4

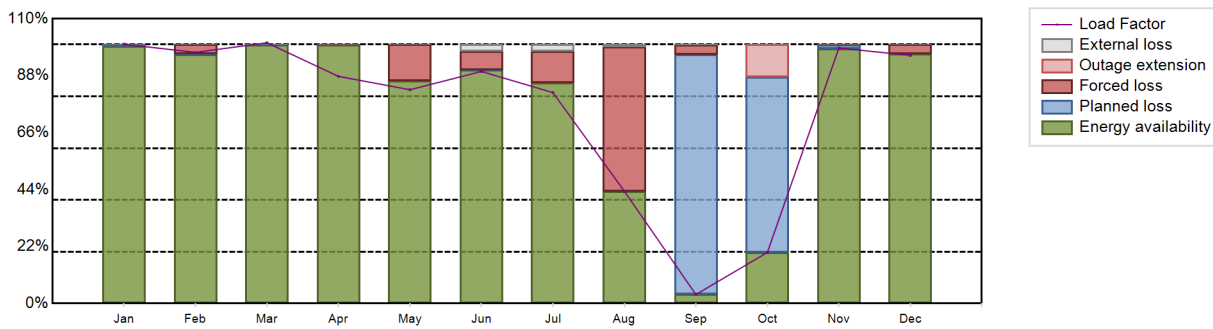
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7354.48 GW(e).h
 Energy Availability Factor (EAF) : 76.36 %
 Unit Capability Factor (UCF) : 76.88 %
 Load Factor (LF) : 74.89 %
 Operating Factor (OF) : 85.68 %
 Forced Loss Rate (FLR) : 9.92 %
 Unplanned Capability Loss Factor (UCL) : 9.52 %
 Planned Unavailability Factor (PUF) : 13.6 %
 Externally cause unavailability (XUF) : 0.51 %
 Total off-line time : 1254 hours

Annual Summary

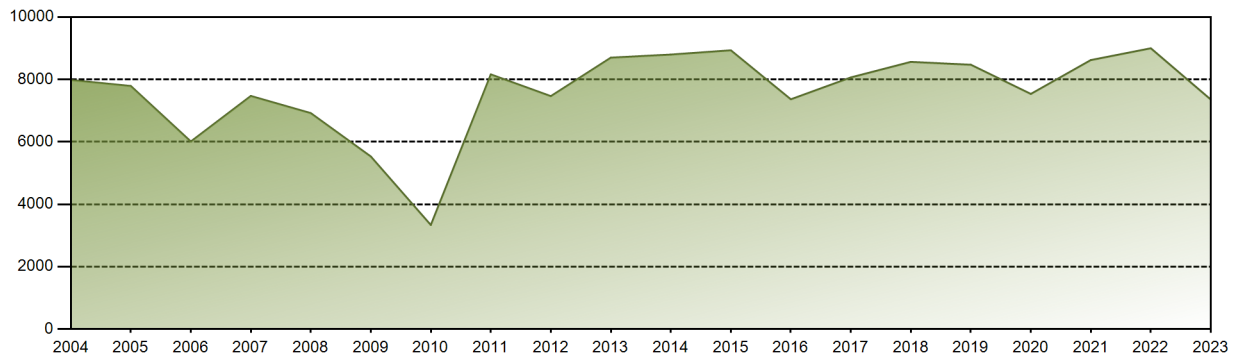


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|---------|
| GW(e)-h | 835.15 | 730.76 | 838.73 | 708.17 | 688.67 | 723.38 | 679.53 | 361.48 | 28.16 | 164.84 | 796.39 | 799.24 | 7354.48 |
| EAF [%] | 99.37 | 96.26 | 99.94 | 99.94 | 85.97 | 90.07 | 85.18 | 43.34 | 3.49 | 19.71 | 98.40 | 96.30 | 76.36 |
| UCF [%] | 99.37 | 96.26 | 99.94 | 99.94 | 85.97 | 92.68 | 87.75 | 44.15 | 3.61 | 19.71 | 98.40 | 96.30 | 76.88 |
| LF [%] | 100.13 | 97.01 | 100.70 | 87.74 | 82.57 | 89.62 | 81.48 | 43.34 | 3.49 | 19.74 | 98.67 | 95.83 | 74.89 |
| OF [%] | 100.00 | 100.00 | 100.00 | 89.72 | 86.83 | 99.17 | 100.00 | 100.00 | 8.61 | 43.89 | 100.00 | 100.00 | 85.68 |
| FLR [%] | 0.00 | 3.69 | 0.00 | 0.01 | 13.99 | 7.23 | 12.18 | 55.85 | 50.66 | 0.00 | 0.06 | 3.70 | 9.92 |
| UCL [%] | 0.00 | 3.69 | 0.00 | 0.01 | 13.99 | 7.22 | 12.17 | 55.85 | 3.71 | 12.44 | 0.06 | 3.70 | 9.52 |
| PUF [%] | 0.63 | 0.05 | 0.06 | 0.05 | 0.04 | 0.10 | 0.08 | 0.00 | 92.68 | 67.85 | 1.55 | 0.00 | 13.60 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.61 | 2.57 | 0.81 | 0.12 | 0.00 | 0.00 | 0.00 | 0.51 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 301755.26 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.48 % |
| Cumulative Energy Availability Factor (EAF) | : 82.84 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.95 % |
| Cumulative Unit Capability Factor (UCF) | : 84.65 % | Cumulative Planned Unavailability Factor (PUF) | : 9.41 % |
| Cumulative Load Factor (LF) | : 81 % | Cumulative Externally cause unavailability (XUF) | : 1.81 % |
| Cumulative Operating Factor (OF) | : 89.22 % | | |

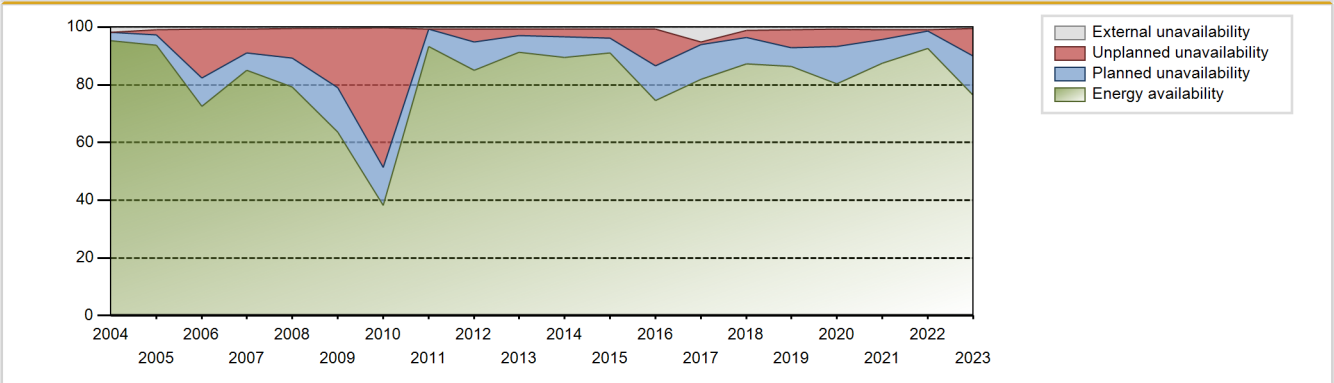
Electricity Production (net) [GWh]



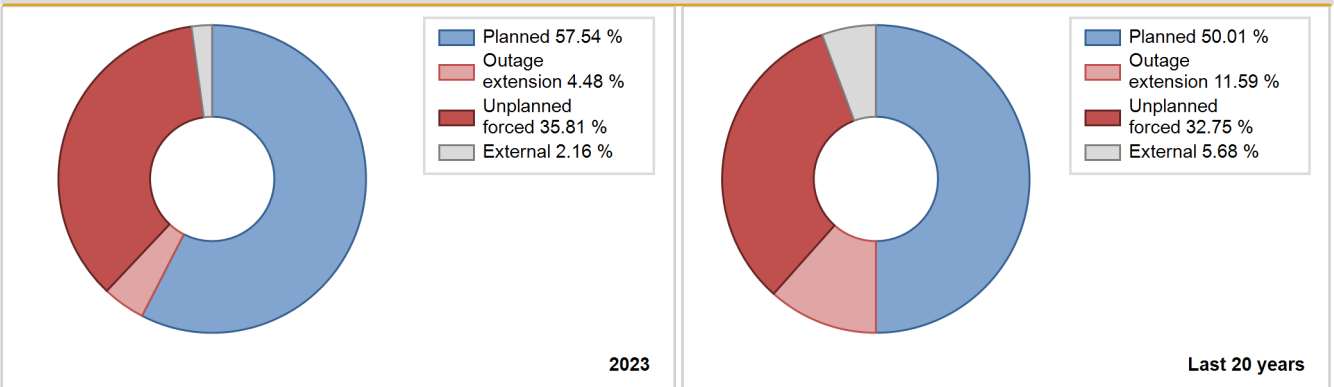
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 2870.70 | 3977 | 900 | 72.23 | 72.23 | 72.23 | 90.06 | 22.48 | 20.94 | 6.83 | 0.00 |
| 1982 | 5316.40 | 6076 | 900 | 67.40 | 67.40 | 67.43 | 69.36 | 24.62 | 22.01 | 10.58 | 0.00 |
| 1983 | 5484.40 | 7879 | 900 | 69.56 | 69.56 | 69.56 | 89.94 | 19.21 | 16.54 | 13.89 | 0.00 |
| 1984 | 5911.73 | 7442 | 900 | 82.56 | 82.57 | 74.78 | 84.72 | 7.71 | 6.90 | 10.53 | 0.01 |
| 1985 | 5735.38 | 8048 | 900 | 83.81 | 83.81 | 72.75 | 91.87 | 4.41 | 3.87 | 12.32 | 0.00 |
| 1986 | 6987.86 | 8231 | 938 | 86.54 | 86.54 | 84.99 | 93.96 | 2.06 | 1.82 | 11.64 | 0.00 |
| 1987 | 6553.84 | 8190 | 949 | 85.48 | 85.48 | 78.84 | 93.49 | 1.47 | 1.27 | 13.25 | 0.00 |
| 1988 | 6976.19 | 8032 | 963 | 83.19 | 83.19 | 82.47 | 91.44 | 4.17 | 3.62 | 13.19 | 0.00 |
| 1989 | 5943.42 | 8222 | 964 | 90.02 | 90.02 | 70.36 | 93.86 | 1.11 | 1.01 | 8.96 | 0.00 |
| 1990 | 6426.24 | 8119 | 972 | 88.64 | 88.64 | 75.47 | 92.68 | 0.20 | 0.18 | 11.18 | 0.00 |
| 1991 | 7155.18 | 8084 | 969 | 84.19 | 85.78 | 84.29 | 92.28 | 0.03 | 0.03 | 14.20 | 1.58 |
| 1992 | 6748.91 | 8294 | 969 | 79.22 | 86.22 | 79.29 | 94.42 | 2.04 | 1.79 | 11.98 | 7.00 |
| 1993 | 6715.51 | 7684 | 969 | 79.14 | 88.82 | 79.11 | 87.72 | 0.30 | 0.27 | 10.91 | 9.68 |
| 1994 | 7679.45 | 8194 | 969 | 90.44 | 92.53 | 90.47 | 93.54 | 0.94 | 0.88 | 6.60 | 2.08 |
| 1995 | 7149.21 | 8144 | 969 | 84.14 | 91.61 | 84.21 | 92.96 | 1.27 | 1.18 | 7.21 | 7.47 |
| 1996 | 7348.24 | 8135 | 969 | 86.21 | 91.24 | 86.32 | 92.60 | 2.72 | 2.55 | 6.20 | 5.03 |
| 1997 | 7325.29 | 7927 | 969 | 87.44 | 87.44 | 86.06 | 90.24 | 2.57 | 2.31 | 10.25 | 0.00 |
| 1998 | 7198.57 | 8240 | 969 | 91.87 | 92.09 | 84.80 | 94.06 | 3.00 | 2.84 | 5.06 | 0.22 |
| 1999 | 7292.27 | 8117 | 964 | 91.75 | 91.75 | 86.02 | 92.66 | 1.27 | 1.18 | 7.07 | 0.00 |
| 2000 | 5428.10 | 6939 | 964 | 66.32 | 79.62 | 64.10 | 79.00 | 6.00 | 5.08 | 15.30 | 13.30 |
| 2001 | 7399.55 | 8321 | 964 | 88.83 | 92.34 | 87.62 | 94.99 | 3.87 | 3.71 | 3.95 | 3.51 |
| 2002 | 6823.89 | 8155 | 959 | 82.20 | 89.92 | 81.02 | 93.09 | 3.82 | 3.57 | 6.51 | 7.72 |
| 2003 | 7303.88 | 7916 | 954 | 87.06 | 87.06 | 87.05 | 90.35 | 0.86 | 1.91 | 11.03 | 0.00 |
| 2004 | 7982.20 | 8529 | 954 | 95.21 | 96.92 | 95.25 | 97.10 | 0.12 | 0.12 | 2.96 | 1.71 |
| 2005 | 7790.11 | 8348 | 951 | 93.68 | 94.64 | 93.51 | 95.30 | 1.78 | 1.72 | 3.64 | 0.96 |
| 2006 | 6011.87 | 6426 | 951 | 72.49 | 73.11 | 72.16 | 73.36 | 18.80 | 16.93 | 9.97 | 0.61 |
| 2007 | 7470.12 | 7750 | 1000 | 85.03 | 85.67 | 85.27 | 88.46 | 8.07 | 8.39 | 5.94 | 0.64 |
| 2008 | 6920.12 | 7342 | 990 | 79.18 | 79.68 | 79.45 | 83.58 | 11.44 | 10.30 | 10.02 | 0.51 |
| 2009 | 5530.68 | 5902 | 990 | 63.57 | 64.13 | 63.77 | 67.37 | 5.11 | 20.46 | 15.42 | 0.56 |
| 2010 | 3334.15 | 7635 | 990 | 38.26 | 38.58 | 38.45 | 87.16 | 54.60 | 48.30 | 13.11 | 0.32 |
| 2011 | 8161.59 | 8259 | 996 | 93.23 | 93.92 | 93.82 | 94.28 | 0.07 | 0.07 | 6.01 | 0.68 |
| 2012 | 7464.89 | 7747 | 996 | 84.98 | 85.66 | 85.32 | 88.19 | 3.91 | 4.46 | 9.88 | 0.67 |
| 2013 | 8697.94 | 8239 | 1120 | 91.22 | 91.85 | 91.14 | 94.05 | 1.06 | 2.39 | 5.76 | 0.64 |
| 2014 | 8796.40 | 7991 | 1120 | 89.39 | 90.15 | 89.66 | 91.22 | 0.35 | 2.60 | 7.25 | 0.76 |
| 2015 | 8933.60 | 8107 | 1120 | 91.07 | 91.82 | 91.06 | 92.55 | 0.06 | 3.18 | 5.00 | 0.75 |
| 2016 | 7362.92 | 6927 | 1120 | 74.53 | 75.21 | 74.84 | 78.86 | 3.12 | 12.84 | 11.95 | 0.68 |
| 2017 | 8063.69 | 7721 | 1120 | 81.92 | 87.02 | 82.19 | 88.14 | 0.63 | 1.05 | 11.93 | 5.10 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2018 | 8562.30 | 7890 | 1116 | 87.17 | 88.38 | 87.48 | 90.07 | 2.05 | 2.36 | 9.26 | 1.21 |
| 2019 | 8470.86 | 8183 | 1118 | 86.33 | 87.28 | 86.49 | 93.41 | 5.94 | 6.11 | 6.61 | 0.95 |
| 2020 | 7535.29 | 7356 | 1118 | 80.28 | 80.90 | 76.73 | 83.74 | 6.91 | 6.00 | 13.10 | 0.69 |
| 2021 | 8620.49 | 7943 | 1118 | 87.48 | 88.46 | 88.02 | 90.67 | 3.68 | 3.38 | 8.16 | 0.98 |
| 2022 | 8998.04 | 8254 | 1121 | 92.53 | 93.35 | 91.63 | 94.22 | 0.33 | 0.55 | 6.09 | 0.83 |
| 2023 | 7354.48 | 7506 | 1121 | 76.36 | 76.88 | 74.89 | 85.68 | 9.92 | 9.52 | 13.60 | 0.51 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|--|------------|-------------|-----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 199 | | | 210 | |
| B. Refuelling without maintenance | | | | 4 | | |
| C. Inspection, maintenance or repair combined with refuelling | 982 | | | 600 | 8 | |
| D. Inspection, maintenance or repair without refuelling | | | | 47 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 33 | | |
| H. Nuclear regulatory requirements | | | | | 19 | |
| J. Grid limitation, failure or grid unavailability | | | 75 | | | 2 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 12 |
| L. Human factor related | | | | | 16 | |
| P. Fire | | | | | 3 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 3 | 6 | |
| Z. Other | | | | | 1 | |
| Subtotal | 982 | 199 | 75 | 687 | 263 | 14 |
| Total | | 1256 | | | 964 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 94 | 81 |
| 12. Reactor I&C Systems | 105 | 7 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | | 38 |
| 15. Reactor Cooling Systems | | 13 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 31. Turbine and auxiliaries | | 52 |
| 32. Feedwater and Main Steam System | | 5 |
| 34. Miscellaneous Systems | | 13 |
| 41. Main Generator Systems | | 0 |
| 42. Electrical Power Supply Systems | | 43 |
| Total | 199 | 258 |

Highlights (2023)

Annual outage in September and October 2023
 Half power due to earth fault in generator, in July - September (G21) and in December - (G22).

2023 Operating Experience

SE-14

FORSMARK-3

SWEDEN

Status at end of year : **Operational**
 Operator : FKA (FORSMARK KRAFTGRUPP AB)
 Owner : FKA (FORSMARK KRAFTGRUPP AB)
 Reactor Supplier : ABB ATOM (ABB ATOM (formerly ASEA-ATOM))
 Turbine Supplier : STAL (STAL-LAVAL)



Reactor Unit Details

Reactor type and model : BWR / AA-IV, BWR-3000
 Thermal power : 3300 MWth
 Gross electrical power : 1208 MWe
 Reference unit power (net) : 1172 MWe

Key Dates

Construction Date : 1979-01-01
 Grid Date : 1985-03-05
 Commercial Date : 1985-08-18
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3.65
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 20
 Average discharge burnup [MWd/t] : 48000
 Active core diameter [m] : 4.6
 Active core height/length [m] : 3.68
 Number of fissile fuel assemblies/bundles : 700
 Fuel linear heat generation rate [kW/m] : 19
 Number of control rod assemblies : 169
 Number of external reactor coolant loops : NA
 Coolant type : H2O

Operating coolant pressure [MPa] : 7
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : Single
 Containment design pressure [MPa] : 0.6

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 1
 HP cylinder inlet steam pressure [MPa] : 5.97
 Output voltage [kV] : 25
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 6
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 4

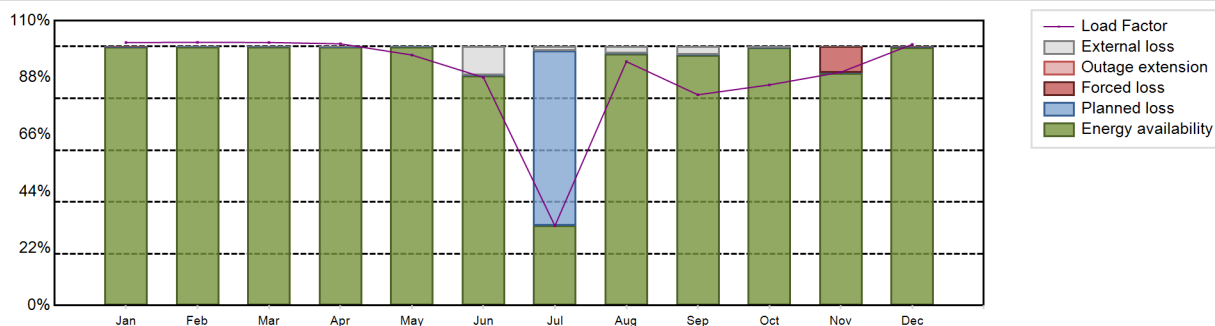
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9170.91 GW(e).h
 Energy Availability Factor (EAF) : 91.67 %
 Unit Capability Factor (UCF) : 93.23 %
 Load Factor (LF) : 89.33 %
 Operating Factor (OF) : 93.87 %
 Forced Loss Rate (FLR) : 0.88 %
 Unplanned Capability Loss Factor (UCL) : 0.83 %
 Planned Unavailability Factor (PUF) : 5.94 %
 Externally cause unavailability (XUF) : 1.55 %
 Total off-line time : 537 hours

Annual Summary

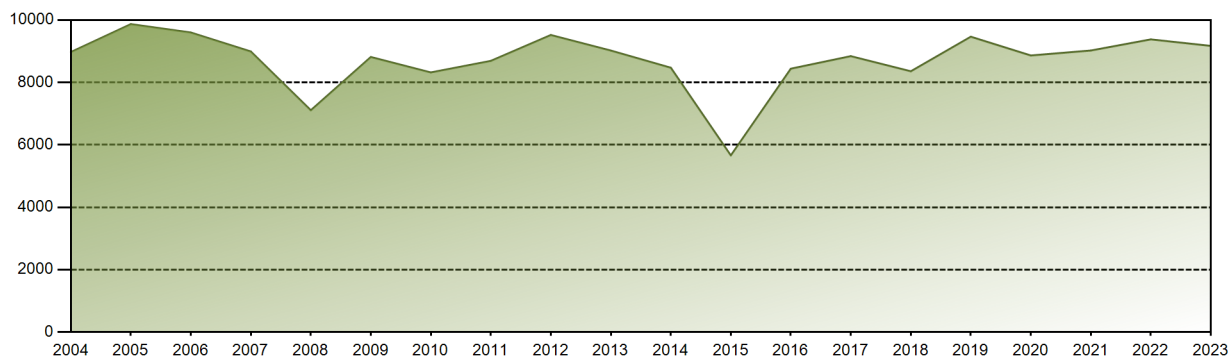


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 885.73 | 800.49 | 884.62 | 852.79 | 843.61 | 743.22 | 268.35 | 821.53 | 686.74 | 744.04 | 760.43 | 879.34 | 9170.91 |
| EAF [%] | 99.76 | 99.81 | 99.79 | 99.87 | 99.94 | 88.80 | 30.77 | 97.14 | 96.56 | 99.50 | 89.68 | 99.51 | 91.67 |
| UCF [%] | 99.76 | 99.81 | 99.79 | 99.89 | 99.94 | 99.76 | 32.43 | 99.70 | 99.71 | 99.90 | 89.68 | 99.51 | 93.23 |
| LF [%] | 101.58 | 101.64 | 101.59 | 101.06 | 96.75 | 88.08 | 30.77 | 94.22 | 81.38 | 85.21 | 90.12 | 100.85 | 89.33 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 36.02 | 100.00 | 100.00 | 100.00 | 91.53 | 100.00 | 93.87 |
| FLR [%] | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.04 | 0.08 | 0.88 |
| UCL [%] | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.01 | 0.08 | 0.83 |
| PUF [%] | 0.22 | 0.19 | 0.21 | 0.11 | 0.06 | 0.24 | 67.57 | 0.30 | 0.29 | 0.10 | 0.31 | 0.41 | 5.94 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 10.95 | 1.66 | 2.56 | 3.15 | 0.40 | 0.00 | 0.00 | 1.55 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 329957.89 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.26 % |
| Cumulative Energy Availability Factor (EAF) | : 85.73 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.19 % |
| Cumulative Unit Capability Factor (UCF) | : 87.79 % | Cumulative Planned Unavailability Factor (PUF) | : 9.02 % |
| Cumulative Load Factor (LF) | : 84.54 % | Cumulative Externally cause unavailability (XUF) | : 2.06 % |
| Cumulative Operating Factor (OF) | : 89.51 % | | |

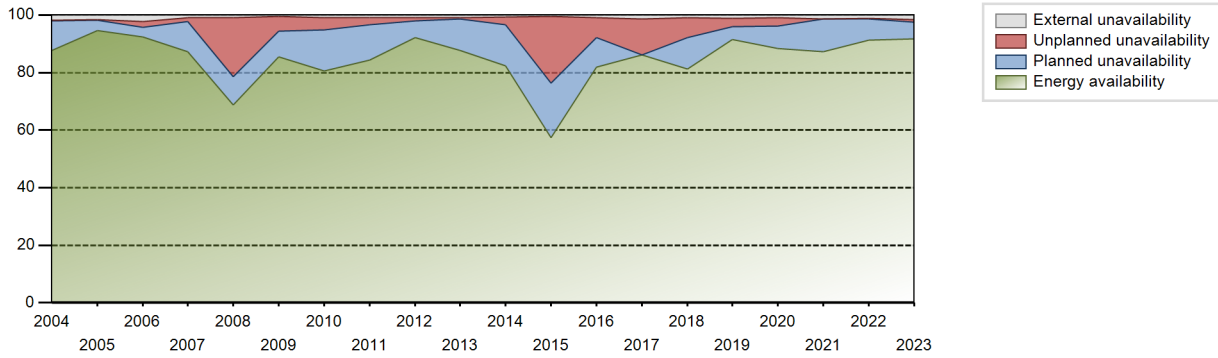
Electricity Production (net) [GWh]



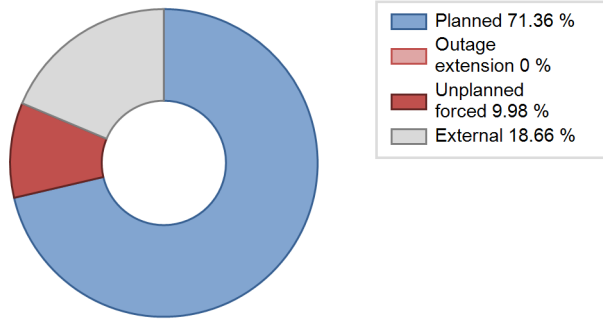
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 4155.51 | 4803 | 1068 | 95.52 | 95.52 | 86.55 | 96.82 | 4.15 | 4.14 | 0.35 | 0.00 |
| 1986 | 8069.60 | 7983 | 1060 | 88.36 | 88.36 | 86.90 | 91.13 | 3.39 | 3.11 | 8.54 | 0.00 |
| 1987 | 7038.90 | 7866 | 1063 | 77.86 | 77.86 | 75.59 | 89.79 | 2.25 | 1.79 | 20.35 | 0.00 |
| 1988 | 7462.87 | 7807 | 1068 | 80.40 | 80.40 | 79.55 | 88.88 | 4.38 | 3.69 | 15.91 | 0.00 |
| 1989 | 7367.20 | 7792 | 1118 | 85.77 | 85.77 | 75.16 | 88.95 | 0.79 | 0.68 | 13.55 | 0.00 |
| 1990 | 7942.08 | 8165 | 1150 | 80.07 | 91.32 | 78.84 | 93.21 | 1.97 | 1.84 | 6.84 | 11.26 |
| 1991 | 8665.07 | 8325 | 1155 | 85.61 | 87.47 | 85.64 | 95.03 | 0.00 | 0.00 | 12.53 | 1.86 |
| 1992 | 8176.17 | 7963 | 1197 | 81.18 | 89.45 | 77.76 | 90.65 | 0.50 | 0.45 | 10.10 | 8.27 |
| 1993 | 8457.86 | 8251 | 1158 | 83.40 | 93.17 | 83.38 | 94.19 | 1.43 | 1.35 | 5.48 | 9.77 |
| 1994 | 9228.82 | 8277 | 1158 | 90.92 | 93.42 | 90.98 | 94.49 | 0.65 | 0.61 | 5.97 | 2.50 |
| 1995 | 8930.86 | 8250 | 1158 | 88.19 | 92.77 | 88.04 | 94.18 | 1.84 | 1.74 | 5.49 | 4.58 |
| 1996 | 8819.19 | 8008 | 1158 | 86.71 | 89.09 | 86.70 | 91.17 | 1.42 | 1.29 | 9.63 | 2.38 |
| 1997 | 8955.24 | 8004 | 1158 | 89.94 | 89.94 | 88.04 | 91.12 | 1.20 | 1.09 | 8.97 | 0.00 |
| 1998 | 8960.71 | 8227 | 1158 | 93.75 | 93.92 | 88.33 | 93.92 | 0.50 | 0.48 | 5.60 | 0.17 |
| 1999 | 8825.52 | 8005 | 1155 | 90.95 | 91.14 | 87.08 | 91.38 | 1.57 | 1.46 | 7.41 | 0.18 |
| 2000 | 7933.87 | 8038 | 1155 | 87.71 | 94.92 | 78.07 | 91.51 | 0.69 | 0.66 | 4.43 | 7.21 |
| 2001 | 8182.42 | 7585 | 1155 | 81.77 | 86.23 | 80.87 | 86.59 | 0.06 | 0.05 | 13.71 | 4.46 |
| 2002 | 9079.36 | 8450 | 1158 | 91.22 | 94.96 | 89.50 | 96.46 | 1.85 | 1.79 | 3.24 | 3.74 |
| 2003 | 9100.31 | 8507 | 1155 | 89.93 | 89.93 | 89.94 | 97.11 | 0.02 | 1.50 | 8.57 | 0.00 |
| 2004 | 8973.49 | 7920 | 1185 | 87.68 | 89.39 | 87.69 | 90.16 | 0.42 | 0.38 | 10.23 | 1.71 |
| 2005 | 9868.82 | 8491 | 1190 | 94.57 | 96.23 | 94.73 | 96.93 | 0.08 | 0.08 | 3.68 | 1.66 |
| 2006 | 9600.51 | 8323 | 1170 | 92.39 | 94.61 | 92.23 | 95.01 | 2.12 | 2.05 | 3.34 | 2.22 |
| 2007 | 8992.59 | 7770 | 1170 | 87.26 | 88.24 | 87.74 | 88.70 | 0.11 | 1.19 | 10.57 | 0.98 |
| 2008 | 7109.80 | 6185 | 1170 | 68.84 | 69.71 | 69.18 | 70.41 | 2.42 | 20.59 | 9.70 | 0.86 |
| 2009 | 8815.50 | 7624 | 1170 | 85.49 | 86.01 | 86.01 | 87.03 | 5.03 | 5.11 | 8.88 | 0.52 |
| 2010 | 8320.23 | 7317 | 1170 | 80.61 | 81.44 | 81.18 | 83.53 | 5.16 | 4.43 | 14.13 | 0.83 |
| 2011 | 8691.28 | 7515 | 1170 | 84.34 | 85.36 | 84.80 | 85.79 | 2.71 | 2.37 | 12.27 | 1.01 |
| 2012 | 9520.47 | 8212 | 1170 | 92.14 | 93.00 | 92.64 | 93.49 | 1.32 | 1.25 | 5.75 | 0.86 |
| 2013 | 9021.75 | 7830 | 1170 | 87.63 | 88.60 | 88.02 | 89.38 | 0.53 | 0.47 | 10.94 | 0.96 |
| 2014 | 8471.77 | 7326 | 1170 | 82.30 | 83.08 | 82.66 | 83.63 | 2.08 | 2.59 | 14.33 | 0.78 |
| 2015 | 5662.11 | 5200 | 1167 | 57.40 | 57.84 | 55.39 | 59.36 | 3.65 | 23.22 | 18.94 | 0.44 |
| 2016 | 8439.79 | 7373 | 1167 | 81.89 | 82.79 | 82.33 | 83.94 | 7.71 | 6.92 | 10.29 | 0.89 |
| 2017 | 8842.13 | 7764 | 1167 | 86.18 | 87.48 | 86.49 | 88.63 | 12.48 | 12.47 | 0.05 | 1.29 |
| 2018 | 8357.50 | 7345 | 1159 | 81.28 | 82.12 | 82.08 | 83.85 | 7.86 | 7.01 | 10.87 | 0.84 |
| 2019 | 9465.61 | 8197 | 1172 | 91.53 | 92.65 | 92.20 | 93.57 | 2.68 | 3.02 | 4.33 | 1.12 |
| 2020 | 8864.05 | 7917 | 1172 | 88.29 | 89.12 | 86.10 | 90.13 | 3.36 | 3.10 | 7.78 | 0.83 |
| 2021 | 9022.92 | 7786 | 1172 | 87.17 | 88.52 | 87.89 | 88.88 | 0.07 | 0.06 | 11.42 | 1.35 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|------|------|
| 2022 | 9379.92 | 8153 | 1172 | 91.30 | 92.57 | 91.36 | 93.07 | 0.10 | 0.10 | 7.34 | 1.27 |
| 2023 | 9170.91 | 8223 | 1172 | 91.67 | 93.23 | 89.33 | 93.87 | 0.88 | 0.83 | 5.94 | 1.55 |

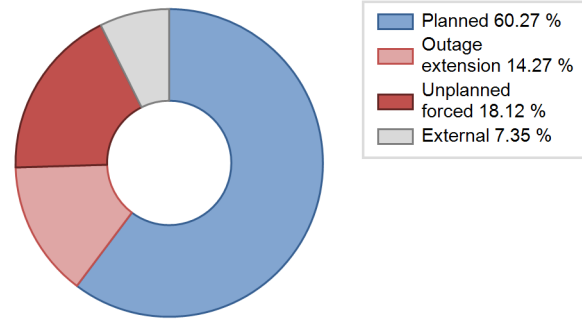
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 61 | | | 201 | |
| C. Inspection, maintenance or repair combined with refuelling | 477 | | | 675 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 1 | | |
| E. Testing of plant systems or components | | | | 3 | 2 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 7 | | |
| H. Nuclear regulatory requirements | | | | | 8 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 5 |
| L. Human factor related | | | | | 18 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 2 | |
| Z. Other | | | | | 0 | 1 |
| Subtotal | 477 | 61 | | 686 | 231 | 6 |
| Total | | 538 | | | 923 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 52 |
| 12. Reactor I&C Systems | | 59 |
| 13. Reactor Auxiliary Systems | | 3 |
| 15. Reactor Cooling Systems | | 9 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 5 |
| 31. Turbine and auxiliaries | | 19 |
| 32. Feedwater and Main Steam System | | 2 |
| 41. Main Generator Systems | 61 | 55 |
| 42. Electrical Power Supply Systems | | 24 |
| Total | 61 | 228 |

Highlights (2023)

Annual outage in July 2023.

2023 Operating Experience

SE-12

OSKARSHAMN-3

SWEDEN

Status at end of year : **Operational**
 Operator : OKG (OKG AKTIEBOLAG)
 Owner : OKG (OKG AKTIEBOLAG)
 Reactor Supplier : ABB ATOM (ABB ATOM (formerly ASEA-ATOM))
 Turbine Supplier : STAL (STAL-LAVAL)



Reactor Unit Details

Reactor type and model : BWR / AA-IV, BWR-3000
 Thermal power : 3900 MWth
 Gross electrical power : 1450 MWe
 Reference unit power (net) : 1400 MWe

Key Dates

Construction Date : 1980-05-01
 Grid Date : 1985-03-03
 Commercial Date : 1985-08-15
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 3
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 20
 Average discharge burnup [MWd/t] : 32000
 Active core diameter [m] : 4.6
 Active core height/length [m] : 3.68
 Number of fissile fuel assemblies/bundles : 700
 Fuel linear heat generation rate [kW/m] : 14.0
 Number of control rod assemblies : 169
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 7
 Reactor outlet temperature [°C] : 288
 Number of SG : NA
 Containment type : Single
 Containment design pressure [MPa] : 6

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.7
 Output voltage [kV] : 20.5
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 4

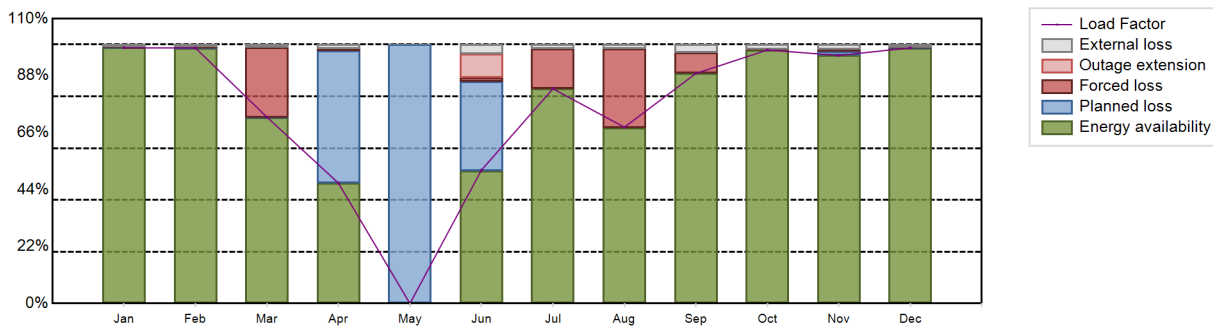
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9177.85 GW(e).h
 Energy Availability Factor (EAF) : 74.79 %
 Unit Capability Factor (UCF) : 76.39 %
 Load Factor (LF) : 74.84 %
 Operating Factor (OF) : 80.92 %
 Forced Loss Rate (FLR) : 8.62 %
 Unplanned Capability Loss Factor (UCL) : 7.96 %
 Planned Unavailability Factor (PUF) : 15.65 %
 Externally cause unavailability (XUF) : 1.6 %
 Total off-line time : 1671 hours

Annual Summary

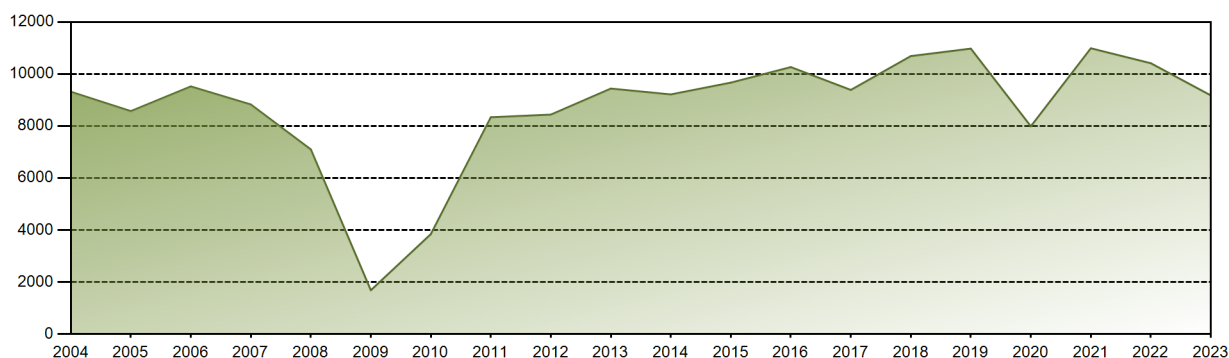


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|---------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|---------|---------|
| GW(e)-h | 1028.64 | 928.42 | 748.91 | 468.56 | 0.00 | 519.23 | 863.85 | 709.24 | 895.60 | 1021.05 | 965.84 | 1028.50 | 9177.85 |
| EAF [%] | 98.76 | 98.68 | 71.86 | 46.48 | 0.00 | 51.31 | 82.93 | 67.92 | 88.85 | 97.90 | 95.82 | 98.74 | 74.79 |
| UCF [%] | 99.69 | 99.66 | 72.91 | 48.01 | 0.00 | 54.95 | 84.64 | 69.44 | 91.88 | 99.80 | 97.72 | 99.75 | 76.39 |
| LF [%] | 98.76 | 98.68 | 72.00 | 46.48 | 0.00 | 51.51 | 82.93 | 68.09 | 88.85 | 97.90 | 95.82 | 98.74 | 74.84 |
| OF [%] | 100.00 | 100.00 | 77.52 | 48.89 | 0.00 | 60.97 | 100.00 | 85.08 | 100.00 | 100.00 | 100.00 | 100.00 | 80.92 |
| FLR [%] | 0.31 | 0.34 | 27.09 | 1.79 | 0.00 | 2.78 | 15.36 | 30.56 | 8.12 | 0.20 | 0.66 | 0.25 | 8.62 |
| UCL [%] | 0.31 | 0.34 | 27.09 | 0.88 | 0.00 | 10.74 | 15.36 | 30.56 | 8.12 | 0.20 | 0.65 | 0.25 | 7.96 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 51.11 | 100.00 | 34.31 | 0.00 | 0.00 | 0.00 | 0.00 | 1.63 | 0.00 | 15.65 |
| XUF [%] | 0.94 | 0.98 | 1.05 | 1.53 | 0.00 | 3.65 | 1.71 | 1.53 | 3.03 | 1.91 | 1.90 | 1.01 | 1.60 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 325618.82 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.92 % |
| Cumulative Energy Availability Factor (EAF) | : 80.98 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.56 % |
| Cumulative Unit Capability Factor (UCF) | : 82.26 % | Cumulative Planned Unavailability Factor (PUF) | : 9.18 % |
| Cumulative Load Factor (LF) | : 78.4 % | Cumulative Externally cause unavailability (XUF) | : 1.28 % |
| Cumulative Operating Factor (OF) | : 85.04 % | | |

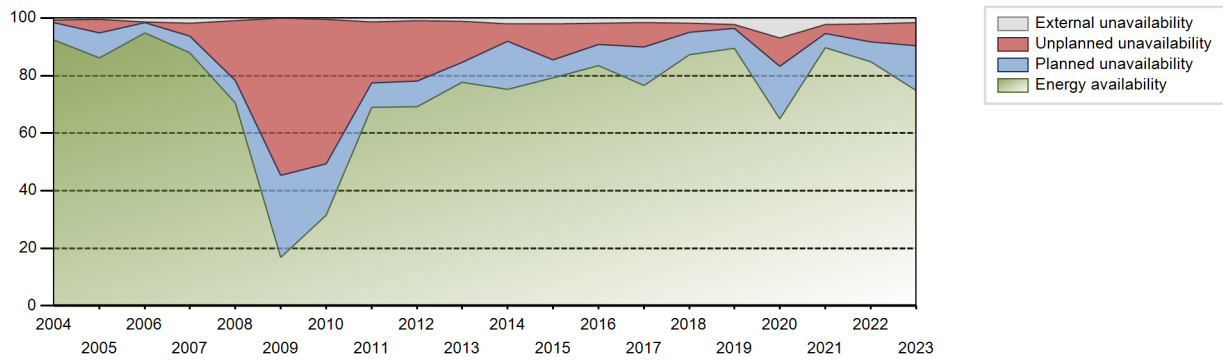
Electricity Production (net) [GWh]



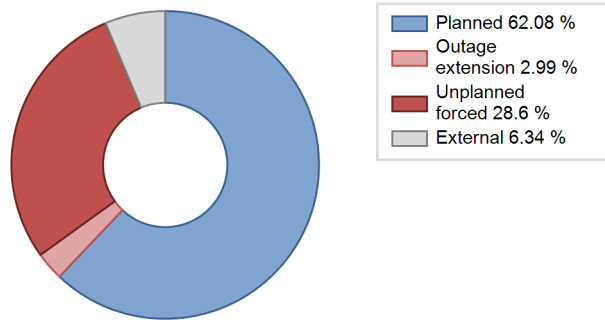
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 3848.48 | 4706 | 1055 | 92.98 | 92.98 | 79.25 | 93.38 | 7.02 | 7.02 | 0.00 | 0.00 |
| 1986 | 8386.93 | 8111 | 1060 | 91.91 | 91.91 | 90.39 | 92.59 | 2.32 | 2.18 | 5.91 | 0.00 |
| 1987 | 7057.96 | 7988 | 1065 | 89.40 | 89.64 | 75.65 | 91.19 | 4.29 | 4.02 | 6.34 | 0.24 |
| 1988 | 7311.93 | 7457 | 1060 | 83.60 | 83.89 | 78.44 | 84.89 | 9.70 | 9.01 | 7.11 | 0.29 |
| 1989 | 7788.21 | 8241 | 1035 | 92.77 | 93.12 | 84.38 | 94.08 | 0.86 | 0.81 | 6.07 | 0.36 |
| 1990 | 7640.22 | 7781 | 1060 | 83.25 | 84.13 | 83.16 | 88.82 | 4.65 | 4.10 | 11.76 | 0.88 |
| 1991 | 8935.78 | 8183 | 1160 | 90.92 | 91.57 | 87.94 | 93.41 | 1.13 | 1.05 | 7.38 | 0.65 |
| 1992 | 8270.64 | 7903 | 1160 | 89.45 | 90.08 | 81.17 | 89.97 | 0.06 | 0.06 | 9.86 | 0.63 |
| 1993 | 8339.49 | 8026 | 1160 | 90.86 | 91.71 | 82.07 | 91.62 | 1.83 | 1.71 | 6.58 | 0.85 |
| 1994 | 8480.44 | 7878 | 1160 | 88.39 | 89.09 | 83.46 | 89.93 | 0.75 | 0.67 | 10.24 | 0.70 |
| 1995 | 8828.15 | 7957 | 1160 | 87.55 | 89.79 | 86.88 | 90.83 | 2.60 | 2.39 | 7.82 | 2.24 |
| 1996 | 8518.40 | 7543 | 1153 | 84.55 | 85.14 | 84.10 | 85.86 | 1.62 | 1.40 | 13.46 | 0.59 |
| 1997 | 8970.42 | 8042 | 1155 | 89.79 | 90.95 | 88.65 | 91.79 | 0.50 | 0.45 | 8.59 | 1.16 |
| 1998 | 8032.25 | 7914 | 1155 | 88.68 | 89.33 | 79.39 | 90.34 | 2.89 | 2.66 | 8.01 | 0.65 |
| 1999 | 8516.73 | 7850 | 1155 | 88.91 | 89.72 | 84.17 | 89.60 | 0.34 | 0.30 | 9.98 | 0.81 |
| 2000 | 7219.13 | 8075 | 1155 | 91.20 | 91.20 | 71.16 | 91.93 | 4.10 | 3.90 | 4.91 | 0.00 |
| 2001 | 9051.96 | 8170 | 1155 | 91.80 | 92.56 | 89.47 | 93.26 | 2.74 | 2.61 | 4.83 | 0.76 |
| 2002 | 8883.98 | 8140 | 1155 | 92.24 | 92.24 | 87.80 | 92.91 | 2.05 | 1.93 | 5.82 | 0.00 |
| 2003 | 7678.01 | 6871 | 1155 | 76.19 | 77.96 | 75.89 | 78.44 | 16.30 | 15.52 | 6.52 | 1.77 |
| 2004 | 9318.51 | 8236 | 1149 | 92.44 | 93.04 | 92.32 | 93.75 | 1.12 | 1.05 | 5.90 | 0.61 |
| 2005 | 8573.43 | 7671 | 1149 | 86.17 | 86.72 | 85.18 | 87.57 | 5.08 | 4.65 | 8.64 | 0.55 |
| 2006 | 9522.49 | 8467 | 1149 | 94.94 | 96.29 | 94.60 | 96.64 | 0.18 | 0.29 | 3.42 | 1.36 |
| 2007 | 8829.23 | 7965 | 1150 | 87.82 | 89.56 | 87.63 | 90.91 | 4.57 | 4.50 | 5.94 | 1.75 |
| 2008 | 7100.89 | 6424 | 1152 | 70.43 | 71.36 | 70.23 | 73.13 | 3.22 | 20.73 | 7.91 | 0.93 |
| 2009 | 1684.68 | 1795 | 1152 | 16.76 | 16.82 | 16.70 | 20.49 | 5.39 | 54.69 | 28.48 | 0.06 |
| 2010 | 3841.75 | 4783 | 1400 | 31.57 | 31.96 | 31.33 | 54.60 | 48.60 | 50.26 | 17.78 | 0.39 |
| 2011 | 8337.26 | 7313 | 1400 | 69.08 | 70.41 | 67.98 | 83.48 | 16.29 | 21.24 | 8.35 | 1.33 |
| 2012 | 8438.86 | 6571 | 1400 | 69.15 | 70.08 | 68.62 | 74.81 | 17.19 | 21.04 | 8.88 | 0.93 |
| 2013 | 9439.44 | 7186 | 1400 | 77.59 | 78.85 | 76.97 | 82.03 | 14.89 | 14.07 | 7.08 | 1.26 |
| 2014 | 9215.46 | 7083 | 1400 | 75.14 | 77.29 | 75.14 | 80.86 | 3.78 | 5.98 | 16.73 | 2.15 |
| 2015 | 9668.25 | 7480 | 1400 | 79.13 | 81.16 | 78.83 | 85.39 | 13.23 | 12.48 | 6.37 | 2.03 |
| 2016 | 10265.41 | 7736 | 1400 | 83.47 | 85.27 | 83.47 | 88.07 | 6.41 | 7.33 | 7.40 | 1.80 |
| 2017 | 9387.81 | 6996 | 1400 | 76.55 | 78.20 | 76.55 | 79.86 | 5.30 | 8.37 | 13.44 | 1.65 |
| 2018 | 10688.89 | 7913 | 1400 | 87.32 | 89.26 | 87.16 | 90.33 | 2.79 | 3.00 | 7.75 | 1.93 |
| 2019 | 10976.04 | 8135 | 1400 | 89.50 | 91.78 | 89.50 | 92.87 | 0.77 | 1.35 | 6.86 | 2.29 |
| 2020 | 7988.94 | 6081 | 1400 | 64.97 | 71.99 | 64.97 | 69.24 | 4.23 | 9.78 | 18.23 | 7.02 |
| 2021 | 10989.44 | 8118 | 1400 | 89.63 | 91.83 | 89.62 | 92.68 | 0.25 | 3.17 | 5.01 | 2.20 |

| | | | | | | | | | | | |
|------|----------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 10414.56 | 7785 | 1400 | 84.91 | 86.98 | 84.92 | 88.87 | 6.60 | 6.15 | 6.86 | 2.08 |
| 2023 | 9177.85 | 7089 | 1400 | 74.79 | 76.39 | 74.84 | 80.92 | 8.62 | 7.96 | 15.65 | 1.60 |

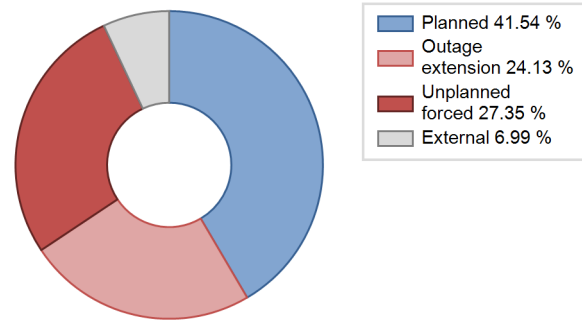
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|--|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 199 | | | 470 | |
| C. Inspection, maintenance or repair combined with refuelling | 1327 | | | 654 | 17 | |
| D. Inspection, maintenance or repair without refuelling | | | | 22 | 0 | |
| E. Testing of plant systems or components | | | | 1 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 57 | | |
| H. Nuclear regulatory requirements | | | | | 31 | |
| L. Human factor related | | | | | 18 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant , spare part delivery problems etc.) | | | | | 15 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | 66 | | | 2 | |
| Z. Other | | 62 | | | 16 | 13 |
| Subtotal | 1327 | 327 | | 734 | 569 | 13 |
| Total | | 1654 | | | 1316 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 168 | 121 |
| 12. Reactor I&C Systems | | 10 |
| 13. Reactor Auxiliary Systems | | 14 |
| 14. Safety Systems | | 21 |
| 15. Reactor Cooling Systems | | 21 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 226 |
| 32. Feedwater and Main Steam System | 31 | 71 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 2 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 16 |
| 42. Electrical Power Supply Systems | | 8 |
| Total | 199 | 513 |

2023 Operating Experience

SE-7

RINGHALS-3

SWEDEN

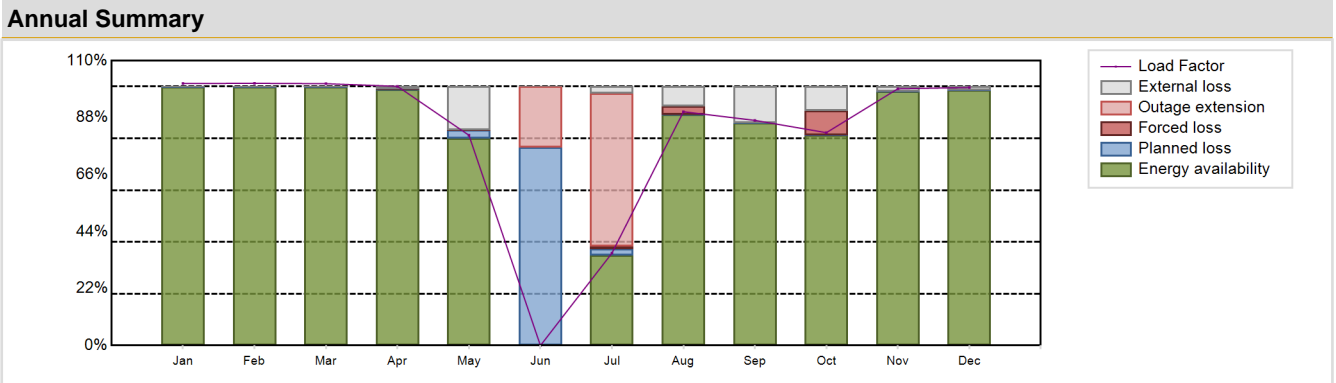
Status at end of year : **Operational**
 Operator : RAB (Ringhals AB)
 Owner : RAB (Ringhals AB)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : STAL (STAL-LAVAL)



| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP | Construction Date | : 1972-09-01 |
| Thermal power | : 3135 MWth | Grid Date | : 1980-09-07 |
| Gross electrical power | : 1128 MWe | Commercial Date | : 1981-09-09 |
| Reference unit power (net) | : 1081 MWe | Age at end of year | : 43 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.51 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 322 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 4.65 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 2 |
| Part of the core refuelled [%] | : 25 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 46000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.75 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.3 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 24 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|------------------|--|--------------|
| Net Energy Production | : 7694.6 GW(e).h | Forced Loss Rate (FLR) | : 1.35 % |
| Energy Availability Factor (EAF) | : 80.47 % | Unplanned Capability Loss Factor (UCL) | : 8.14 % |
| Unit Capability Factor (UCF) | : 85.06 % | Planned Unavailability Factor (PUF) | : 6.8 % |
| Load Factor (LF) | : 81.47 % | Externally cause unavailability (XUF) | : 4.59 % |
| Operating Factor (OF) | : 85.65 % | Total off-line time | : 1257 hours |

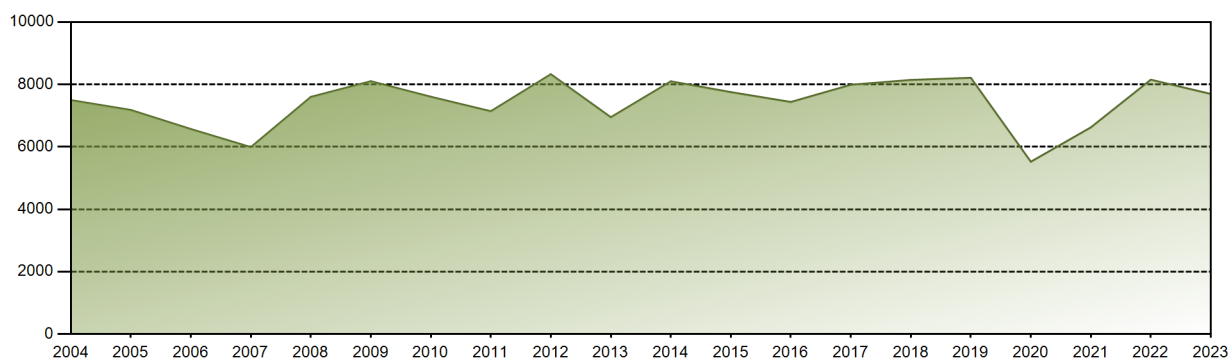


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 808.54 | 730.82 | 808.09 | 774.05 | 648.94 | 0.00 | 286.86 | 726.20 | 676.73 | 661.22 | 771.82 | 801.33 | 7694.60 |
| EAF [%] | 99.91 | 99.84 | 99.96 | 98.98 | 80.06 | 0.00 | 34.78 | 89.28 | 85.93 | 81.22 | 98.15 | 98.61 | 80.47 |
| UCF [%] | 99.99 | 99.99 | 99.99 | 99.91 | 96.77 | 0.00 | 37.30 | 96.76 | 99.98 | 90.61 | 99.98 | 99.98 | 85.06 |
| LF [%] | 101.19 | 101.26 | 101.13 | 100.10 | 81.21 | 0.00 | 35.67 | 90.29 | 86.95 | 82.21 | 99.16 | 99.64 | 81.47 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 97.18 | 0.00 | 41.40 | 100.00 | 100.00 | 89.25 | 100.00 | 100.00 | 85.65 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.08 | 0.03 | 0.00 | 2.69 | 3.22 | 0.00 | 9.36 | 0.00 | 0.00 | 1.35 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.08 | 0.03 | 23.50 | 60.22 | 3.22 | 0.00 | 9.36 | 0.00 | 0.00 | 8.14 |
| PUF [%] | 0.01 | 0.01 | 0.01 | 0.01 | 3.20 | 76.50 | 2.49 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 6.80 |
| XUF [%] | 0.08 | 0.15 | 0.03 | 0.93 | 16.71 | 0.00 | 2.51 | 7.48 | 14.05 | 9.39 | 1.84 | 1.36 | 4.59 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 280487.03 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.88 % |
| Cumulative Energy Availability Factor (EAF) | : 78.52 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.77 % |
| Cumulative Unit Capability Factor (UCF) | : 80.56 % | Cumulative Planned Unavailability Factor (PUF) | : 11.67 % |
| Cumulative Load Factor (LF) | : 77.07 % | Cumulative Externally cause unavailability (XUF) | : 2.03 % |
| Cumulative Operating Factor (OF) | : 84.44 % | | |

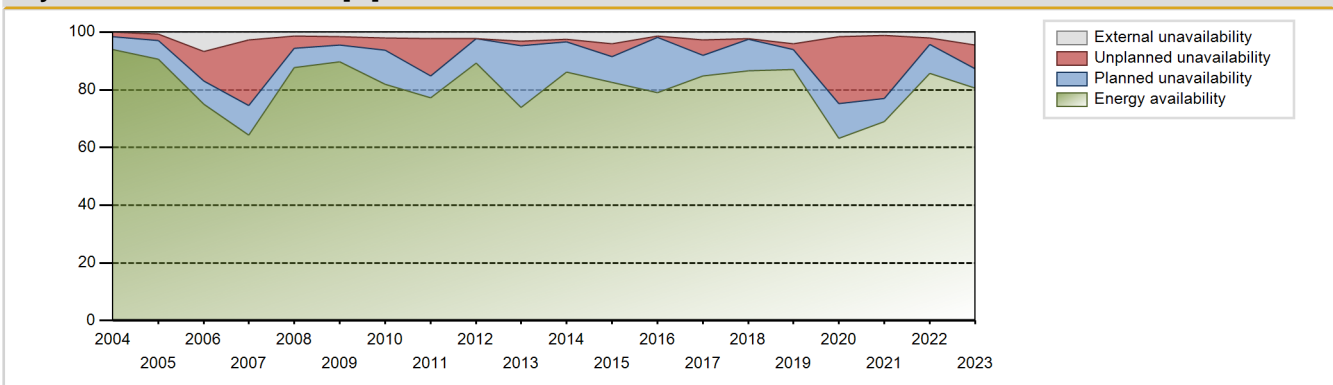
Electricity Production (net) [GWh]



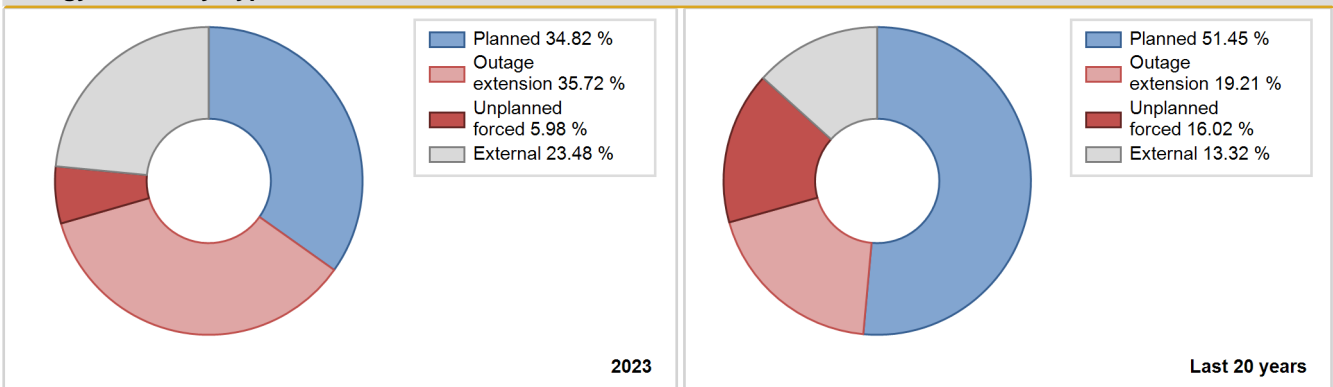
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 2859.20 | 4560 | 920 | 26.75 | 26.75 | 26.77 | 29.51 | 73.25 | 73.25 | 0.00 | 0.00 |
| 1982 | 1251.60 | 3680 | 915 | 15.62 | 15.62 | 15.61 | 42.01 | 73.78 | 43.95 | 40.43 | 0.00 |
| 1983 | 2909.90 | 5886 | 867 | 38.25 | 38.25 | 38.24 | 67.19 | 46.42 | 33.13 | 28.63 | 0.00 |
| 1984 | 5346.56 | 6450 | 915 | 72.44 | 72.44 | 66.52 | 73.43 | 15.69 | 13.48 | 14.07 | 0.00 |
| 1985 | 6090.25 | 7580 | 915 | 84.79 | 84.79 | 75.98 | 86.53 | 1.48 | 1.27 | 13.94 | 0.00 |
| 1986 | 6233.87 | 7026 | 915 | 78.79 | 78.79 | 77.77 | 80.21 | 2.40 | 1.94 | 19.28 | 0.00 |
| 1987 | 6169.21 | 7485 | 915 | 83.09 | 83.09 | 76.97 | 85.45 | 5.67 | 4.99 | 11.92 | 0.00 |
| 1988 | 6151.17 | 7645 | 915 | 77.14 | 77.14 | 76.53 | 87.03 | 8.53 | 7.19 | 15.67 | 0.00 |
| 1989 | 5829.68 | 7757 | 915 | 82.60 | 82.60 | 72.73 | 88.55 | 10.37 | 9.56 | 7.84 | 0.00 |
| 1990 | 5871.27 | 7855 | 915 | 74.05 | 74.18 | 73.25 | 89.67 | 18.98 | 17.38 | 8.44 | 0.13 |
| 1991 | 5923.60 | 8007 | 915 | 75.66 | 75.66 | 73.90 | 91.40 | 14.25 | 12.57 | 11.77 | 0.00 |
| 1992 | 5622.12 | 7941 | 915 | 82.27 | 82.33 | 69.95 | 90.40 | 3.55 | 3.03 | 14.64 | 0.06 |
| 1993 | 6685.76 | 7964 | 915 | 89.81 | 89.81 | 83.41 | 90.91 | 2.84 | 2.62 | 7.57 | 0.00 |
| 1994 | 6873.37 | 8097 | 918 | 86.13 | 86.13 | 85.47 | 92.43 | 0.58 | 0.50 | 13.37 | 0.00 |
| 1995 | 4873.56 | 6040 | 918 | 60.66 | 60.66 | 60.60 | 68.95 | 14.30 | 10.12 | 29.22 | 0.00 |
| 1996 | 6816.76 | 8166 | 910 | 87.31 | 92.49 | 85.28 | 92.96 | 0.60 | 0.56 | 6.95 | 5.18 |
| 1997 | 6581.42 | 8107 | 910 | 81.73 | 85.50 | 82.55 | 92.54 | 8.04 | 7.53 | 6.97 | 3.77 |
| 1998 | 6382.65 | 8008 | 915 | 81.30 | 90.17 | 79.63 | 91.42 | 2.57 | 2.38 | 7.45 | 8.87 |
| 1999 | 6975.98 | 7899 | 911 | 88.02 | 90.01 | 87.41 | 90.17 | 0.37 | 0.34 | 9.65 | 1.99 |
| 2000 | 6165.84 | 7966 | 911 | 89.53 | 92.26 | 77.05 | 90.69 | 0.69 | 0.65 | 7.09 | 2.73 |
| 2001 | 6285.26 | 7942 | 911 | 79.44 | 88.58 | 78.76 | 90.66 | 2.41 | 2.19 | 9.23 | 9.15 |
| 2002 | 6890.61 | 7930 | 915 | 88.77 | 90.83 | 85.97 | 90.53 | 0.85 | 0.78 | 8.39 | 2.06 |
| 2003 | 6714.60 | 7475 | 915 | 84.43 | 85.29 | 83.77 | 85.33 | 0.41 | 0.35 | 14.37 | 0.86 |
| 2004 | 7497.90 | 8295 | 915 | 93.86 | 93.98 | 93.29 | 94.43 | 1.65 | 1.58 | 4.44 | 0.11 |
| 2005 | 7181.56 | 8075 | 915 | 90.51 | 91.19 | 89.60 | 92.18 | 1.20 | 2.19 | 6.63 | 0.68 |
| 2006 | 6570.84 | 7249 | 1045 | 74.97 | 81.77 | 76.42 | 82.75 | 8.85 | 10.06 | 8.16 | 6.80 |
| 2007 | 5990.80 | 6565 | 1045 | 64.27 | 67.04 | 65.44 | 74.94 | 12.79 | 22.60 | 10.36 | 2.78 |
| 2008 | 7599.80 | 7980 | 985 | 87.79 | 89.22 | 87.84 | 90.85 | 3.48 | 4.26 | 6.52 | 1.43 |
| 2009 | 8102.89 | 8093 | 1044 | 89.73 | 91.37 | 89.85 | 92.39 | 2.34 | 2.81 | 5.82 | 1.64 |
| 2010 | 7605.45 | 7590 | 1051 | 81.87 | 84.02 | 82.61 | 86.64 | 1.60 | 4.14 | 11.84 | 2.16 |
| 2011 | 7141.61 | 7032 | 1057 | 77.21 | 79.48 | 77.13 | 80.27 | 12.93 | 12.98 | 7.54 | 2.28 |
| 2012 | 8327.82 | 8088 | 1064 | 89.17 | 91.41 | 89.59 | 92.08 | 0.10 | 0.12 | 8.47 | 2.24 |
| 2013 | 6949.96 | 6852 | 1064 | 73.84 | 76.99 | 74.57 | 78.22 | 1.74 | 1.59 | 21.41 | 3.15 |
| 2014 | 8099.92 | 7887 | 1062 | 86.23 | 88.68 | 86.97 | 90.03 | 1.09 | 0.98 | 10.35 | 2.44 |
| 2015 | 7753.27 | 7853 | 1063 | 82.47 | 86.55 | 83.26 | 89.65 | 2.73 | 4.47 | 8.98 | 4.08 |
| 2016 | 7437.54 | 7106 | 1065 | 78.91 | 80.36 | 79.64 | 80.90 | 0.16 | 0.44 | 19.20 | 1.45 |
| 2017 | 7988.55 | 8027 | 1065 | 84.88 | 87.54 | 85.63 | 91.63 | 5.76 | 5.35 | 7.11 | 2.66 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|-------|-------|------|
| 2018 | 8144.41 | 7821 | 1062 | 86.48 | 88.80 | 87.54 | 89.28 | 0.09 | 0.08 | 11.12 | 2.32 |
| 2019 | 8212.36 | 8107 | 1062 | 87.05 | 91.10 | 88.28 | 92.55 | 2.20 | 2.05 | 6.85 | 4.05 |
| 2020 | 5522.53 | 5452 | 1072 | 63.08 | 64.61 | 58.97 | 62.07 | 6.80 | 23.32 | 12.07 | 1.53 |
| 2021 | 6623.06 | 6214 | 1072 | 69.06 | 70.28 | 70.53 | 70.94 | 1.04 | 21.80 | 7.92 | 1.23 |
| 2022 | 8151.85 | 7780 | 1074 | 85.63 | 87.70 | 86.65 | 88.81 | 2.40 | 2.16 | 10.14 | 2.08 |
| 2023 | 7694.60 | 7503 | 1081 | 80.47 | 85.06 | 81.47 | 85.65 | 1.35 | 8.14 | 6.80 | 4.59 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 622 | | | 363 | |
| C. Inspection, maintenance or repair combined with refuelling | 576 | | | 753 | 15 | |
| D. Inspection, maintenance or repair without refuelling | | | | 179 | | |
| E. Testing of plant systems or components | | | | 4 | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 12 |
| L. Human factor related | | 45 | | | 14 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 13 | |
| Subtotal | 576 | 667 | | 936 | 406 | 15 |
| Total | | 1243 | | | 1357 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 19 | 27 |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | 20 | 8 |
| 14. Safety Systems | 217 | 54 |
| 15. Reactor Cooling Systems | 230 | 43 |
| 16. Steam generation systems | | 107 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 30 |
| 31. Turbine and auxiliaries | | 33 |
| 32. Feedwater and Main Steam System | | 26 |
| 34. Miscellaneous Systems | 57 | 1 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | 20 | 14 |
| 42. Electrical Power Supply Systems | 58 | 26 |
| Total | 621 | 376 |

2023 Operating Experience

SE-10

RINGHALS-4

SWEDEN

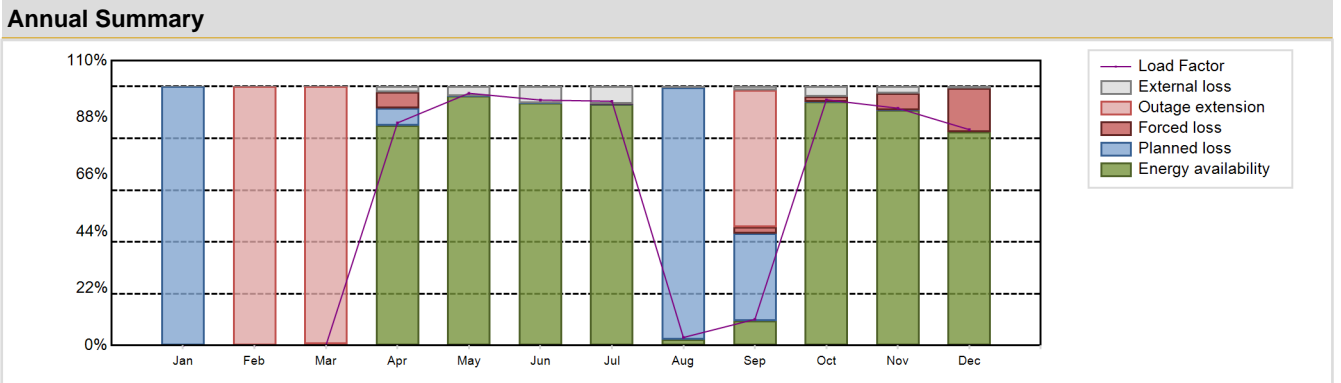
Status at end of year : **Operational**
 Operator : RAB (Ringhals AB)
 Owner : RAB (Ringhals AB)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : STAL (STAL-LAVAL)



| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP | Construction Date | : 1973-11-01 |
| Thermal power | : 3300 MWth | Grid Date | : 1982-06-23 |
| Gross electrical power | : 1178 MWe | Commercial Date | : 1983-11-21 |
| Reference unit power (net) | : 1130 MWe | Age at end of year | : 41 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.51 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 322 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 4.65 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 2 |
| Part of the core refuelled [%] | : 25 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 46000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.75 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.3 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 24 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 5436.26 GW(e).h | Forced Loss Rate (FLR) | : 4.79 % |
| Energy Availability Factor (EAF) | : 54.24 % | Unplanned Capability Loss Factor (UCL) | : 23.3 % |
| Unit Capability Factor (UCF) | : 56.54 % | Planned Unavailability Factor (PUF) | : 20.16 % |
| Load Factor (LF) | : 54.92 % | Externally cause unavailability (XUF) | : 2.3 % |
| Operating Factor (OF) | : 59.32 % | Total off-line time | : 3564 hours |

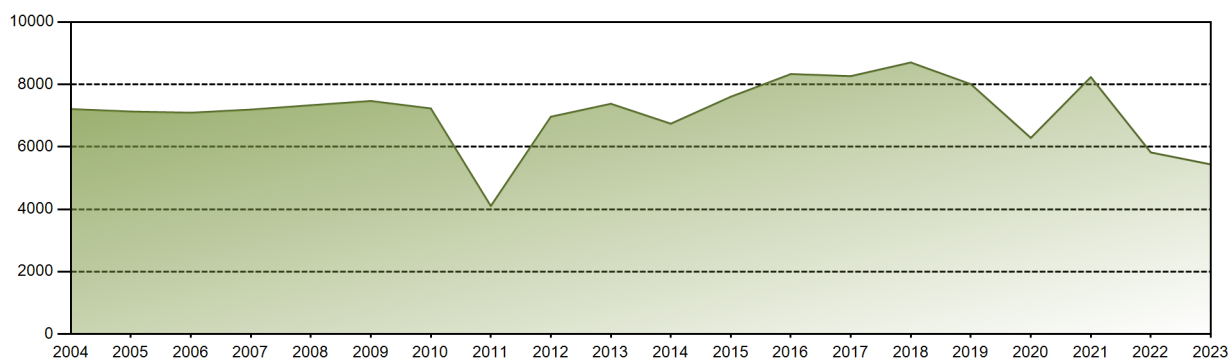


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|--------|--------|--------|--------|-------|-------|--------|--------|--------|---------|
| GW(e)-h | 0.00 | 0.00 | 0.61 | 699.51 | 819.00 | 771.32 | 793.05 | 26.09 | 82.22 | 797.77 | 745.72 | 700.97 | 5436.26 |
| EAF [%] | 0.00 | 0.00 | 0.07 | 84.91 | 96.35 | 93.74 | 93.27 | 2.29 | 9.43 | 94.09 | 90.86 | 82.60 | 54.24 |
| UCF [%] | 0.00 | 0.00 | 0.07 | 87.12 | 99.97 | 99.98 | 99.77 | 2.72 | 10.83 | 98.00 | 93.46 | 83.17 | 56.54 |
| LF [%] | 0.00 | 0.00 | 0.07 | 85.98 | 97.42 | 94.80 | 94.33 | 3.10 | 10.11 | 94.89 | 91.66 | 83.38 | 54.92 |
| OF [%] | 0.00 | 0.00 | 0.54 | 100.00 | 100.00 | 100.00 | 100.00 | 3.63 | 20.83 | 100.00 | 93.61 | 89.92 | 59.32 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 6.46 | 0.00 | 0.00 | 0.22 | 0.00 | 18.10 | 1.96 | 6.52 | 16.83 | 4.79 |
| UCL [%] | 0.00 | 100.00 | 99.46 | 6.01 | 0.00 | 0.00 | 0.22 | 0.00 | 55.22 | 1.96 | 6.52 | 16.83 | 23.30 |
| PUF [%] | 100.00 | 0.00 | 0.47 | 6.87 | 0.03 | 0.02 | 0.01 | 97.28 | 33.96 | 0.04 | 0.02 | 0.00 | 20.16 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 2.20 | 3.62 | 6.24 | 6.50 | 0.43 | 1.40 | 3.91 | 2.60 | 0.57 | 2.30 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 269532.21 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.69 % |
| Cumulative Energy Availability Factor (EAF) | : 81.51 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.67 % |
| Cumulative Unit Capability Factor (UCF) | : 83.76 % | Cumulative Planned Unavailability Factor (PUF) | : 10.57 % |
| Cumulative Load Factor (LF) | : 78.92 % | Cumulative Externally cause unavailability (XUF) | : 2.25 % |
| Cumulative Operating Factor (OF) | : 85.83 % | | |

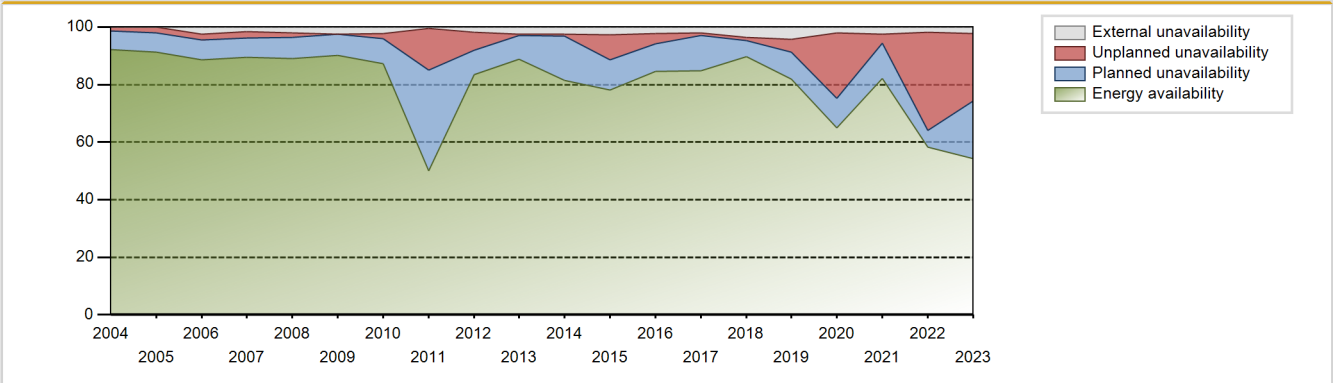
Electricity Production (net) [GWh]



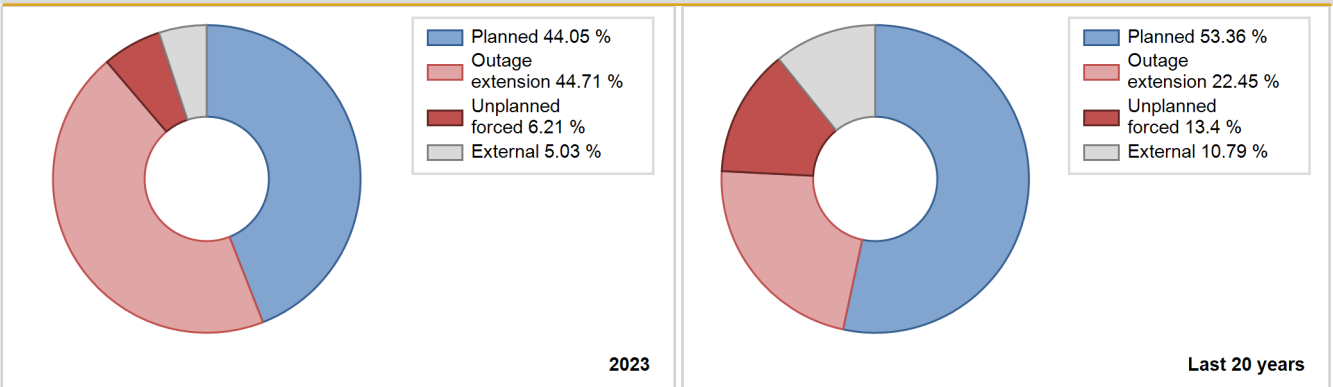
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 2653.10 | 4122 | 915 | 56.37 | 56.37 | 56.38 | 74.60 | 24.02 | 17.82 | 25.81 | 0.00 |
| 1984 | 5987.71 | 7517 | 915 | 82.17 | 82.26 | 74.50 | 85.58 | 9.40 | 8.53 | 9.21 | 0.09 |
| 1985 | 5923.72 | 7755 | 915 | 87.92 | 87.92 | 73.90 | 88.53 | 1.75 | 1.56 | 10.51 | 0.00 |
| 1986 | 5619.26 | 6839 | 915 | 70.67 | 70.67 | 70.11 | 78.07 | 9.98 | 7.83 | 21.50 | 0.00 |
| 1987 | 5665.94 | 7827 | 915 | 88.21 | 88.21 | 70.69 | 89.35 | 1.44 | 1.29 | 10.50 | 0.00 |
| 1988 | 6641.73 | 7945 | 915 | 83.43 | 83.43 | 82.64 | 90.45 | 0.68 | 0.57 | 16.00 | 0.00 |
| 1989 | 5536.82 | 7624 | 915 | 85.79 | 85.79 | 69.08 | 87.03 | 6.32 | 5.79 | 8.42 | 0.00 |
| 1990 | 6467.30 | 8080 | 915 | 89.11 | 89.11 | 80.69 | 92.24 | 0.88 | 0.79 | 10.10 | 0.00 |
| 1991 | 6916.15 | 8041 | 915 | 85.85 | 85.85 | 86.29 | 91.79 | 0.64 | 0.55 | 13.59 | 0.00 |
| 1992 | 6432.41 | 8156 | 915 | 90.03 | 90.09 | 80.03 | 92.85 | 1.18 | 1.08 | 8.83 | 0.06 |
| 1993 | 6342.34 | 7906 | 915 | 88.75 | 88.75 | 79.13 | 90.25 | 2.67 | 2.44 | 8.81 | 0.00 |
| 1994 | 6234.70 | 7476 | 914 | 84.84 | 84.84 | 77.87 | 85.34 | 7.04 | 6.43 | 8.74 | 0.00 |
| 1995 | 6251.70 | 7684 | 912 | 80.60 | 88.39 | 78.25 | 87.72 | 4.14 | 3.81 | 7.79 | 7.79 |
| 1996 | 6426.77 | 8067 | 912 | 79.62 | 91.83 | 80.22 | 91.84 | 0.63 | 0.58 | 7.58 | 12.21 |
| 1997 | 6372.26 | 7665 | 912 | 78.83 | 87.03 | 79.75 | 87.49 | 1.27 | 2.53 | 10.44 | 8.20 |
| 1998 | 6809.80 | 8146 | 915 | 86.52 | 92.52 | 84.96 | 92.99 | 0.71 | 0.66 | 6.82 | 6.00 |
| 1999 | 6986.83 | 8042 | 907 | 88.63 | 91.73 | 87.94 | 91.80 | 1.42 | 1.33 | 6.94 | 3.11 |
| 2000 | 4060.71 | 5898 | 907 | 63.43 | 66.52 | 50.97 | 67.14 | 25.24 | 22.46 | 11.01 | 3.10 |
| 2001 | 6623.98 | 7758 | 909 | 86.51 | 88.38 | 83.19 | 88.56 | 3.12 | 2.85 | 8.77 | 1.88 |
| 2002 | 5942.20 | 7056 | 915 | 75.53 | 80.25 | 74.13 | 80.55 | 5.38 | 4.57 | 15.19 | 4.72 |
| 2003 | 6996.51 | 7843 | 915 | 88.86 | 89.19 | 87.29 | 89.53 | 0.68 | 3.47 | 7.34 | 0.33 |
| 2004 | 7209.61 | 8092 | 915 | 92.10 | 92.10 | 89.70 | 92.12 | 1.15 | 1.45 | 6.45 | 0.00 |
| 2005 | 7129.78 | 8073 | 915 | 91.36 | 91.46 | 88.95 | 92.16 | 0.30 | 1.97 | 6.57 | 0.11 |
| 2006 | 7092.37 | 8054 | 907 | 88.68 | 91.15 | 89.26 | 91.94 | 1.55 | 2.13 | 6.72 | 2.48 |
| 2007 | 7192.87 | 8126 | 907 | 89.43 | 91.03 | 90.53 | 92.76 | 1.45 | 2.26 | 6.71 | 1.60 |
| 2008 | 7331.95 | 8046 | 935 | 88.97 | 91.12 | 89.27 | 91.60 | 0.87 | 1.43 | 7.46 | 2.15 |
| 2009 | 7467.66 | 8165 | 936 | 90.24 | 92.81 | 91.08 | 93.21 | 0.00 | 0.00 | 7.19 | 2.57 |
| 2010 | 7229.47 | 7948 | 935 | 87.33 | 89.57 | 88.27 | 90.73 | 0.96 | 1.84 | 8.59 | 2.23 |
| 2011 | 4102.44 | 4678 | 945 | 50.12 | 50.68 | 49.56 | 53.40 | 4.24 | 14.34 | 34.98 | 0.57 |
| 2012 | 6963.03 | 7541 | 940 | 83.57 | 85.49 | 83.96 | 85.85 | 0.95 | 6.20 | 8.30 | 1.92 |
| 2013 | 7379.26 | 8054 | 940 | 88.85 | 91.38 | 89.61 | 91.94 | 0.33 | 0.47 | 8.15 | 2.53 |
| 2014 | 6740.44 | 7396 | 938 | 81.47 | 83.99 | 81.93 | 84.43 | 0.80 | 0.68 | 15.33 | 2.52 |
| 2015 | 7604.79 | 7215 | 1115 | 78.03 | 80.73 | 78.92 | 82.36 | 9.62 | 8.63 | 10.63 | 2.70 |
| 2016 | 8331.54 | 7862 | 1106 | 84.63 | 86.92 | 84.92 | 89.50 | 3.98 | 3.60 | 9.48 | 2.28 |
| 2017 | 8265.10 | 7664 | 1106 | 84.84 | 86.88 | 85.31 | 87.49 | 1.02 | 0.89 | 12.22 | 2.04 |
| 2018 | 8702.45 | 8273 | 1102 | 89.78 | 93.43 | 90.08 | 94.44 | 1.07 | 1.01 | 5.56 | 3.65 |
| 2019 | 8008.02 | 7627 | 1117 | 81.90 | 86.23 | 82.67 | 87.07 | 0.36 | 4.31 | 9.46 | 4.33 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|-------|-------|-------|------|
| 2020 | 6285.45 | 6739 | 1130 | 64.86 | 66.92 | 63.32 | 76.72 | 23.55 | 22.69 | 10.39 | 2.06 |
| 2021 | 8234.53 | 7649 | 1130 | 82.12 | 84.58 | 83.19 | 87.32 | 2.71 | 3.14 | 12.28 | 2.45 |
| 2022 | 5819.96 | 5318 | 1130 | 58.19 | 59.97 | 58.79 | 60.71 | 0.00 | 34.20 | 5.83 | 1.78 |
| 2023 | 5436.26 | 5196 | 1130 | 54.24 | 56.54 | 54.92 | 59.32 | 4.79 | 23.30 | 20.16 | 2.30 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1913 | | | 325 | 1 |
| C. Inspection, maintenance or repair combined with refuelling | 1656 | | | 862 | 1 | |
| D. Inspection, maintenance or repair without refuelling | | | | 150 | | |
| E. Testing of plant systems or components | | | | 28 | 13 | |
| H. Nuclear regulatory requirements | | | | | 2 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 17 | |
| Z. Other | | | | 1 | 11 | |
| Subtotal | 1656 | 1913 | | 1041 | 369 | 1 |
| Total | | 3569 | | | 1411 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 379 | 75 |
| 12. Reactor I&C Systems | | 4 |
| 13. Reactor Auxiliary Systems | | 14 |
| 14. Safety Systems | | 17 |
| 15. Reactor Cooling Systems | 1412 | 160 |
| 16. Steam generation systems | | 29 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 8 |
| 32. Feedwater and Main Steam System | 122 | 25 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 0 |
| Total | 1913 | 335 |

2023 Operating Experience

CH-1

BEZNAU-1

SWITZERLAND

Status at end of year : **Operational**
 Operator : Axpo AG (Kernkraftwerk Beznau)
 Owner : Axpo AG (Kernkraftwerk Beznau)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : BBC (BROWN BOVERI ET CIE)



| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 2LP | Construction Date | : 1965-09-01 |
| Thermal power | : 1130 MWth | Grid Date | : 1969-07-17 |
| Gross electrical power | : 380 MWe | Commercial Date | : 1969-12-09 |
| Reference unit power (net) | : 365 MWe | Age at end of year | : 54 years |

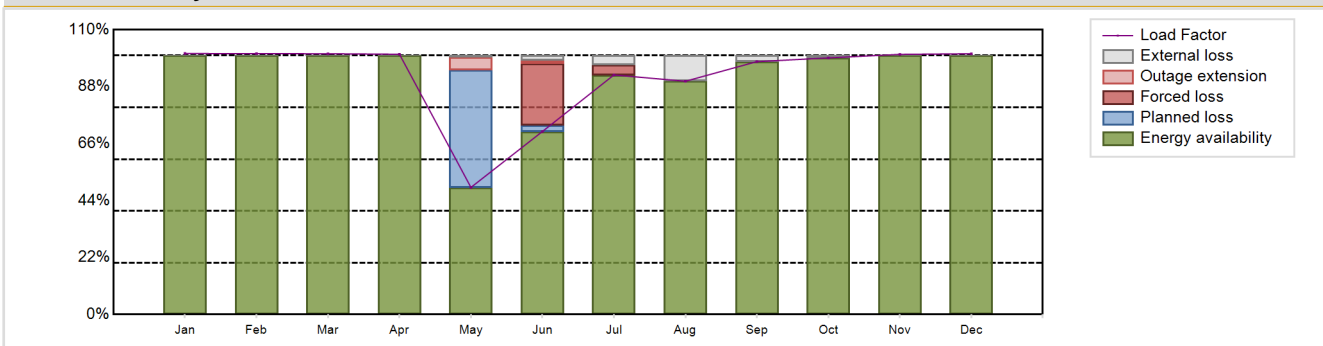
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|------------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.3 |
| Fuel material | : UO2/MOX | Reactor outlet temperature [°C] | : 313 |
| Refuelling type | : OFF-line | Number of SG | : 2 |
| Moderator material | : H2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : 4.68 | Containment design pressure [MPa] | : 0.31 |
| Refuelling frequency [month] | : 12 | Secondary systems | |
| Part of the core refuelled [%] | : 17 | Number of turbine-generators per unit/reactor | : 2 |
| Average discharge burnup [MWd/t] | : 42000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 2.45 | Number of LP cylinders per turbine | : 2 |
| Active core height/length [m] | : 3.05 | HP cylinder inlet steam pressure [MPa] | : 5.3 |
| Number of fissile fuel assemblies/bundles | : 121 | Output voltage [kV] | : 15 |
| Fuel linear heat generation rate [kW/m] | : 16.7 | Primary means of condenser cooling | : River (once-through) |
| Number of control rod assemblies | : 17 | Number of main condensate pumps | : 2 |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : 1 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 3 |
| | | Non-electrical applications | : DH |

Annual Production Results (2023)

| | | | |
|--|-------------------|--|-------------|
| Net Energy Production | : 2937.08 GW(e).h | Forced Loss Rate (FLR) | : 2.4 % |
| Energy Availability Factor (EAF) | : 91.52 % | Unplanned Capability Loss Factor (UCL) | : 2.81 % |
| Unit Capability Factor (UCF) | : 93.14 % | Planned Unavailability Factor (PUF) | : 4.05 % |
| Load Factor (LF) | : 91.86 % | Externally cause unavailability (XUF) | : 1.62 % |
| Operating Factor (OF) | : 95.63 % | Total off-line time | : 383 hours |
| Equivalent non-electrical energy generated (NEG) | : 49.33 GW(e).h | | |

Annual Summary

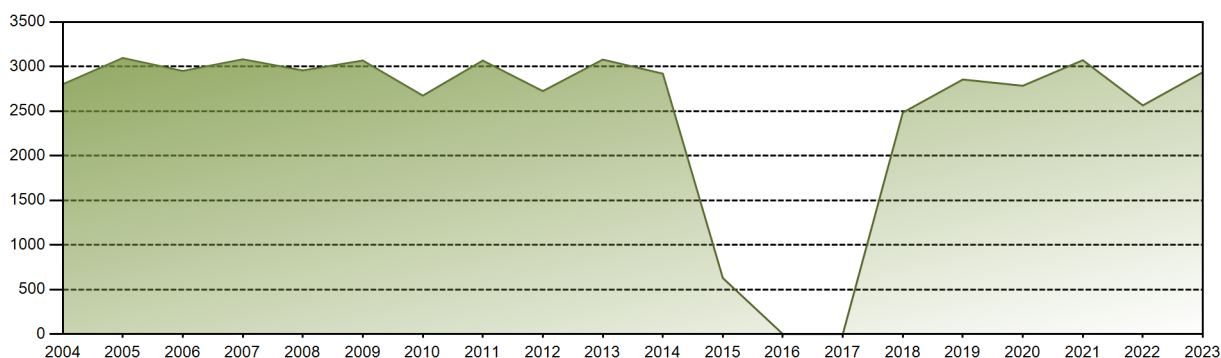


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 273.78 | 247.18 | 273.15 | 264.18 | 133.31 | 185.77 | 251.25 | 244.66 | 256.69 | 269.52 | 264.05 | 273.53 | 2937.08 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 49.09 | 70.69 | 92.52 | 90.09 | 97.67 | 99.11 | 100.00 | 100.00 | 91.52 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 49.61 | 72.55 | 96.19 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.14 |
| LF [%] | 100.82 | 100.78 | 100.72 | 100.52 | 49.09 | 70.69 | 92.52 | 90.09 | 97.67 | 99.11 | 100.48 | 100.73 | 91.86 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 49.73 | 98.75 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.63 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.77 | 3.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.40 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 4.97 | 25.13 | 3.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.81 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 45.41 | 2.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.05 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.52 | 1.86 | 3.67 | 9.91 | 2.33 | 0.89 | 0.00 | 0.00 | 1.62 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 272182.39 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.64 % |
| Cumulative Energy Availability Factor (EAF) | : 80.83 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.35 % |
| Cumulative Unit Capability Factor (UCF) | : 81.15 % | Cumulative Planned Unavailability Factor (PUF) | : 11.49 % |
| Cumulative Load Factor (LF) | : 80.44 % | Cumulative Externally cause unavailability (XUF) | : 0.32 % |
| Cumulative Operating Factor (OF) | : 82.39 % | | |

Electricity Production (net) [GWh]

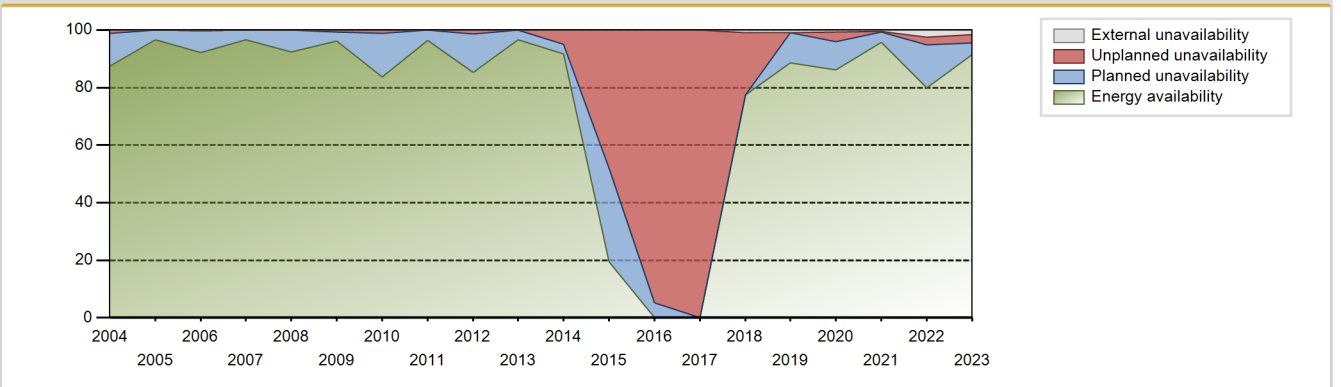


Performance for Years of Commercial Operation

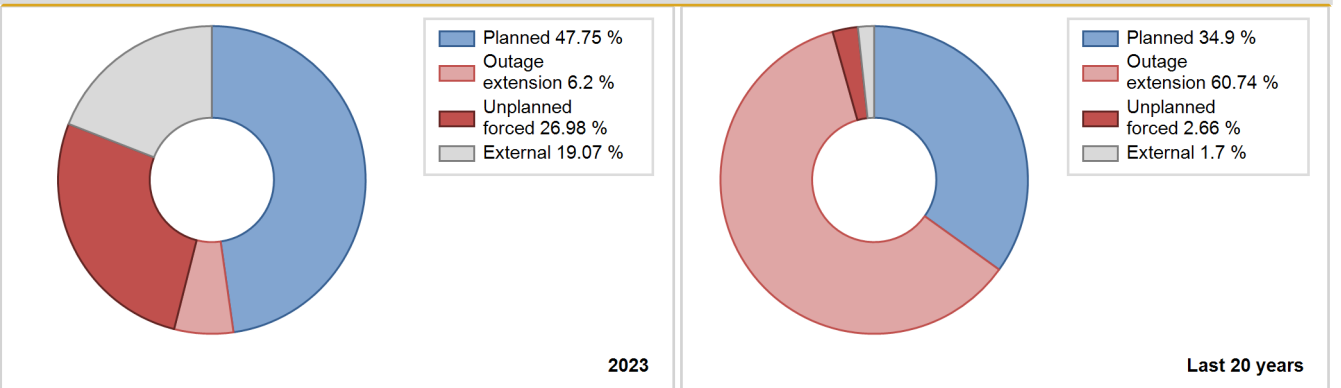
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------------------|-------|-------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1969 | | | | Data not provided | | | | | | | |
| 1970 | 1947.00 | 5917 | 364 | 61.05 | 61.05 | 61.06 | 67.55 | 0.00 | 0.00 | 38.95 | 0.00 |
| 1971 | 1700.50 | 5123 | 364 | 58.99 | 58.99 | 53.33 | 58.48 | 27.48 | 22.35 | 18.66 | 0.00 |
| 1972 | 1402.90 | 5391 | 280 | 61.32 | 61.32 | 57.04 | 61.37 | 38.68 | 38.68 | 0.00 | 0.00 |
| 1973 | 1655.00 | 6654 | 350 | 71.57 | 71.57 | 53.98 | 75.96 | 8.53 | 6.67 | 21.76 | 0.00 |
| 1974 | 2346.70 | 7177 | 350 | 78.10 | 78.10 | 76.54 | 81.93 | 2.77 | 2.22 | 19.67 | 0.00 |
| 1975 | 2490.90 | 7490 | 350 | 81.22 | 81.22 | 81.24 | 85.50 | 5.62 | 4.83 | 13.95 | 0.00 |
| 1976 | 2548.10 | 7530 | 350 | 83.46 | 83.46 | 82.88 | 85.72 | 0.65 | 0.55 | 15.99 | 0.00 |
| 1977 | 2596.30 | 7592 | 350 | 85.21 | 85.21 | 84.68 | 86.67 | 2.68 | 2.34 | 12.44 | 0.00 |
| 1978 | 2761.90 | 8031 | 350 | 89.46 | 89.46 | 90.08 | 91.68 | 0.13 | 0.12 | 10.42 | 0.00 |
| 1979 | 2658.80 | 7746 | 350 | 86.11 | 86.11 | 86.72 | 88.42 | 0.01 | 0.01 | 13.88 | 0.00 |
| 1980 | 2650.50 | 7682 | 350 | 85.69 | 85.69 | 86.21 | 87.45 | 4.56 | 4.09 | 10.21 | 0.00 |
| 1981 | 2569.70 | 7486 | 350 | 83.46 | 83.46 | 83.81 | 85.46 | 5.43 | 4.79 | 11.74 | 0.00 |
| 1982 | 2566.90 | 7553 | 350 | 83.52 | 83.52 | 83.72 | 86.22 | 3.14 | 2.71 | 13.77 | 0.00 |
| 1983 | 2551.70 | 7546 | 350 | 83.49 | 83.49 | 83.23 | 86.14 | 0.64 | 0.54 | 15.97 | 0.00 |
| 1984 | 2732.94 | 8001 | 350 | 88.85 | 88.85 | 88.89 | 91.09 | 0.29 | 0.26 | 10.89 | 0.00 |
| 1985 | 2634.26 | 7906 | 350 | 86.01 | 86.01 | 85.92 | 90.25 | 4.17 | 3.74 | 10.25 | 0.00 |
| 1986 | 2496.27 | 7403 | 350 | 81.60 | 81.60 | 81.42 | 84.51 | 9.03 | 8.10 | 10.30 | 0.00 |
| 1987 | 2486.26 | 7256 | 350 | 80.71 | 80.71 | 81.09 | 82.83 | 1.90 | 1.56 | 17.73 | 0.00 |
| 1988 | 2566.55 | 7499 | 350 | 82.97 | 82.97 | 83.48 | 85.37 | 1.56 | 1.32 | 15.72 | 0.00 |
| 1989 | 2433.15 | 7062 | 350 | 78.65 | 78.65 | 79.36 | 80.62 | 7.30 | 6.19 | 15.16 | 0.00 |
| 1990 | 2562.48 | 7506 | 350 | 84.38 | 84.38 | 83.58 | 85.68 | 0.41 | 0.34 | 15.28 | 0.00 |
| 1991 | 2495.26 | 7430 | 350 | 83.48 | 83.48 | 81.38 | 84.82 | 1.61 | 1.36 | 15.16 | 0.00 |
| 1992 | 2477.39 | 7303 | 350 | 81.70 | 81.70 | 80.58 | 83.14 | 0.71 | 0.58 | 17.71 | 0.00 |
| 1993 | 2158.43 | 6241 | 350 | 69.37 | 69.88 | 70.40 | 71.24 | 1.02 | 0.72 | 29.39 | 0.52 |
| 1994 | 2686.88 | 7610 | 350 | 85.05 | 86.19 | 87.63 | 86.87 | 0.35 | 0.30 | 13.51 | 1.13 |
| 1995 | 2850.46 | 7993 | 350 | 90.15 | 90.48 | 92.97 | 91.24 | 0.32 | 0.29 | 9.23 | 0.33 |
| 1996 | 2753.18 | 7704 | 353 | 86.81 | 87.45 | 88.60 | 87.70 | 0.35 | 0.31 | 12.24 | 0.64 |
| 1997 | 2708.21 | 7731 | 365 | 85.12 | 87.46 | 84.70 | 88.25 | 0.18 | 0.16 | 12.38 | 2.35 |
| 1998 | 3183.13 | 8760 | 365 | 99.84 | 99.89 | 99.55 | 100.00 | 0.06 | 0.06 | 0.05 | 0.06 |
| 1999 | 2841.27 | 8074 | 365 | 88.60 | 91.33 | 88.86 | 92.17 | 0.15 | 0.13 | 8.54 | 2.72 |
| 2000 | 2539.20 | 7113 | 365 | 78.30 | 79.22 | 79.20 | 80.98 | 0.46 | 0.36 | 20.41 | 0.92 |
| 2001 | 3090.18 | 8504 | 365 | 96.76 | 96.76 | 96.65 | 97.08 | 0.00 | 0.00 | 3.24 | 0.00 |
| 2002 | 2908.78 | 8000 | 365 | 91.03 | 91.26 | 90.97 | 91.32 | 0.03 | 0.89 | 7.85 | 0.23 |
| 2003 | 3061.76 | 8494 | 365 | 96.18 | 96.92 | 95.76 | 96.96 | 0.00 | 0.00 | 3.08 | 0.74 |
| 2004 | 2801.17 | 7758 | 365 | 87.44 | 87.53 | 87.36 | 88.31 | 0.37 | 1.15 | 11.32 | 0.09 |
| 2005 | 3095.96 | 8491 | 365 | 96.64 | 96.67 | 96.82 | 96.92 | 0.01 | 0.01 | 3.32 | 0.03 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|--------|-------|------|
| 2006 | 2950.68 | 8114 | 365 | 92.19 | 92.35 | 92.28 | 92.63 | 0.01 | 0.01 | 7.65 | 0.15 |
| 2007 | 3081.34 | 8486 | 365 | 96.67 | 96.70 | 96.37 | 96.87 | 0.00 | 0.00 | 3.30 | 0.03 |
| 2008 | 2956.58 | 8143 | 365 | 92.45 | 92.45 | 92.22 | 92.70 | 0.11 | 0.10 | 7.44 | 0.00 |
| 2009 | 3067.33 | 8460 | 365 | 96.27 | 96.30 | 95.93 | 96.58 | 0.57 | 0.68 | 3.02 | 0.03 |
| 2010 | 2673.99 | 7347 | 365 | 83.66 | 83.66 | 83.63 | 83.87 | 0.04 | 1.13 | 15.21 | 0.00 |
| 2011 | 3067.13 | 8458 | 365 | 96.42 | 96.42 | 95.93 | 96.55 | 0.00 | 0.02 | 3.56 | 0.00 |
| 2012 | 2724.73 | 7508 | 365 | 85.26 | 85.26 | 84.98 | 85.47 | 0.02 | 1.32 | 13.42 | 0.00 |
| 2013 | 3078.45 | 8473 | 365 | 96.59 | 96.59 | 96.28 | 96.72 | 0.00 | 0.00 | 3.41 | 0.00 |
| 2014 | 2920.61 | 8047 | 365 | 91.64 | 91.64 | 91.34 | 91.86 | 4.87 | 4.88 | 3.48 | 0.00 |
| 2015 | 628.54 | 1715 | 365 | 19.56 | 19.56 | 19.66 | 19.58 | 0.00 | 47.99 | 32.46 | 0.00 |
| 2016 | 0.00 | 0 | 365 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 94.81 | 5.19 | 0.00 |
| 2017 | 0.00 | 0 | 365 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 |
| 2018 | 2483.69 | 6897 | 365 | 77.34 | 78.25 | 77.68 | 78.73 | 0.42 | 21.75 | 0.00 | 0.91 |
| 2019 | 2854.84 | 7851 | 365 | 88.65 | 89.60 | 89.29 | 89.62 | 0.00 | 0.00 | 10.40 | 0.95 |
| 2020 | 2784.66 | 7661 | 365 | 86.25 | 87.02 | 86.85 | 87.22 | 3.61 | 3.26 | 9.71 | 0.78 |
| 2021 | 3071.24 | 8449 | 365 | 95.64 | 96.21 | 96.05 | 96.45 | 0.09 | 0.08 | 3.71 | 0.57 |
| 2022 | 2564.59 | 7244 | 365 | 79.92 | 82.35 | 80.21 | 82.69 | 0.21 | 2.68 | 14.97 | 2.43 |
| 2023 | 2937.08 | 8377 | 365 | 91.52 | 93.14 | 91.86 | 95.63 | 2.40 | 2.81 | 4.05 | 1.62 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1969 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 46 | | | 191 | |
| B. Refuelling without maintenance | 337 | | | 44 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 783 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 13 | | |
| E. Testing of plant systems or components | | | | | 0 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 62 | | |
| H. Nuclear regulatory requirements | | | | | 437 | |
| L. Human factor related | | | | | 0 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| Subtotal | 337 | 46 | | 902 | 628 | 2 |
| Total | | 383 | | | 1532 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1969 to 2023 | |
|--|------------|----------|-------------------------------------|----------|
| | Hours Lost | External | Average hours lost per reactor-year | External |
| 11. Reactor and Accessories | | 46 | | 454 |
| 12. Reactor I&C Systems | | | | 67 |
| 13. Reactor Auxiliary Systems | | | | 9 |
| 14. Safety Systems | | | | 3 |
| 15. Reactor Cooling Systems | | | | 12 |
| 16. Steam generation systems | | | | 66 |
| 21. Fuel Handling and Storage Facilities | | | | 0 |
| 31. Turbine and auxiliaries | | | | 2 |
| 32. Feedwater and Main Steam System | | | | 9 |
| 35. All other I&C Systems | | | | 0 |
| 42. Electrical Power Supply Systems | | | | 5 |
| Total | | 46 | | 627 |

Highlights (2023)

Plant refuelling outage
 Shutdown TG 12 due to leak in feedwater system

2023 Operating Experience

CH-3

BEZNAU-2

SWITZERLAND

Status at end of year : **Operational**
 Operator : Axpo AG (Kernkraftwerk Beznau)
 Owner : Axpo AG (Kernkraftwerk Beznau)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : BBC (BROWN BOVERI ET CIE)



| Reactor Unit Details | | Key Dates | |
|----------------------------|----------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 2LP | Construction Date | : 1968-01-01 |
| Thermal power | : 1130 MWth | Grid Date | : 1971-10-23 |
| Gross electrical power | : 380 MWe | Commercial Date | : 1972-03-04 |
| Reference unit power (net) | : 365 MWe | Age at end of year | : 52 years |

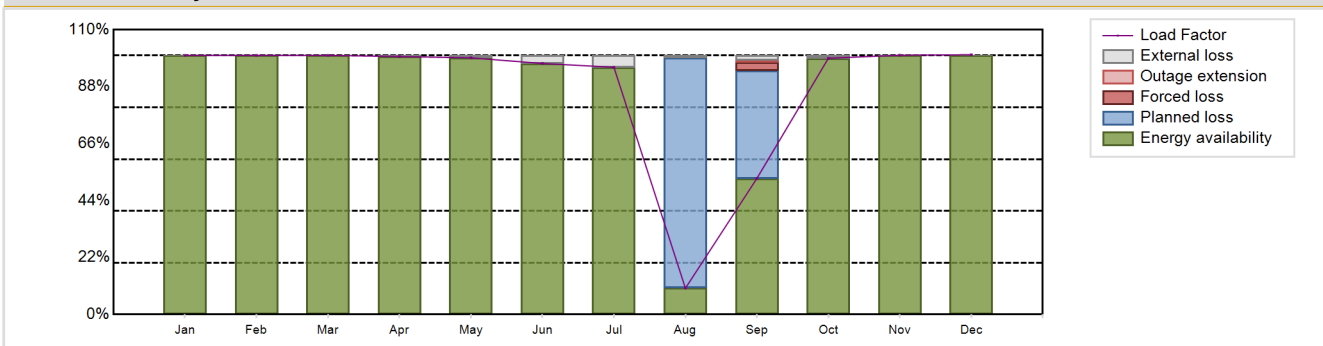
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|------------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.5 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 313 |
| Refuelling type | : OFF-line | Number of SG | : 2 |
| Moderator material | : H2O | Containment type | : Double |
| Average fuel enrichment [% of U235] | : 4.68 | Containment design pressure [MPa] | : 0.31 |
| Refuelling frequency [month] | : 12 | Secondary systems | |
| Part of the core refuelled [%] | : 17 | Number of turbine-generators per unit/reactor | : 2 |
| Average discharge burnup [MWd/t] | : 42000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 2.45 | Number of LP cylinders per turbine | : 2 |
| Active core height/length [m] | : 3.05 | HP cylinder inlet steam pressure [MPa] | : 5.3 |
| Number of fissile fuel assemblies/bundles | : 121 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 16.7 | Primary means of condenser cooling | : River (once-through) |
| Number of control rod assemblies | : 25 | Number of main condensate pumps | : 2 |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : 1 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 3 |
| | | Non-electrical applications | : DH |

Annual Production Results (2023)

| | | | |
|--|-------------------|--|-------------|
| Net Energy Production | : 2804.42 GW(e).h | Forced Loss Rate (FLR) | : 0.31 % |
| Energy Availability Factor (EAF) | : 87.65 % | Unplanned Capability Loss Factor (UCL) | : 0.34 % |
| Unit Capability Factor (UCF) | : 88.69 % | Planned Unavailability Factor (PUF) | : 10.97 % |
| Load Factor (LF) | : 87.71 % | Externally cause unavailability (XUF) | : 1.04 % |
| Operating Factor (OF) | : 89.26 % | Total off-line time | : 941 hours |
| Equivalent non-electrical energy generated (NEG) | : 2.83 GW(e).h | | |

Annual Summary

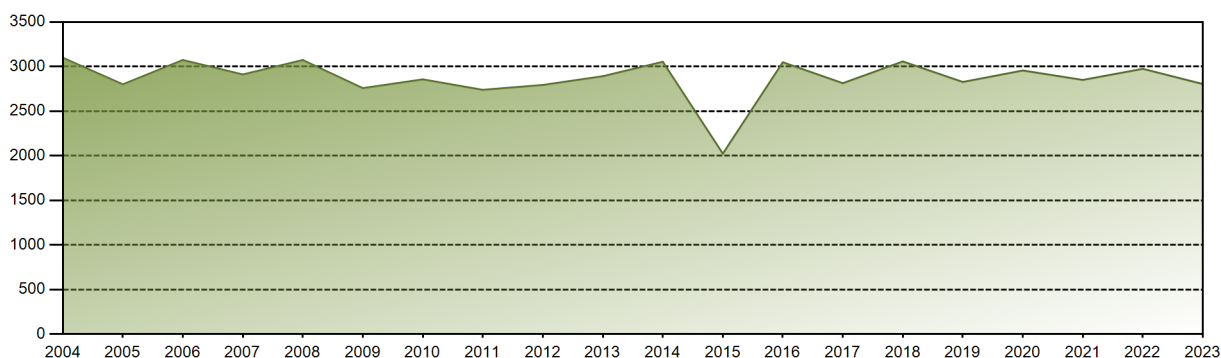


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|---------|
| GW(e)-h | 271.79 | 245.46 | 271.40 | 261.89 | 269.20 | 254.81 | 259.35 | 27.57 | 138.16 | 269.15 | 263.17 | 272.45 | 2804.42 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 99.65 | 99.13 | 96.96 | 95.50 | 10.15 | 52.57 | 98.98 | 100.00 | 100.00 | 87.65 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 10.94 | 54.45 | 100.00 | 100.00 | 100.00 | 88.69 |
| LF [%] | 100.09 | 100.07 | 100.08 | 99.65 | 99.13 | 96.96 | 95.50 | 10.15 | 52.57 | 98.98 | 100.14 | 100.33 | 87.71 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 11.16 | 61.11 | 100.00 | 100.00 | 100.00 | 89.26 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.86 | 0.00 | 0.00 | 0.00 | 0.31 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.08 | 0.00 | 0.00 | 0.00 | 0.34 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 89.06 | 41.47 | 0.00 | 0.00 | 0.00 | 10.97 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.35 | 0.87 | 3.04 | 4.50 | 0.79 | 1.87 | 1.02 | 0.00 | 0.00 | 1.04 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 286421.08 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.11 % |
| Cumulative Energy Availability Factor (EAF) | : 87.6 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.14 % |
| Cumulative Unit Capability Factor (UCF) | : 87.84 % | Cumulative Planned Unavailability Factor (PUF) | : 11.02 % |
| Cumulative Load Factor (LF) | : 87.83 % | Cumulative Externally cause unavailability (XUF) | : 0.25 % |
| Cumulative Operating Factor (OF) | : 88.86 % | | |

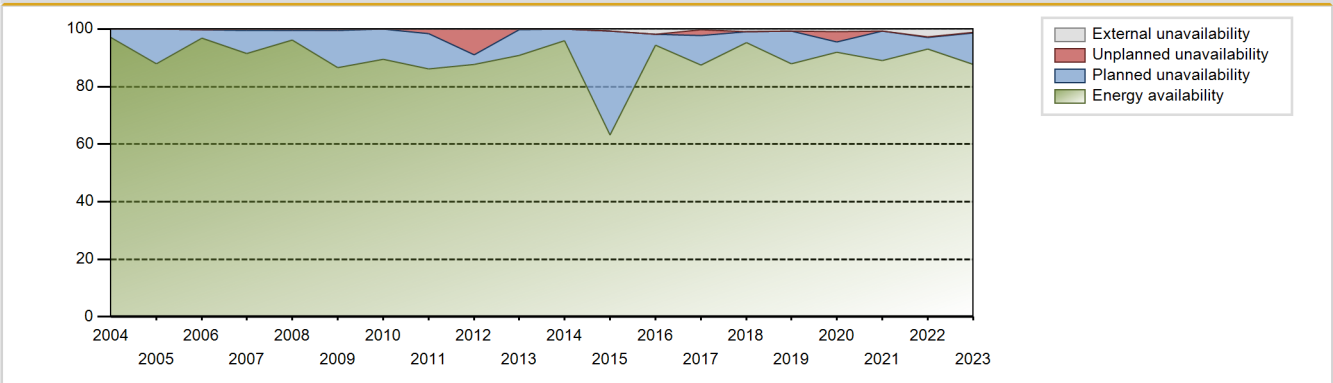
Electricity Production (net) [GWh]



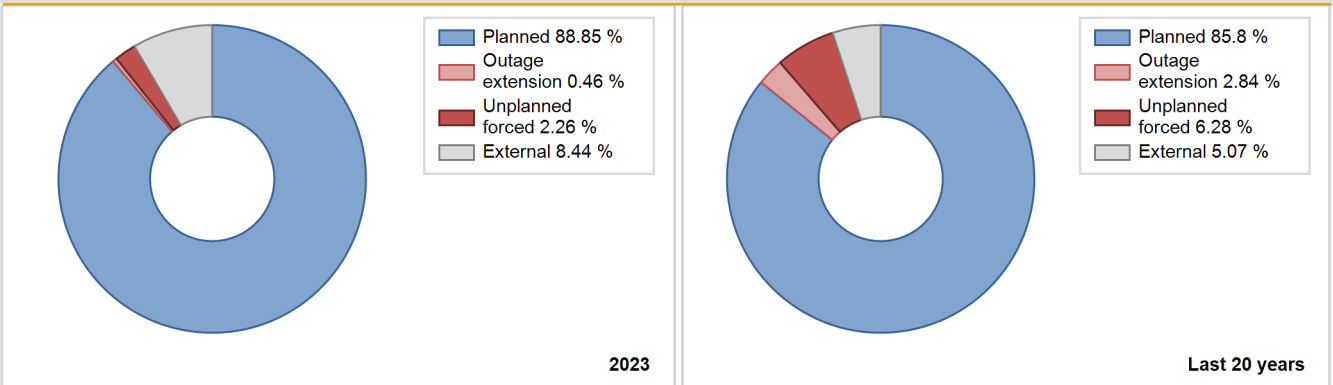
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1972 | 2618.50 | 7624 | 364 | 83.06 | 83.06 | 82.10 | 84.20 | 9.60 | 8.82 | 8.12 | 0.00 |
| 1973 | 2220.70 | 7042 | 350 | 78.45 | 78.45 | 72.43 | 80.39 | 1.91 | 1.53 | 20.02 | 0.00 |
| 1974 | 2527.80 | 7607 | 350 | 83.53 | 83.53 | 82.45 | 86.84 | 0.65 | 0.55 | 15.92 | 0.00 |
| 1975 | 2547.00 | 7503 | 350 | 83.05 | 83.05 | 83.07 | 85.65 | 3.98 | 3.45 | 13.50 | 0.00 |
| 1976 | 2652.20 | 7777 | 350 | 86.62 | 86.62 | 86.27 | 88.54 | 0.29 | 0.25 | 13.13 | 0.00 |
| 1977 | 2690.90 | 7758 | 350 | 85.55 | 85.55 | 87.77 | 88.56 | 0.67 | 0.58 | 13.87 | 0.00 |
| 1978 | 2753.10 | 7888 | 350 | 86.69 | 86.69 | 89.79 | 90.05 | 3.14 | 2.81 | 10.49 | 0.00 |
| 1979 | 2700.00 | 7835 | 350 | 86.70 | 86.70 | 88.06 | 89.44 | 2.84 | 2.54 | 10.77 | 0.00 |
| 1980 | 2559.00 | 7279 | 350 | 81.05 | 81.05 | 83.24 | 82.87 | 6.13 | 5.29 | 13.66 | 0.00 |
| 1981 | 2768.80 | 7868 | 350 | 88.77 | 88.77 | 90.31 | 89.82 | 0.13 | 0.11 | 11.12 | 0.00 |
| 1982 | 2722.10 | 7811 | 350 | 87.58 | 87.58 | 88.78 | 89.17 | 0.25 | 0.22 | 12.20 | 0.00 |
| 1983 | 2790.50 | 7977 | 350 | 89.60 | 89.60 | 91.01 | 91.06 | 0.70 | 0.63 | 9.77 | 0.00 |
| 1984 | 2724.21 | 7874 | 350 | 87.54 | 87.54 | 88.61 | 89.64 | 0.19 | 0.17 | 12.29 | 0.00 |
| 1985 | 2629.06 | 7647 | 350 | 84.95 | 84.95 | 85.75 | 87.29 | 2.99 | 2.62 | 12.44 | 0.00 |
| 1986 | 2769.81 | 7983 | 350 | 90.18 | 90.18 | 90.34 | 91.13 | 0.06 | 0.05 | 9.76 | 0.00 |
| 1987 | 2527.62 | 7535 | 350 | 82.38 | 82.38 | 82.44 | 86.02 | 2.34 | 1.98 | 15.64 | 0.00 |
| 1988 | 2630.19 | 7604 | 350 | 84.53 | 84.53 | 85.55 | 86.57 | 0.57 | 0.49 | 14.98 | 0.00 |
| 1989 | 2643.34 | 7614 | 350 | 85.11 | 85.11 | 86.21 | 86.92 | 0.65 | 0.55 | 14.34 | 0.00 |
| 1990 | 2636.07 | 7568 | 350 | 85.25 | 85.25 | 85.98 | 86.39 | 0.23 | 0.20 | 14.55 | 0.00 |
| 1991 | 2619.53 | 7551 | 350 | 84.48 | 84.48 | 85.44 | 86.20 | 0.37 | 0.31 | 15.21 | 0.00 |
| 1992 | 2375.90 | 6836 | 350 | 76.26 | 76.26 | 77.28 | 77.82 | 0.19 | 0.15 | 23.60 | 0.00 |
| 1993 | 2650.93 | 7517 | 350 | 84.86 | 85.09 | 86.46 | 85.81 | 0.25 | 0.21 | 14.70 | 0.23 |
| 1994 | 3062.80 | 8710 | 350 | 98.78 | 98.94 | 99.90 | 99.43 | 1.01 | 1.01 | 0.05 | 0.16 |
| 1995 | 2560.94 | 7247 | 350 | 82.58 | 82.72 | 83.53 | 82.73 | 0.41 | 0.34 | 16.94 | 0.14 |
| 1996 | 2754.10 | 7912 | 351 | 87.91 | 88.51 | 89.13 | 90.07 | 0.80 | 0.71 | 10.78 | 0.60 |
| 1997 | 3090.24 | 8732 | 357 | 99.54 | 99.54 | 98.81 | 99.68 | 0.18 | 0.18 | 0.28 | 0.01 |
| 1998 | 2717.82 | 7755 | 357 | 87.26 | 87.76 | 86.91 | 88.53 | 0.44 | 0.38 | 11.85 | 0.50 |
| 1999 | 2217.19 | 6322 | 357 | 70.28 | 70.68 | 70.90 | 72.17 | 3.67 | 2.69 | 26.62 | 0.41 |
| 2000 | 3071.03 | 8499 | 365 | 96.20 | 96.20 | 95.79 | 96.76 | 0.00 | 0.00 | 3.80 | 0.00 |
| 2001 | 2568.68 | 7107 | 365 | 80.67 | 80.68 | 80.34 | 81.13 | 0.33 | 0.27 | 19.05 | 0.01 |
| 2002 | 3012.01 | 8292 | 365 | 94.62 | 94.63 | 94.20 | 94.66 | 0.26 | 1.98 | 3.39 | 0.00 |
| 2003 | 2920.29 | 8070 | 365 | 91.85 | 92.05 | 91.33 | 92.12 | 0.79 | 0.74 | 7.21 | 0.20 |
| 2004 | 3099.37 | 8556 | 365 | 97.02 | 97.02 | 96.66 | 97.39 | 0.00 | 0.00 | 2.98 | 0.00 |
| 2005 | 2801.02 | 7728 | 365 | 87.84 | 87.95 | 87.60 | 88.22 | 0.01 | 0.01 | 12.03 | 0.11 |
| 2006 | 3073.23 | 8517 | 365 | 96.80 | 97.06 | 96.12 | 97.23 | 0.00 | 0.00 | 2.94 | 0.26 |
| 2007 | 2911.65 | 8063 | 365 | 91.46 | 91.48 | 91.06 | 92.04 | 0.15 | 0.41 | 8.11 | 0.02 |
| 2008 | 3073.36 | 8505 | 365 | 96.25 | 96.25 | 95.86 | 96.82 | 0.52 | 0.51 | 3.25 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2009 | 2758.47 | 7615 | 365 | 86.56 | 86.67 | 86.27 | 86.93 | 0.52 | 0.45 | 12.88 | 0.10 |
| 2010 | 2856.53 | 7865 | 365 | 89.59 | 89.59 | 89.34 | 89.78 | 0.00 | 0.00 | 10.41 | 0.00 |
| 2011 | 2739.21 | 7564 | 365 | 86.11 | 86.11 | 85.67 | 86.35 | 0.00 | 1.68 | 12.21 | 0.00 |
| 2012 | 2793.97 | 7715 | 365 | 87.65 | 87.65 | 87.14 | 87.83 | 6.98 | 9.01 | 3.33 | 0.00 |
| 2013 | 2892.03 | 7968 | 365 | 90.82 | 90.82 | 90.45 | 90.96 | 0.00 | 0.18 | 9.00 | 0.00 |
| 2014 | 3053.52 | 8433 | 365 | 95.99 | 95.99 | 95.50 | 96.27 | 0.13 | 0.13 | 3.89 | 0.00 |
| 2015 | 2023.36 | 5611 | 365 | 63.18 | 63.87 | 63.28 | 64.05 | 0.00 | 0.00 | 36.13 | 0.68 |
| 2016 | 3048.37 | 8474 | 365 | 94.49 | 96.27 | 95.08 | 96.47 | 0.00 | 0.13 | 3.60 | 1.78 |
| 2017 | 2813.62 | 7735 | 365 | 87.42 | 87.75 | 88.00 | 88.30 | 1.18 | 1.94 | 10.31 | 0.33 |
| 2018 | 3057.41 | 8445 | 365 | 95.26 | 96.28 | 95.62 | 96.40 | 0.00 | 0.00 | 3.72 | 1.02 |
| 2019 | 2827.27 | 7790 | 365 | 88.01 | 88.73 | 88.42 | 88.93 | 0.06 | 0.05 | 11.22 | 0.72 |
| 2020 | 2956.04 | 8175 | 365 | 91.92 | 92.83 | 92.20 | 93.07 | 3.52 | 3.54 | 3.63 | 0.91 |
| 2021 | 2850.23 | 7871 | 365 | 89.08 | 89.69 | 89.14 | 89.85 | 0.00 | 0.00 | 10.31 | 0.61 |
| 2022 | 2974.93 | 8406 | 365 | 93.02 | 95.78 | 93.04 | 95.96 | 0.21 | 0.21 | 4.02 | 2.75 |
| 2023 | 2804.42 | 7819 | 365 | 87.65 | 88.69 | 87.71 | 89.26 | 0.31 | 0.34 | 10.97 | 1.04 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1972 to 2023 | | |
|--|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 5 | | | 90 | |
| B. Refuelling without maintenance | | | | 58 | | |
| C. Inspection, maintenance or repair combined with refuelling | 936 | | | 749 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 28 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 61 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 1 | |
| Subtotal | 936 | 5 | | 896 | 91 | 0 |
| Total | | 941 | | | 987 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1972 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 5 | 5 |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 22 |
| 16. Steam generation systems | | 19 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 10 |
| 32. Feedwater and Main Steam System | | 3 |
| 33. Circulating Water System | | 3 |
| 34. Miscellaneous Systems | | 8 |
| 35. All other I&C Systems | | 1 |
| 42. Electrical Power Supply Systems | | 9 |
| Total | 5 | 90 |

Highlights (2023)

Plant refuelling outage

2023 Operating Experience

CH-4

GOESGEN

SWITZERLAND

Status at end of year : **Operational**
 Operator : KKG (KERNKRAFTWERK GÖSGEN-DÄNIKEN AG)
 Owner : KKG (KERNKRAFTWERK GÖSGEN-DÄNIKEN AG)
 Reactor Supplier : KWU (KRAFTWERK UNION, AG)
 Turbine Supplier : KWU (KRAFTWERK UNION, AG)

Reactor Unit Details

Reactor type and model : PWR / PWR 3 Loop
 Thermal power : 3002 MWth
 Gross electrical power : 1060 MWe
 Reference unit power (net) : 1010 MWe

Key Dates

Construction Date : 1973-12-01
 Grid Date : 1979-02-02
 Commercial Date : 1979-11-01
 Age at end of year : 44 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 52000
 Active core diameter [m] : 3.24
 Active core height/length [m] : 3.58
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 22.6
 Number of control rod assemblies : 36
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.3
 Reactor outlet temperature [°C] : 324.5
 Number of SG : 3
 Containment type : Double
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.65
 Output voltage [kV] : 27
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : 6

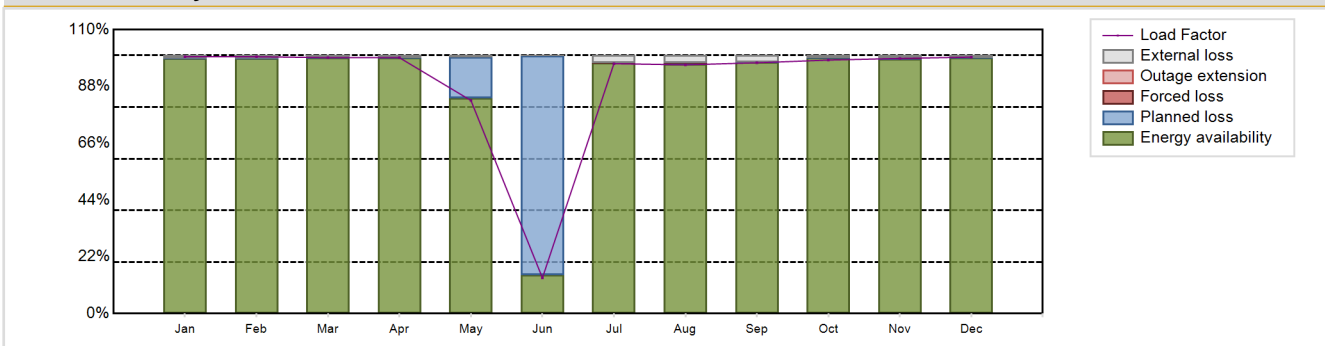
Non-electrical applications : PH

Annual Production Results (2023)

Net Energy Production : 7973.07 GW(e).h
 Energy Availability Factor (EAF) : 90.28 %
 Unit Capability Factor (UCF) : 91.61 %
 Load Factor (LF) : 90.11 %
 Operating Factor (OF) : 91.98 %
 Equivalent non-electrical energy generated (NEG) : 22.72 GW(e).h

Forced Loss Rate (FLR) : 0.06 %
 Unplanned Capability Loss Factor (UCL) : 0.05 %
 Planned Unavailability Factor (PUF) : 8.34 %
 Externally cause unavailability (XUF) : 1.34 %
 Total off-line time : 703 hours

Annual Summary

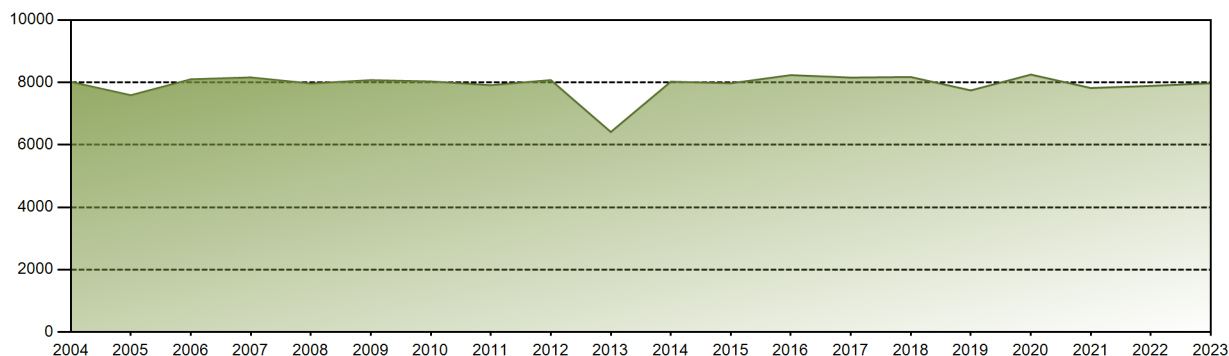


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 748.00 | 675.45 | 745.01 | 720.85 | 620.38 | 100.77 | 727.54 | 724.12 | 706.57 | 739.02 | 718.75 | 746.60 | 7973.07 |
| EAF [%] | 98.95 | 98.95 | 99.02 | 99.00 | 83.49 | 15.05 | 97.09 | 96.76 | 97.46 | 99.05 | 98.68 | 99.00 | 90.28 |
| UCF [%] | 99.96 | 99.97 | 99.97 | 99.98 | 84.22 | 15.11 | 99.97 | 99.63 | 99.98 | 99.98 | 99.74 | 99.98 | 91.61 |
| LF [%] | 99.54 | 99.52 | 99.14 | 99.13 | 82.56 | 13.86 | 96.82 | 96.36 | 97.16 | 98.21 | 98.84 | 99.36 | 90.11 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 84.54 | 18.33 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.98 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.35 | 0.00 | 0.00 | 0.24 | 0.00 | 0.06 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.35 | 0.00 | 0.00 | 0.24 | 0.00 | 0.05 |
| PUF [%] | 0.04 | 0.03 | 0.03 | 0.02 | 15.78 | 84.89 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 8.34 |
| XUF [%] | 1.01 | 1.03 | 0.96 | 0.98 | 0.73 | 0.06 | 2.88 | 2.87 | 2.52 | 0.93 | 1.06 | 0.98 | 1.34 |

Historical Summary

| | | | | | |
|---|---|-------------------|---|---|--------|
| Lifetime energy generation | : | 329212.12 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 1.04 % |
| Cumulative Energy Availability Factor (EAF) | : | 89.03 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 0.95 % |
| Cumulative Unit Capability Factor (UCF) | : | 89.86 % | Cumulative Planned Unavailability Factor (PUF) | : | 9.19 % |
| Cumulative Load Factor (LF) | : | 89.36 % | Cumulative Externally cause unavailability (XUF) | : | 0.84 % |
| Cumulative Operating Factor (OF) | : | 90.73 % | | | |

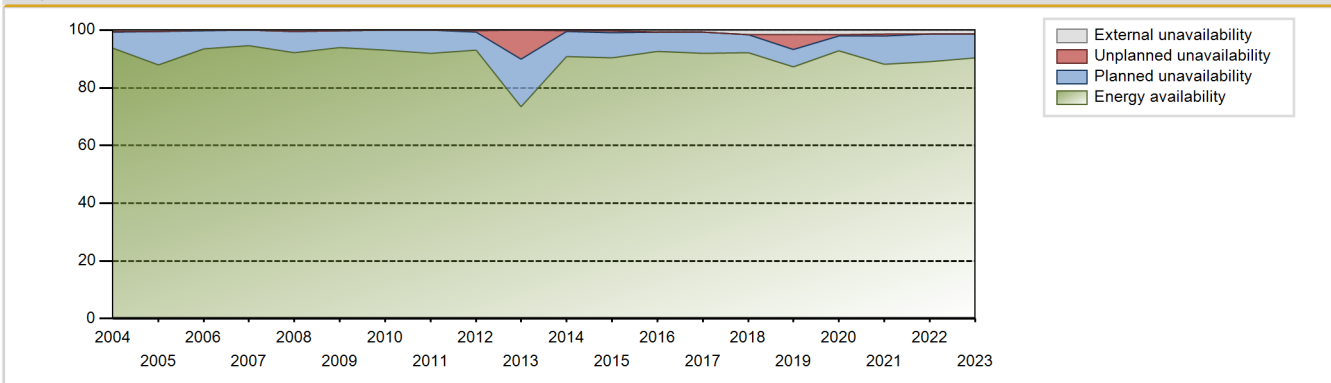
Electricity Production (net) [GWh]



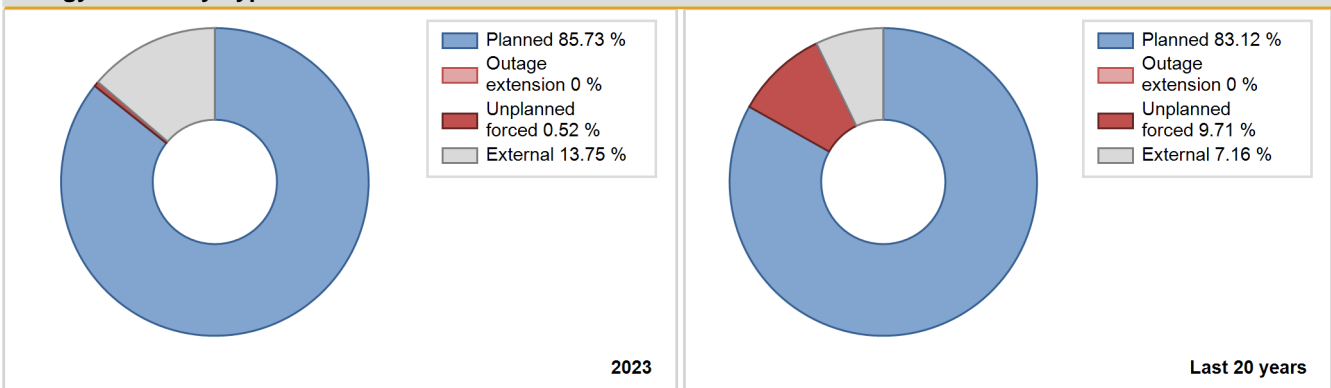
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1979 | 3398.70 | 4724 | 924 | 93.20 | 93.20 | 93.22 | 97.13 | 6.80 | 6.80 | 0.00 | 0.00 |
| 1980 | 5935.70 | 6819 | 920 | 73.47 | 73.47 | 73.45 | 77.63 | 9.11 | 7.37 | 19.16 | 0.00 |
| 1981 | 6527.60 | 7523 | 920 | 80.66 | 80.66 | 81.00 | 85.88 | 0.87 | 0.71 | 18.64 | 0.00 |
| 1982 | 6436.10 | 7665 | 920 | 79.81 | 79.81 | 79.86 | 87.50 | 5.99 | 5.08 | 15.10 | 0.00 |
| 1983 | 6891.60 | 7790 | 920 | 86.17 | 86.17 | 85.51 | 88.93 | 2.77 | 2.46 | 11.38 | 0.00 |
| 1984 | 7134.78 | 8015 | 900 | 89.85 | 90.60 | 90.25 | 91.25 | 0.54 | 0.50 | 8.91 | 0.75 |
| 1985 | 6747.72 | 7789 | 909 | 84.62 | 85.68 | 84.74 | 88.92 | 3.31 | 2.93 | 11.39 | 1.06 |
| 1986 | 6754.54 | 7386 | 941 | 82.76 | 84.14 | 81.94 | 84.32 | 0.03 | 0.02 | 15.83 | 1.38 |
| 1987 | 6910.34 | 7521 | 935 | 84.39 | 85.18 | 84.37 | 85.86 | 0.19 | 0.16 | 14.66 | 0.79 |
| 1988 | 6858.97 | 7476 | 936 | 83.36 | 84.71 | 83.42 | 85.11 | 0.11 | 0.09 | 15.20 | 1.35 |
| 1989 | 6878.68 | 7514 | 931 | 84.31 | 85.40 | 84.34 | 85.78 | 0.02 | 0.02 | 14.58 | 1.08 |
| 1990 | 7131.49 | 7983 | 929 | 87.61 | 89.42 | 87.63 | 91.13 | 0.04 | 0.03 | 10.55 | 1.81 |
| 1991 | 7141.94 | 7918 | 925 | 88.08 | 89.68 | 88.14 | 90.39 | 0.32 | 0.29 | 10.02 | 1.61 |
| 1992 | 7406.91 | 8107 | 934 | 90.16 | 92.11 | 90.23 | 92.29 | 0.04 | 0.03 | 7.85 | 1.95 |
| 1993 | 7408.12 | 8075 | 950 | 88.93 | 89.26 | 89.02 | 92.18 | 0.00 | 0.00 | 10.74 | 0.34 |
| 1994 | 7661.09 | 8102 | 947 | 91.07 | 92.13 | 92.35 | 92.49 | 0.00 | 0.00 | 7.87 | 1.06 |
| 1995 | 7820.85 | 8109 | 971 | 91.07 | 91.77 | 91.95 | 92.57 | 0.00 | 0.00 | 8.23 | 0.70 |
| 1996 | 7928.35 | 8204 | 986 | 91.54 | 93.40 | 91.54 | 93.40 | 0.00 | 0.00 | 6.60 | 1.86 |
| 1997 | 7967.77 | 8189 | 986 | 91.55 | 93.48 | 92.25 | 93.48 | 0.00 | 0.00 | 6.52 | 1.93 |
| 1998 | 7839.73 | 8179 | 986 | 90.77 | 93.18 | 90.77 | 93.37 | 0.00 | 0.00 | 6.82 | 2.42 |
| 1999 | 7533.93 | 7887 | 970 | 88.75 | 89.93 | 88.66 | 90.03 | 1.27 | 1.16 | 8.91 | 1.18 |
| 2000 | 7804.26 | 8089 | 970 | 91.66 | 92.02 | 91.59 | 92.09 | 0.43 | 0.40 | 7.58 | 0.36 |
| 2001 | 7870.47 | 8206 | 970 | 92.64 | 93.50 | 92.61 | 93.67 | 0.36 | 0.34 | 6.15 | 0.86 |
| 2002 | 7853.30 | 8154 | 970 | 92.34 | 92.89 | 92.42 | 93.08 | 1.55 | 1.46 | 5.64 | 0.56 |
| 2003 | 7988.68 | 8291 | 970 | 93.88 | 94.46 | 94.02 | 94.65 | 0.01 | 0.01 | 5.53 | 0.58 |
| 2004 | 8015.60 | 8300 | 970 | 93.79 | 94.31 | 94.07 | 94.49 | 0.24 | 0.23 | 5.46 | 0.52 |
| 2005 | 7588.23 | 7754 | 970 | 87.99 | 88.38 | 89.30 | 88.52 | 0.14 | 0.12 | 11.50 | 0.39 |
| 2006 | 8099.10 | 8230 | 970 | 93.59 | 93.74 | 95.31 | 93.95 | 0.10 | 0.10 | 6.17 | 0.15 |
| 2007 | 8158.91 | 8313 | 970 | 94.64 | 94.77 | 96.02 | 94.90 | 0.00 | 0.00 | 5.23 | 0.13 |
| 2008 | 7964.01 | 8148 | 970 | 92.19 | 92.63 | 93.47 | 92.76 | 0.00 | 0.00 | 7.37 | 0.44 |
| 2009 | 8072.42 | 8267 | 970 | 93.96 | 94.18 | 95.00 | 94.37 | 0.01 | 0.01 | 5.81 | 0.23 |
| 2010 | 8029.09 | 8220 | 970 | 93.11 | 93.21 | 94.49 | 93.84 | 0.01 | 0.00 | 6.78 | 0.10 |
| 2011 | 7910.31 | 8122 | 970 | 91.95 | 92.02 | 93.09 | 92.72 | 0.00 | 0.00 | 7.98 | 0.07 |
| 2012 | 8073.93 | 8281 | 985 | 93.12 | 93.35 | 93.32 | 94.27 | 0.51 | 0.48 | 6.17 | 0.23 |
| 2013 | 6410.20 | 6491 | 985 | 73.39 | 73.43 | 74.29 | 74.10 | 12.09 | 10.09 | 16.47 | 0.04 |
| 2014 | 8021.58 | 8029 | 1010 | 90.80 | 91.11 | 91.79 | 91.66 | 0.13 | 0.12 | 8.77 | 0.31 |
| 2015 | 7971.20 | 7980 | 1010 | 90.34 | 90.65 | 90.09 | 91.10 | 0.69 | 0.63 | 8.72 | 0.31 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|------|------|
| 2016 | 8233.25 | 8232 | 1010 | 92.63 | 93.32 | 92.80 | 93.72 | 0.07 | 0.06 | 6.61 | 0.69 |
| 2017 | 8154.30 | 8148 | 1010 | 92.01 | 92.66 | 92.16 | 93.01 | 0.00 | 0.00 | 7.33 | 0.65 |
| 2018 | 8172.01 | 8244 | 1010 | 92.14 | 93.77 | 92.36 | 94.11 | 0.00 | 0.00 | 6.23 | 1.63 |
| 2019 | 7743.07 | 7835 | 1010 | 87.36 | 89.00 | 87.52 | 89.44 | 5.34 | 5.02 | 5.97 | 1.64 |
| 2020 | 8249.56 | 8360 | 1010 | 92.94 | 94.52 | 92.99 | 95.17 | 0.40 | 0.38 | 5.10 | 1.58 |
| 2021 | 7819.83 | 7900 | 1010 | 88.25 | 89.59 | 88.38 | 90.18 | 0.85 | 0.77 | 9.64 | 1.34 |
| 2022 | 7886.66 | 7968 | 1010 | 89.15 | 90.56 | 89.14 | 90.96 | 0.00 | 0.00 | 9.44 | 1.41 |
| 2023 | 7973.07 | 8058 | 1010 | 90.28 | 91.61 | 90.11 | 91.98 | 0.06 | 0.05 | 8.34 | 1.34 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1979 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 55 | |
| C. Inspection, maintenance or repair combined with refuelling | 705 | | | 757 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 0 | | |
| E. Testing of plant systems or components | | | | 0 | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 0 | |
| Subtotal | 705 | | | 757 | 55 | 0 |
| Total | | 705 | | | 812 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1979 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 0 |
| 15. Reactor Cooling Systems | | 0 |
| 16. Steam generation systems | | 1 |
| 31. Turbine and auxiliaries | | 3 |
| 32. Feedwater and Main Steam System | | 16 |
| 41. Main Generator Systems | | 22 |
| 42. Electrical Power Supply Systems | | 9 |
| Total | | 54 |

Highlights (2023)

26.08.2023: Power reduction to 50 % due to a unplanned closed turbine valve.
20.11.2023: Power reduction to 30 % due to a unplanned trip of a reactor coolant pump.

2023 Operating Experience

CH-5

LEIBSTADT

SWITZERLAND

Status at end of year : **Operational**
 Operator : KKL (KERNKRAFTWERK LEIBSTADT)
 Owner : KKL (KERNKRAFTWERK LEIBSTADT)
 Reactor Supplier : GETSCO (GENERAL ELECTRIC TECHNICAL SERVICES CO.)
 Turbine Supplier : BBC (BROWN BOVERI ET CIE)



Reactor Unit Details

Reactor type and model : BWR / BWR-6
 Thermal power : 3600 MWth
 Gross electrical power : 1275 MWe
 Reference unit power (net) : 1233 MWe

Key Dates

Construction Date : 1974-01-01
 Grid Date : 1984-05-24
 Commercial Date : 1984-12-15
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 18
 Average discharge burnup [MWd/t] : 43000
 Active core diameter [m] : 4.38
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 648
 Fuel linear heat generation rate [kW/m] : 13.3
 Number of control rod assemblies : 211
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.31
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : -
 Containment design pressure [MPa] : -

Secondary systems

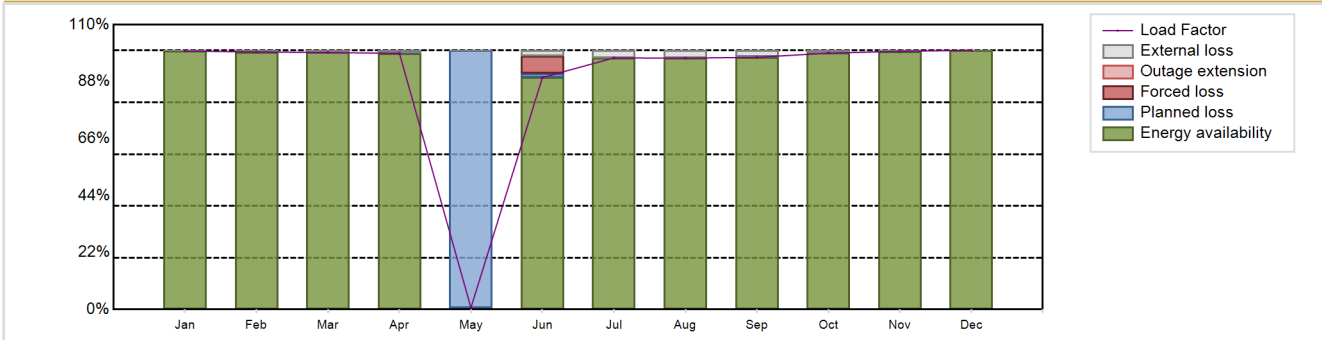
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.76
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9689.42 GW(e).h
 Energy Availability Factor (EAF) : 89.7 %
 Unit Capability Factor (UCF) : 90.81 %
 Load Factor (LF) : 89.71 %
 Operating Factor (OF) : 91.51 %
 Forced Loss Rate (FLR) : 0.61 %
 Unplanned Capability Loss Factor (UCL) : 0.56 %
 Planned Unavailability Factor (PUF) : 8.63 %
 Externally cause unavailability (XUF) : 1.11 %
 Total off-line time : 744 hours

Annual Summary

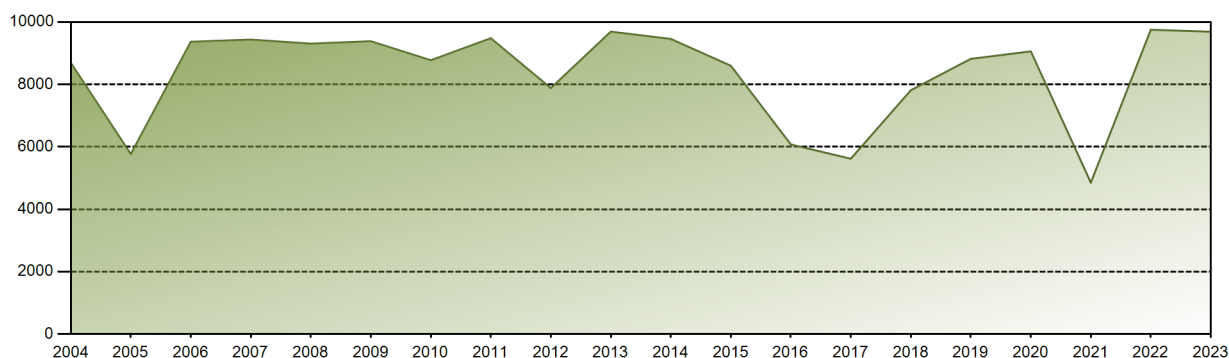


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 915.69 | 824.29 | 909.20 | 878.21 | 6.51 | 795.45 | 891.43 | 890.68 | 864.86 | 909.39 | 885.36 | 918.34 | 9689.42 |
| EAF [%] | 99.82 | 99.48 | 99.24 | 98.92 | 0.71 | 89.60 | 97.17 | 97.09 | 97.42 | 99.00 | 99.73 | 100.00 | 89.70 |
| UCF [%] | 100.00 | 99.80 | 99.88 | 99.84 | 0.72 | 91.68 | 100.00 | 100.00 | 99.81 | 100.00 | 99.76 | 100.00 | 90.81 |
| LF [%] | 99.82 | 99.48 | 99.24 | 98.92 | 0.71 | 89.60 | 97.17 | 97.09 | 97.42 | 99.00 | 99.73 | 100.11 | 89.71 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 3.09 | 96.81 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.51 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.61 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.56 |
| PUF [%] | 0.00 | 0.20 | 0.12 | 0.16 | 99.28 | 1.52 | 0.00 | 0.00 | 0.19 | 0.00 | 0.24 | 0.00 | 8.63 |
| XUF [%] | 0.18 | 0.32 | 0.63 | 0.91 | 0.01 | 2.08 | 2.83 | 2.91 | 2.39 | 1.00 | 0.03 | 0.00 | 1.11 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 317764.41 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.23 % |
| Cumulative Energy Availability Factor (EAF) | : 82.41 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.12 % |
| Cumulative Unit Capability Factor (UCF) | : 84 % | Cumulative Planned Unavailability Factor (PUF) | : 12.88 % |
| Cumulative Load Factor (LF) | : 82.56 % | Cumulative Externally cause unavailability (XUF) | : 1.58 % |
| Cumulative Operating Factor (OF) | : 86.06 % | | |

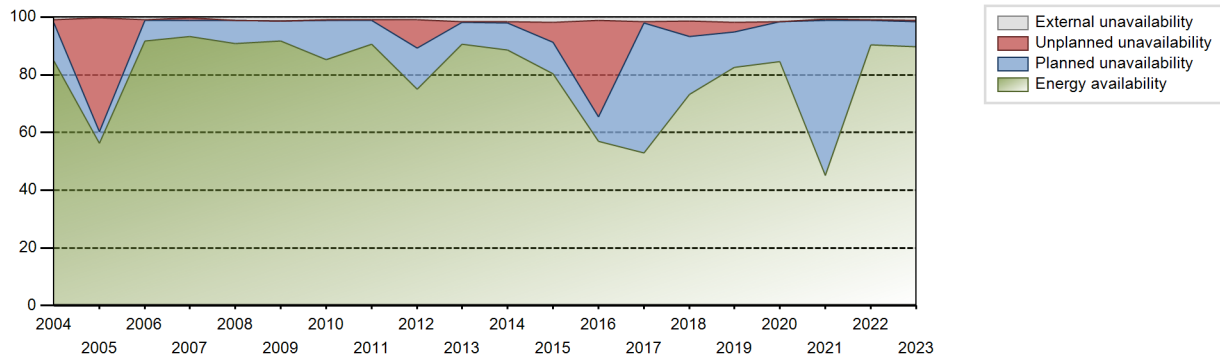
Electricity Production (net) [GWh]



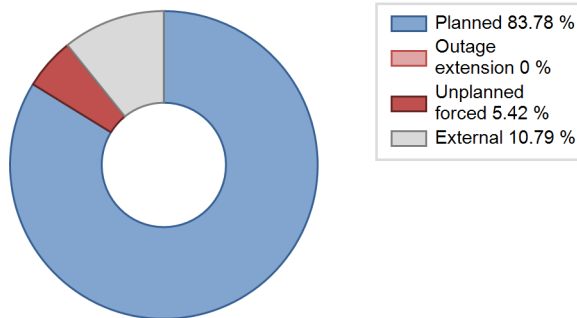
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|--------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 2.21 | 3361 | 1030 | 100.00 | 100.00 | 0.09 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1985 | 6769.30 | 7233 | 951 | 80.12 | 80.12 | 81.24 | 82.57 | 1.82 | 1.48 | 18.40 | 0.00 |
| 1986 | 7209.23 | 7668 | 957 | 83.24 | 83.24 | 85.91 | 87.53 | 1.10 | 0.93 | 15.83 | 0.00 |
| 1987 | 7376.42 | 7917 | 990 | 85.24 | 85.24 | 85.06 | 90.38 | 0.50 | 0.43 | 14.33 | 0.00 |
| 1988 | 7003.53 | 7536 | 990 | 79.99 | 79.99 | 80.54 | 85.79 | 1.29 | 1.05 | 18.96 | 0.00 |
| 1989 | 7364.21 | 7671 | 990 | 85.52 | 85.52 | 84.92 | 87.57 | 1.37 | 1.19 | 13.29 | 0.00 |
| 1990 | 7596.23 | 7905 | 990 | 89.85 | 89.85 | 87.59 | 90.24 | 0.44 | 0.40 | 9.75 | 0.00 |
| 1991 | 7060.30 | 7580 | 990 | 81.27 | 86.01 | 81.41 | 86.53 | 0.56 | 0.48 | 13.51 | 4.74 |
| 1992 | 7537.62 | 7986 | 990 | 86.44 | 90.38 | 86.68 | 90.92 | 0.60 | 0.55 | 9.08 | 3.93 |
| 1993 | 7338.05 | 7898 | 990 | 84.38 | 89.14 | 84.61 | 90.16 | 0.46 | 0.41 | 10.44 | 4.76 |
| 1994 | 6988.22 | 7108 | 1003 | 79.42 | 81.37 | 79.51 | 81.14 | 1.34 | 1.10 | 17.53 | 1.95 |
| 1995 | 7673.83 | 7819 | 1030 | 84.18 | 89.07 | 85.05 | 89.26 | 1.53 | 1.38 | 9.55 | 4.89 |
| 1996 | 7705.13 | 7734 | 1030 | 84.75 | 87.58 | 85.16 | 88.05 | 0.17 | 0.15 | 12.26 | 2.83 |
| 1997 | 7762.50 | 7830 | 1030 | 86.20 | 89.23 | 86.03 | 89.38 | 0.69 | 0.62 | 10.15 | 3.03 |
| 1998 | 8046.20 | 8102 | 1030 | 88.21 | 92.35 | 89.18 | 92.49 | 0.03 | 0.03 | 7.62 | 4.14 |
| 1999 | 8319.99 | 8126 | 1080 | 86.82 | 91.82 | 87.94 | 92.76 | 0.01 | 0.01 | 8.17 | 5.00 |
| 2000 | 8823.19 | 8159 | 1115 | 89.48 | 92.32 | 90.09 | 92.88 | 0.50 | 0.47 | 7.21 | 2.84 |
| 2001 | 9089.77 | 8187 | 1115 | 90.38 | 91.17 | 93.06 | 93.46 | 0.22 | 0.20 | 8.63 | 0.78 |
| 2002 | 9173.83 | 8250 | 1115 | 90.83 | 91.47 | 93.92 | 94.18 | 1.83 | 1.71 | 6.83 | 0.64 |
| 2003 | 9309.34 | 8204 | 1165 | 90.08 | 90.92 | 91.21 | 93.64 | 0.00 | 0.00 | 9.08 | 0.84 |
| 2004 | 8692.04 | 7633 | 1165 | 84.89 | 85.74 | 84.94 | 86.90 | 1.33 | 1.16 | 13.10 | 0.86 |
| 2005 | 5768.08 | 5004 | 1165 | 56.34 | 56.51 | 56.51 | 57.12 | 41.21 | 39.61 | 3.88 | 0.17 |
| 2006 | 9367.04 | 8206 | 1165 | 91.70 | 92.72 | 91.79 | 93.68 | 0.02 | 0.02 | 7.26 | 1.02 |
| 2007 | 9436.80 | 8276 | 1165 | 93.23 | 93.43 | 92.46 | 94.46 | 1.09 | 1.03 | 5.55 | 0.20 |
| 2008 | 9307.65 | 8119 | 1165 | 90.72 | 91.86 | 90.95 | 92.43 | 0.07 | 0.06 | 8.07 | 1.14 |
| 2009 | 9385.05 | 8203 | 1165 | 91.69 | 93.12 | 91.96 | 93.64 | 0.04 | 0.03 | 6.85 | 1.42 |
| 2010 | 8774.54 | 7640 | 1165 | 85.14 | 86.14 | 85.98 | 87.21 | 0.30 | 0.26 | 13.60 | 1.00 |
| 2011 | 9481.35 | 8094 | 1190 | 90.71 | 91.56 | 90.95 | 92.40 | 0.22 | 0.21 | 8.24 | 0.84 |
| 2012 | 7881.30 | 6746 | 1190 | 74.92 | 75.92 | 75.40 | 76.80 | 0.13 | 9.82 | 14.26 | 1.00 |
| 2013 | 9691.67 | 8150 | 1220 | 90.59 | 92.15 | 90.68 | 93.04 | 0.20 | 0.18 | 7.66 | 1.56 |
| 2014 | 9457.60 | 7970 | 1220 | 88.49 | 90.08 | 88.49 | 90.98 | 0.51 | 0.46 | 9.46 | 1.59 |
| 2015 | 8598.52 | 7322 | 1220 | 80.45 | 82.39 | 80.45 | 83.57 | 7.57 | 6.75 | 10.87 | 1.94 |
| 2016 | 6075.41 | 5147 | 1220 | 57.01 | 58.19 | 56.70 | 58.60 | 0.00 | 33.33 | 8.48 | 1.18 |
| 2017 | 5618.75 | 5347 | 1220 | 52.86 | 54.52 | 52.57 | 61.04 | 0.65 | 0.36 | 45.13 | 1.66 |
| 2018 | 7812.96 | 7658 | 1220 | 73.11 | 74.43 | 73.11 | 87.42 | 6.86 | 5.48 | 20.09 | 1.32 |
| 2019 | 8819.52 | 7792 | 1220 | 82.54 | 84.38 | 82.52 | 88.95 | 3.67 | 3.22 | 12.40 | 1.84 |
| 2020 | 9058.71 | 7727 | 1220 | 84.53 | 86.02 | 84.53 | 87.97 | 0.04 | 0.03 | 13.95 | 1.49 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 4851.90 | 4102 | 1220 | 45.03 | 45.80 | 45.40 | 46.83 | 0.74 | 0.34 | 53.86 | 0.40 |
| 2022 | 9753.38 | 8048 | 1233 | 90.28 | 91.23 | 90.30 | 91.87 | 0.26 | 0.24 | 8.53 | 0.95 |
| 2023 | 9689.42 | 8016 | 1233 | 89.70 | 90.81 | 89.71 | 91.51 | 0.61 | 0.56 | 8.63 | 1.11 |

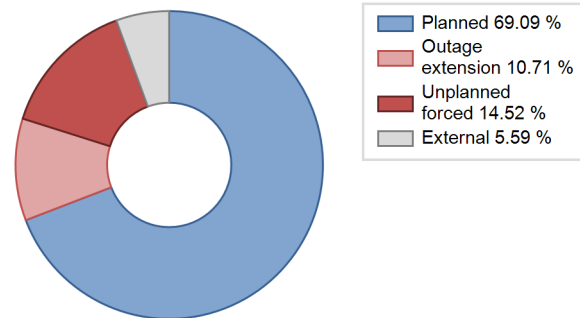
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 23 | | | 255 | |
| C. Inspection, maintenance or repair combined with refuelling | 720 | | | 910 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 11 | | |
| E. Testing of plant systems or components | | | | 0 | 1 | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| L. Human factor related | | | | | 5 | |
| Z. Other | | | | 2 | | |
| Subtotal | 720 | 23 | | 923 | 262 | |
| Total | | 743 | | | 1185 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 99 |
| 12. Reactor I&C Systems | | 4 |
| 14. Safety Systems | | 11 |
| 15. Reactor Cooling Systems | | 3 |
| 16. Steam generation systems | | 2 |
| 31. Turbine and auxiliaries | 23 | 19 |
| 32. Feedwater and Main Steam System | | 7 |
| 34. Miscellaneous Systems | | 2 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 111 |
| Total | 23 | 260 |

2023 Operating Experience

TW-4 **KUOSHENG-2** **TAIWAN, CHINA**

Status at end of year : **Permanent Shutdown**
 Operator : TPC (Taiwan Power Co.)
 Owner : TPC (Taiwan Power Co.)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)

| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-6 | Construction Date | : 1976-03-15 |
| Thermal power | : 2894 MWth | Grid Date | : 1982-06-29 |
| Gross electrical power | : 985 MWe | Commercial Date | : 1983-03-16 |
| Reference unit power (net) | : 985 MWe | Age at end of year | : 41 years |

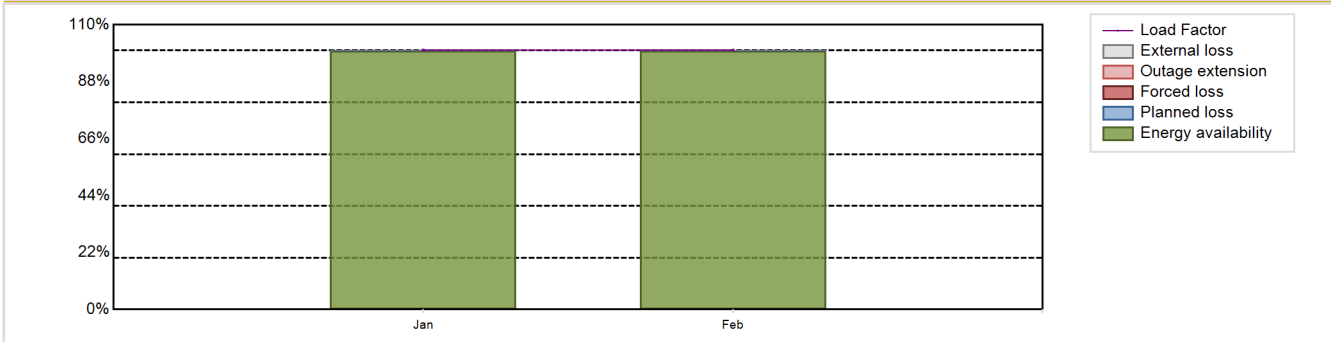
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 7.32 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 284 |
| Refuelling type | : OFF-line | Number of SG | : NA |
| Moderator material | : H2O | Containment type | : - |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 1.06 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 29 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : - | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 4.18 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.81 | HP cylinder inlet steam pressure [MPa] | : 6.64 |
| Number of fissile fuel assemblies/bundles | : 624 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 145 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 1720.15 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.93 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 99.93 % | Planned Unavailability Factor (PUF) | : 0.07 % |
| Load Factor (LF) | : 100.18 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 6 hours |

Annual Summary

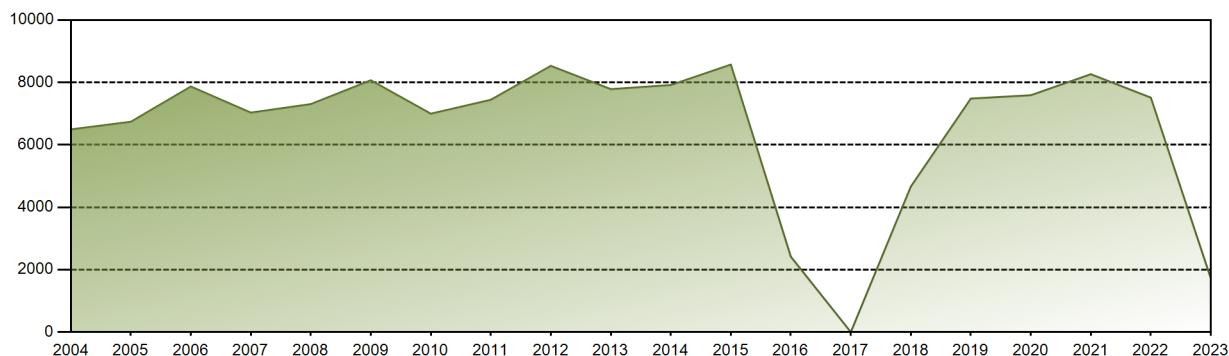


| | Oct | Nov | Dec | Mar | Apr | May | Jun | Jul | Sep | Aug | Jan | Feb | Annual |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|--------|---------|
| GW(e)-h | | | | | | | | | | | 734.12 | 663.11 | 1397.22 |
| EAF [%] | | | | | | | | | | | 99.94 | 99.92 | 99.93 |
| UCF [%] | | | | | | | | | | | 99.94 | 99.92 | 99.93 |
| LF [%] | | | | | | | | | | | 100.17 | 100.18 | 100.18 |
| OF [%] | | | | | | | | | | | 100.00 | 100.00 | 100.00 |
| FLR [%] | | | | | | | | | | | 0.00 | 0.00 | 0.00 |
| UCL [%] | | | | | | | | | | | 0.00 | 0.00 | 0.00 |
| PUF [%] | | | | | | | | | | | 0.06 | 0.08 | 0.07 |
| XUF [%] | | | | | | | | | | | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 266066.92 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.34 % |
| Cumulative Energy Availability Factor (EAF) | : 83.89 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.04 % |
| Cumulative Unit Capability Factor (UCF) | : 84.84 % | Cumulative Planned Unavailability Factor (PUF) | : 13.12 % |
| Cumulative Load Factor (LF) | : 79.53 % | Cumulative Externally cause unavailability (XUF) | : 0.95 % |
| Cumulative Operating Factor (OF) | : 82.76 % | | |

Electricity Production (net) [GWh]

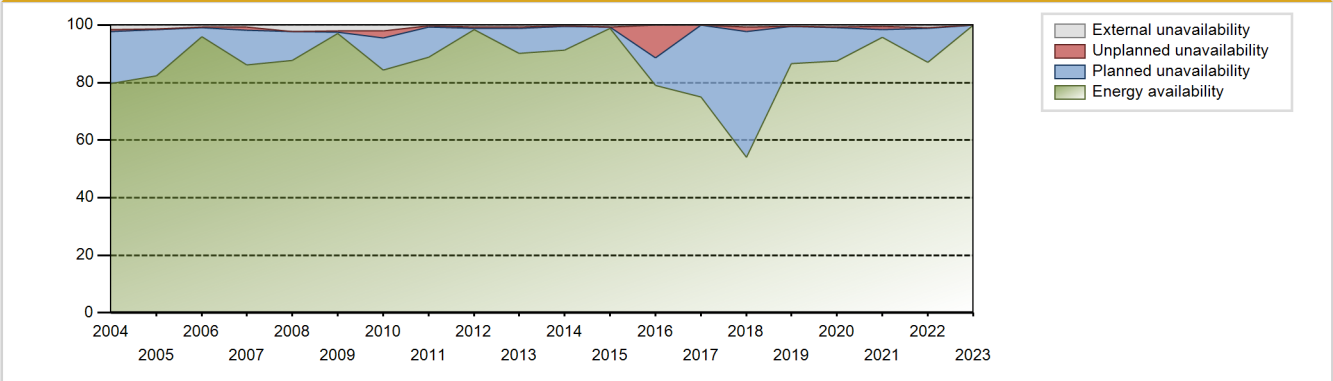


Performance for Years of Commercial Operation

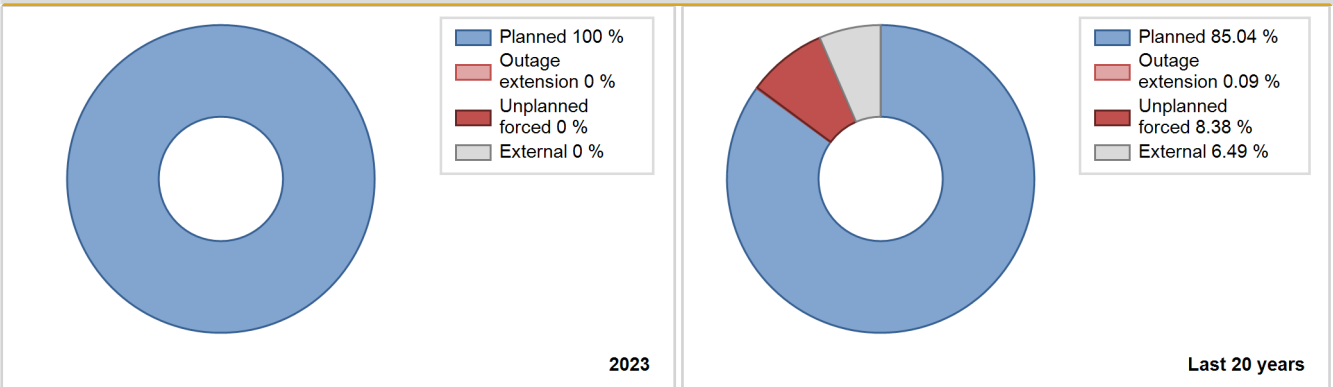
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|-------------------|---------------------------|---------------------------------|-------|-------|-------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | Data not provided | | | | | | | | | | |
| 1984 | | | | | | | | | | | |
| 1985 | | | | | | | | | | | |
| 1986 | | | | | | | | | | | |
| 1987 | | | | | | | | | | | |
| 1988 | | | | | | | | | | | |
| 1989 | 5227.30 | 6390 | 951 | 61.88 | 65.32 | 62.75 | 72.95 | 6.82 | 4.78 | 29.90 | 3.43 |
| 1990 | 6000.55 | 6819 | 936 | 73.46 | 73.99 | 73.18 | 77.84 | 2.86 | 2.18 | 23.83 | 0.53 |
| 1991 | 7186.35 | 8101 | 951 | 89.34 | 89.34 | 86.26 | 92.48 | 1.90 | 1.73 | 8.93 | 0.00 |
| 1992 | 6176.28 | 6985 | 951 | 76.77 | 76.77 | 73.94 | 79.52 | 4.16 | 3.33 | 19.89 | 0.00 |
| 1993 | 6138.11 | 6921 | 951 | 74.94 | 74.94 | 73.68 | 79.01 | 5.10 | 4.03 | 21.03 | 0.00 |
| 1994 | 6224.08 | 6868 | 950 | 74.80 | 76.04 | 74.79 | 78.40 | 2.42 | 1.89 | 22.07 | 1.24 |
| 1995 | 5999.72 | 6543 | 948 | 72.20 | 72.92 | 72.25 | 74.69 | 3.91 | 2.96 | 24.12 | 0.72 |
| 1996 | 7423.24 | 7978 | 948 | 89.61 | 90.03 | 89.14 | 90.82 | 1.76 | 1.61 | 8.36 | 0.42 |
| 1997 | 7087.25 | 7745 | 948 | 86.08 | 88.69 | 85.34 | 88.41 | 6.15 | 5.82 | 5.50 | 2.61 |
| 1998 | 6549.57 | 7242 | 948 | 79.35 | 80.27 | 78.87 | 82.67 | 4.52 | 3.80 | 15.93 | 0.92 |
| 1999 | 6831.88 | 7544 | 948 | 84.17 | 85.92 | 82.27 | 86.12 | 1.11 | 0.97 | 13.12 | 1.75 |
| 2000 | 7237.59 | 8234 | 948 | 89.28 | 91.45 | 86.91 | 93.74 | 7.11 | 7.00 | 1.55 | 2.16 |
| 2001 | 5976.73 | 6772 | 948 | 72.43 | 74.10 | 71.97 | 77.31 | 4.93 | 3.84 | 22.06 | 1.67 |
| 2002 | 6922.55 | 7530 | 948 | 85.05 | 85.47 | 83.36 | 85.96 | 0.00 | 0.00 | 14.53 | 0.42 |
| 2003 | 7623.10 | 8427 | 948 | 93.52 | 93.68 | 91.80 | 96.20 | 4.62 | 4.54 | 1.78 | 0.16 |
| 2004 | 6493.97 | 7301 | 948 | 79.75 | 81.29 | 77.98 | 83.12 | 0.95 | 0.78 | 17.93 | 1.54 |
| 2005 | 6737.82 | 7424 | 948 | 82.26 | 83.53 | 81.13 | 84.75 | 0.22 | 0.42 | 16.04 | 1.27 |
| 2006 | 7868.39 | 8560 | 948 | 95.93 | 96.58 | 94.75 | 97.72 | 0.29 | 0.28 | 3.14 | 0.65 |
| 2007 | 7031.52 | 7716 | 948 | 86.07 | 86.74 | 84.67 | 88.08 | 1.22 | 1.07 | 12.18 | 0.67 |
| 2008 | 7304.97 | 8029 | 948 | 87.72 | 89.92 | 87.72 | 91.40 | 0.00 | 0.00 | 10.08 | 2.19 |
| 2009 | 8068.14 | 8739 | 948 | 97.15 | 99.22 | 97.15 | 99.76 | 0.33 | 0.33 | 0.45 | 2.07 |
| 2010 | 6997.81 | 7649 | 948 | 84.27 | 86.28 | 84.27 | 87.32 | 2.82 | 2.51 | 11.22 | 2.01 |
| 2011 | 7443.47 | 7909 | 985 | 88.78 | 89.13 | 89.34 | 90.29 | 0.43 | 0.39 | 10.49 | 0.35 |
| 2012 | 8530.25 | 8765 | 985 | 98.51 | 99.26 | 98.59 | 99.78 | 0.48 | 0.48 | 0.26 | 0.75 |
| 2013 | 7784.60 | 8057 | 985 | 90.16 | 90.96 | 90.22 | 91.97 | 0.49 | 0.45 | 8.59 | 0.80 |
| 2014 | 7917.00 | 8098 | 985 | 91.27 | 91.53 | 91.75 | 92.44 | 0.33 | 0.30 | 8.17 | 0.26 |
| 2015 | 8571.33 | 8760 | 985 | 98.86 | 99.59 | 99.34 | 100.00 | 0.07 | 0.07 | 0.34 | 0.73 |
| 2016 | 2415.47 | 2450 | 985 | 79.09 | 79.12 | 27.92 | 27.89 | 12.57 | 11.38 | 9.50 | 0.03 |
| 2017 | 0.00 | 0 | 985 | 75.07 | 75.07 | 0.00 | 0.00 | 0.00 | 0.00 | 24.93 | 0.00 |
| 2018 | 4661.56 | 4960 | 985 | 54.02 | 54.74 | 54.02 | 56.62 | 2.80 | 1.58 | 43.68 | 0.71 |
| 2019 | 7481.74 | 7712 | 985 | 86.59 | 87.02 | 86.71 | 88.04 | 0.06 | 0.05 | 12.94 | 0.43 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|--------|--------|------|------|-------|------|
| 2020 | 7589.27 | 7801 | 985 | 87.56 | 88.16 | 87.71 | 88.81 | 0.34 | 0.30 | 11.53 | 0.61 |
| 2021 | 8263.28 | 8587 | 985 | 95.70 | 96.28 | 95.77 | 98.03 | 0.97 | 0.95 | 2.78 | 0.57 |
| 2022 | 7512.73 | 7793 | 985 | 87.03 | 88.04 | 87.07 | 88.96 | 0.09 | 0.08 | 11.88 | 1.02 |
| 2023 | 1720.15 | 1746 | 985 | 99.93 | 99.93 | 100.18 | 100.00 | 0.00 | 0.00 | 0.07 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|------------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 115 | |
| B. Refuelling without maintenance | | | | 32 | | |
| C. Inspection, maintenance or repair combined with refuelling | 6 | | | 762 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 238 | | |
| E. Testing of plant systems or components | | | | 12 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 6 |
| L. Human factor related | | | | | 11 | |
| M. Governmental requirements or court decisions | | | | | | 325 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 9 |
| Z. Other | | | | | 1 | 1 |
| Subtotal | 6 | | | 1044 | 127 | 341 |
| Total | | 6 | | | 1512 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 28 |
| 12. Reactor I&C Systems | | 6 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 3 |
| 15. Reactor Cooling Systems | | 13 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 10 |
| 32. Feedwater and Main Steam System | | 20 |
| 33. Circulating Water System | | 4 |
| 35. All other I&C Systems | | 6 |
| 41. Main Generator Systems | | 4 |
| 42. Electrical Power Supply Systems | | 362 |
| Total | | 459 |

2023 Operating Experience

TW-5 **MAANSHAN-1** **TAIWAN, CHINA**

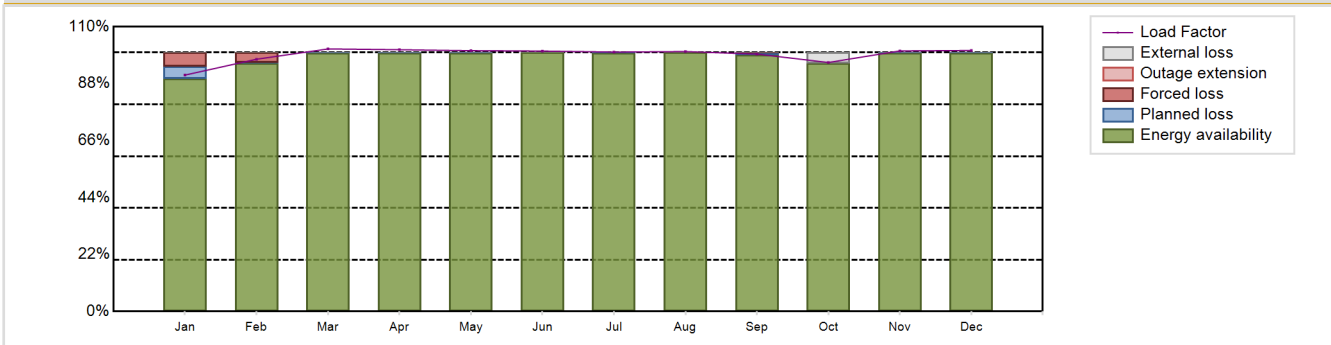
Status at end of year : **Operational**
 Operator : TPC (Taiwan Power Co.)
 Owner : TPC (Taiwan Power Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP (WE 312) | Construction Date | : 1978-08-21 |
| Thermal power | : 2822 MWth | Grid Date | : 1984-05-09 |
| Gross electrical power | : 951 MWe | Commercial Date | : 1984-07-27 |
| Reference unit power (net) | : 936 MWe | Age at end of year | : 39 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.7 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 328.7 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 4.22 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 3 |
| Part of the core refuelled [%] | : 40 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 43000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 6.56 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.75 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 28 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|------------|
| Net Energy Production | : 8133.04 GW(e).h | Forced Loss Rate (FLR) | : 0.77 % |
| Energy Availability Factor (EAF) | : 98.37 % | Unplanned Capability Loss Factor (UCL) | : 0.77 % |
| Unit Capability Factor (UCF) | : 98.73 % | Planned Unavailability Factor (PUF) | : 0.5 % |
| Load Factor (LF) | : 99.19 % | Externally cause unavailability (XUF) | : 0.36 % |
| Operating Factor (OF) | : 99.36 % | Total off-line time | : 56 hours |

Annual Summary

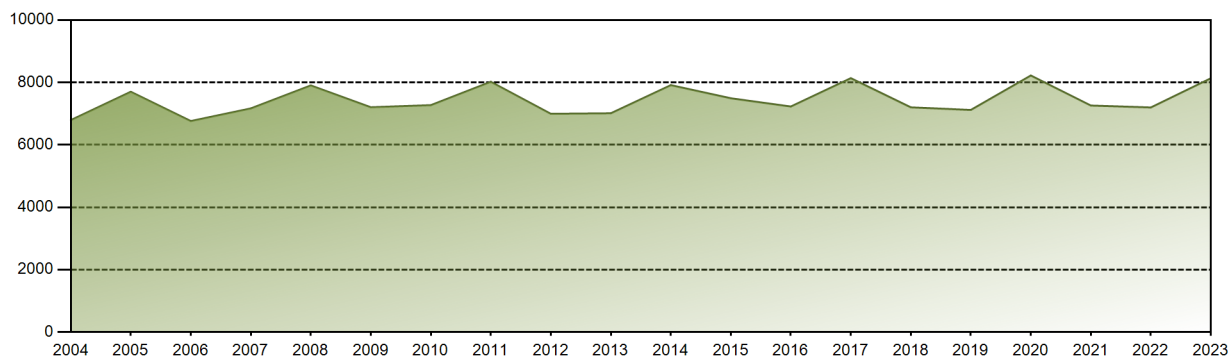


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 635.91 | 612.85 | 706.24 | 681.40 | 701.61 | 677.81 | 697.87 | 699.12 | 670.00 | 669.82 | 678.26 | 702.15 | 8133.04 |
| EAF [%] | 89.82 | 95.98 | 99.96 | 99.95 | 99.95 | 100.00 | 99.90 | 100.00 | 99.16 | 95.82 | 99.95 | 99.95 | 98.37 |
| UCF [%] | 89.82 | 95.98 | 99.96 | 99.95 | 99.95 | 100.00 | 99.90 | 100.00 | 99.16 | 100.00 | 99.95 | 99.95 | 98.73 |
| LF [%] | 91.32 | 97.43 | 101.42 | 101.11 | 100.75 | 100.58 | 100.21 | 100.39 | 99.42 | 96.19 | 100.64 | 100.83 | 99.19 |
| OF [%] | 96.64 | 97.17 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.39 | 100.00 | 100.00 | 99.36 |
| FLR [%] | 5.50 | 3.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | 0.00 | 0.00 | 0.00 | 0.77 |
| UCL [%] | 5.23 | 3.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | 0.00 | 0.00 | 0.00 | 0.77 |
| PUF [%] | 4.95 | 0.05 | 0.04 | 0.05 | 0.05 | 0.00 | 0.10 | 0.00 | 0.58 | 0.00 | 0.05 | 0.05 | 0.50 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.18 | 0.00 | 0.00 | 0.36 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 262209.72 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.67 % |
| Cumulative Energy Availability Factor (EAF) | : 87.16 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.49 % |
| Cumulative Unit Capability Factor (UCF) | : 88.11 % | Cumulative Planned Unavailability Factor (PUF) | : 9.4 % |
| Cumulative Load Factor (LF) | : 88.04 % | Cumulative Externally cause unavailability (XUF) | : 0.95 % |
| Cumulative Operating Factor (OF) | : 88.15 % | | |

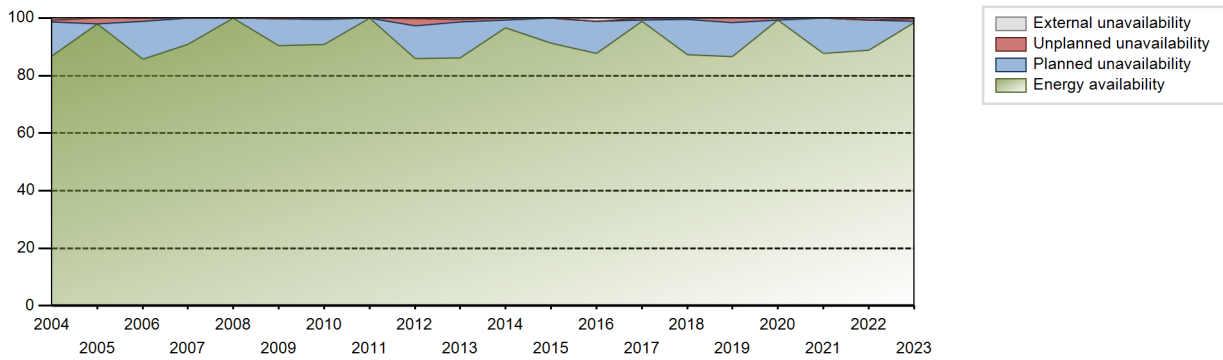
Electricity Production (net) [GWh]



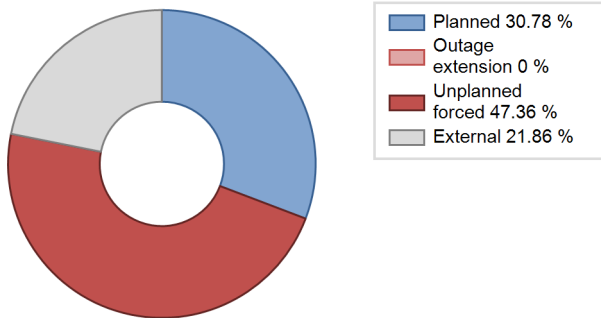
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | | | | Data not provided | | | | | | | |
| 1985 | | | | | | | | | | | |
| 1986 | | | | | | | | | | | |
| 1987 | | | | | | | | | | | |
| 1988 | | | | | | | | | | | |
| 1989 | 5418.45 | 6305 | 890 | 65.98 | 66.28 | 69.50 | 71.97 | 27.44 | 25.06 | 8.66 | 0.30 |
| 1990 | 6098.90 | 7079 | 894 | 76.76 | 77.76 | 77.88 | 80.81 | 4.19 | 3.40 | 18.84 | 1.00 |
| 1991 | 6479.06 | 7368 | 890 | 82.72 | 84.01 | 83.10 | 84.11 | 2.67 | 2.30 | 13.68 | 1.30 |
| 1992 | 6038.78 | 6826 | 890 | 76.16 | 76.75 | 77.24 | 77.71 | 1.02 | 0.79 | 22.47 | 0.58 |
| 1993 | 6258.75 | 6930 | 890 | 78.48 | 78.48 | 80.28 | 79.11 | 5.43 | 4.50 | 17.01 | 0.00 |
| 1994 | 6322.62 | 7098 | 890 | 79.62 | 79.75 | 81.10 | 81.03 | 3.76 | 3.11 | 17.14 | 0.13 |
| 1995 | 6741.14 | 7495 | 890 | 84.36 | 84.51 | 86.46 | 85.56 | 0.67 | 0.57 | 14.92 | 0.14 |
| 1996 | 7537.00 | 8329 | 890 | 93.79 | 95.81 | 96.41 | 94.82 | 3.80 | 3.79 | 0.41 | 2.02 |
| 1997 | 5949.22 | 6752 | 890 | 74.35 | 74.80 | 76.31 | 77.08 | 11.04 | 9.28 | 15.92 | 0.45 |
| 1998 | 5514.47 | 6101 | 890 | 69.16 | 69.16 | 70.73 | 69.65 | 20.87 | 18.23 | 12.61 | 0.00 |
| 1999 | 7392.65 | 8328 | 890 | 92.61 | 96.34 | 94.82 | 95.07 | 1.56 | 1.53 | 2.13 | 3.73 |
| 2000 | 6729.03 | 7502 | 890 | 84.33 | 84.59 | 86.07 | 85.41 | 0.69 | 0.59 | 14.82 | 0.26 |
| 2001 | 5333.31 | 6046 | 890 | 67.57 | 86.08 | 68.41 | 69.02 | 2.66 | 2.35 | 11.56 | 18.52 |
| 2002 | 7800.80 | 8726 | 890 | 98.70 | 98.85 | 100.06 | 99.61 | 0.24 | 0.24 | 0.91 | 0.15 |
| 2003 | 6751.01 | 7579 | 890 | 86.23 | 87.35 | 86.59 | 86.52 | 0.04 | 0.04 | 12.62 | 1.11 |
| 2004 | 6793.74 | 7742 | 890 | 86.79 | 87.41 | 86.90 | 88.14 | 0.17 | 0.83 | 11.76 | 0.62 |
| 2005 | 7701.72 | 8693 | 890 | 97.97 | 98.09 | 98.79 | 99.24 | 1.88 | 1.88 | 0.04 | 0.11 |
| 2006 | 6763.25 | 7599 | 890 | 85.78 | 85.78 | 86.75 | 86.75 | 1.31 | 1.14 | 13.08 | 0.00 |
| 2007 | 7168.16 | 8001 | 890 | 90.81 | 90.86 | 91.94 | 91.34 | 0.09 | 0.08 | 9.06 | 0.06 |
| 2008 | 7904.88 | 8784 | 900 | 99.96 | 99.96 | 99.99 | 100.00 | 0.00 | 0.00 | 0.04 | 0.00 |
| 2009 | 7205.22 | 7959 | 918 | 90.31 | 90.52 | 90.33 | 90.86 | 0.07 | 0.06 | 9.41 | 0.21 |
| 2010 | 7272.45 | 8009 | 919 | 90.73 | 90.73 | 90.34 | 91.43 | 0.47 | 0.43 | 8.84 | 0.00 |
| 2011 | 8022.09 | 8760 | 918 | 99.87 | 99.91 | 99.76 | 100.00 | 0.00 | 0.00 | 0.09 | 0.03 |
| 2012 | 6994.76 | 7620 | 928 | 86.02 | 86.24 | 86.27 | 86.75 | 0.88 | 2.53 | 11.23 | 0.22 |
| 2013 | 7011.65 | 7615 | 926 | 86.11 | 86.62 | 86.44 | 86.93 | 0.98 | 0.86 | 12.53 | 0.51 |
| 2014 | 7913.59 | 8517 | 926 | 96.64 | 96.65 | 97.56 | 97.23 | 0.56 | 0.65 | 2.71 | 0.01 |
| 2015 | 7492.71 | 8035 | 936 | 91.27 | 91.27 | 91.38 | 91.72 | 0.01 | 0.01 | 8.72 | 0.00 |
| 2016 | 7228.08 | 7799 | 936 | 87.79 | 88.92 | 87.91 | 88.79 | 0.02 | 0.02 | 11.06 | 1.13 |
| 2017 | 8136.28 | 8682 | 936 | 98.85 | 98.85 | 99.23 | 99.11 | 0.74 | 0.73 | 0.42 | 0.00 |
| 2018 | 7201.98 | 7681 | 936 | 87.27 | 87.27 | 87.84 | 87.68 | 0.52 | 0.45 | 12.28 | 0.00 |
| 2019 | 7118.57 | 7652 | 936 | 86.50 | 86.61 | 86.82 | 87.35 | 1.75 | 1.54 | 11.84 | 0.12 |
| 2020 | 8222.12 | 8728 | 936 | 99.19 | 99.19 | 100.00 | 99.36 | 0.74 | 0.74 | 0.07 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 7259.81 | 7716 | 936 | 87.75 | 87.75 | 88.54 | 88.08 | 0.03 | 0.03 | 12.22 | 0.00 |
| 2022 | 7197.97 | 7677 | 936 | 88.73 | 89.40 | 87.79 | 87.64 | 0.00 | 0.00 | 10.60 | 0.67 |
| 2023 | 8133.04 | 8704 | 936 | 98.37 | 98.73 | 99.19 | 99.36 | 0.77 | 0.77 | 0.50 | 0.36 |

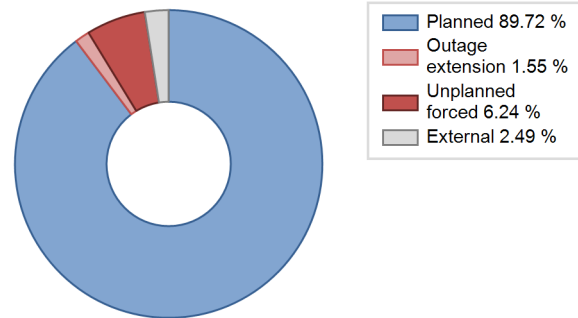
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 27 | | | 182 | |
| B. Refuelling without maintenance | | | | 22 | | |
| C. Inspection, maintenance or repair combined with refuelling | 17 | | | 755 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 15 | | |
| E. Testing of plant systems or components | | | | 5 | | |
| H. Nuclear regulatory requirements | | | | | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 48 |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 12 | | | 5 |
| Z. Other | | | | | | 5 |
| Subtotal | 17 | 27 | 12 | 797 | 188 | 58 |
| Total | | 56 | | | 1043 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 60 |
| 13. Reactor Auxiliary Systems | | 6 |
| 15. Reactor Cooling Systems | | 16 |
| 16. Steam generation systems | | 16 |
| 31. Turbine and auxiliaries | 8 | 12 |
| 32. Feedwater and Main Steam System | | 6 |
| 33. Circulating Water System | 19 | 1 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 50 |
| 42. Electrical Power Supply Systems | | 27 |
| Total | 27 | 194 |

Highlights (2023)

- 1.2023-01-01 00:00 EOC-27 refueling outage.
- 2.2023-01-07 08:35 Unit off-line repair main turbine High vibration.
- 3.2023-02-26 07:20 Unit off-line repair AD-P010 Leakage of mechanical shaft seals.
- 4.2023-10-05 11:59 Typhoon Strikes,unit shutdown.

2023 Operating Experience

TW-6

MAANSHAN-2

TAIWAN, CHINA

Status at end of year : **Operational**
 Operator : TPC (Taiwan Power Co.)
 Owner : TPC (Taiwan Power Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP (WE 312) | Construction Date | : 1979-02-21 |
| Thermal power | : 2822 MWth | Grid Date | : 1985-02-25 |
| Gross electrical power | : 951 MWe | Commercial Date | : 1985-05-18 |
| Reference unit power (net) | : 938 MWe | Age at end of year | : 38 years |

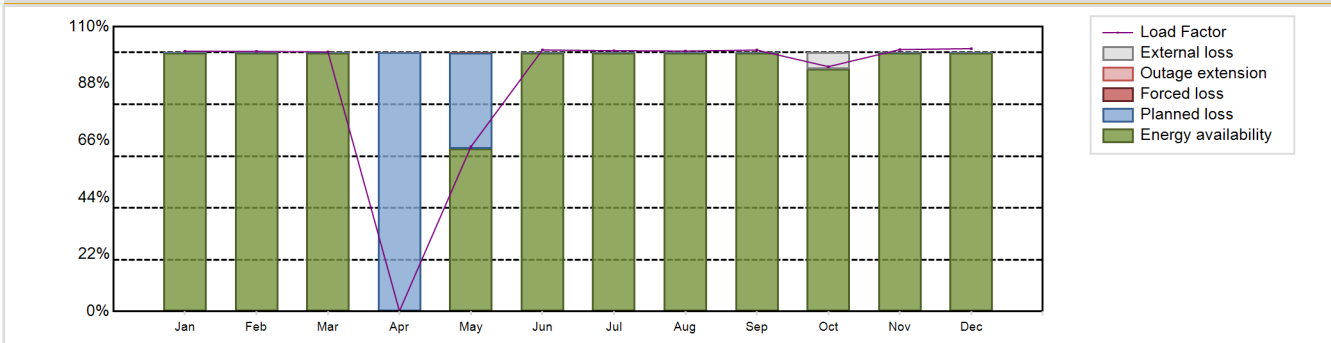
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.7 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 326 |
| Refuelling type | : OFF-line | Number of SG | : 3 |
| Moderator material | : H2O | Containment type | : - |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 4.22 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 40 | Number of turbine-generators per unit/reactor | : 3 |
| Average discharge burnup [MWd/t] | : 43000 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 3.04 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 6.56 |
| Number of fissile fuel assemblies/bundles | : 157 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.75 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 28 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 3 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 7300.69 GW(e).h | Forced Loss Rate (FLR) | : 0.01 % |
| Energy Availability Factor (EAF) | : 88.04 % | Unplanned Capability Loss Factor (UCL) | : 0.01 % |
| Unit Capability Factor (UCF) | : 88.58 % | Planned Unavailability Factor (PUF) | : 11.41 % |
| Load Factor (LF) | : 88.85 % | Externally cause unavailability (XUF) | : 0.54 % |
| Operating Factor (OF) | : 88.48 % | Total off-line time | : 1009 hours |

Annual Summary

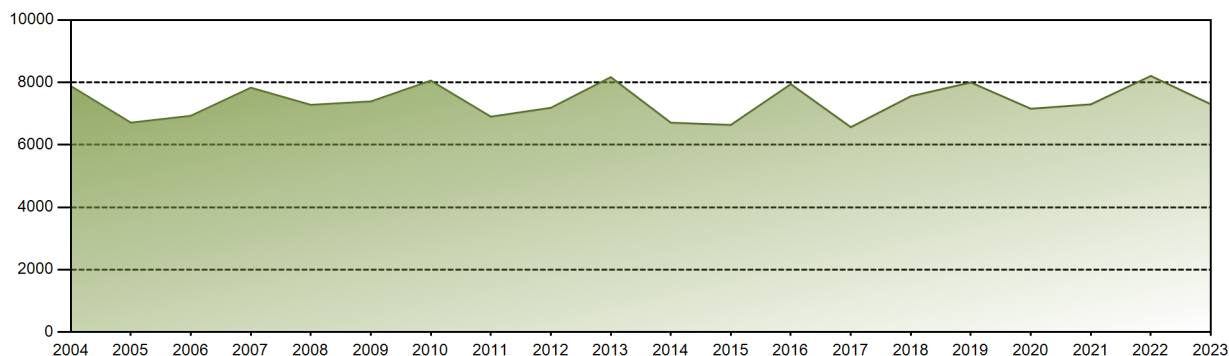


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 701.65 | 633.15 | 699.67 | 1.16 | 444.27 | 682.23 | 702.93 | 701.94 | 681.97 | 659.93 | 683.22 | 708.56 | 7300.69 |
| EAF [%] | 99.95 | 99.94 | 99.83 | 0.17 | 62.88 | 99.95 | 99.95 | 99.74 | 99.96 | 93.67 | 99.96 | 99.96 | 88.04 |
| UCF [%] | 99.95 | 99.94 | 99.83 | 0.17 | 62.88 | 99.95 | 99.95 | 99.74 | 99.96 | 100.00 | 99.96 | 99.96 | 88.58 |
| LF [%] | 100.54 | 100.45 | 100.26 | 0.17 | 63.66 | 101.02 | 100.72 | 100.58 | 100.98 | 94.56 | 101.16 | 101.53 | 88.85 |
| OF [%] | 100.00 | 100.00 | 100.00 | 0.56 | 65.46 | 100.00 | 100.00 | 100.00 | 100.00 | 95.16 | 100.00 | 100.00 | 88.48 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| PUF [%] | 0.05 | 0.06 | 0.17 | 99.83 | 37.04 | 0.05 | 0.05 | 0.26 | 0.04 | 0.00 | 0.04 | 0.04 | 11.41 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.33 | 0.00 | 0.00 | 0.54 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 263896.84 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.94 % |
| Cumulative Energy Availability Factor (EAF) | : 86.7 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.23 % |
| Cumulative Unit Capability Factor (UCF) | : 87.84 % | Cumulative Planned Unavailability Factor (PUF) | : 9.92 % |
| Cumulative Load Factor (LF) | : 87.91 % | Cumulative Externally cause unavailability (XUF) | : 1.14 % |
| Cumulative Operating Factor (OF) | : 88.44 % | | |

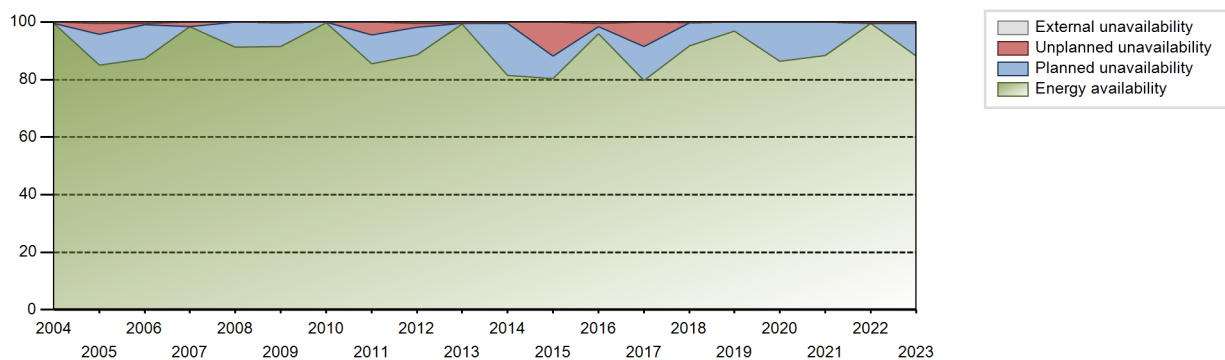
Electricity Production (net) [GWh]



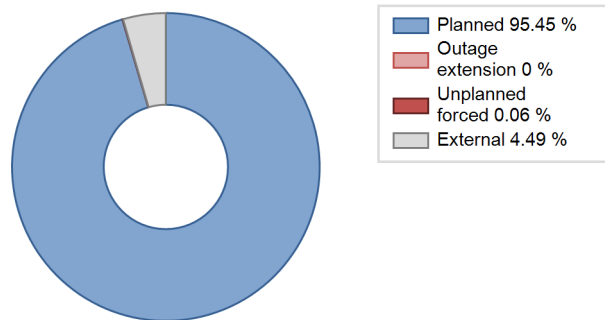
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | | | | Data not provided | | | | | | | |
| 1986 | | | | | | | | | | | |
| 1987 | | | | | | | | | | | |
| 1988 | | | | | | | | | | | |
| 1989 | 5283.33 | 6434 | 890 | 58.14 | 58.84 | 67.77 | 73.45 | 17.86 | 12.79 | 28.37 | 0.70 |
| 1990 | 6141.34 | 7143 | 896 | 77.26 | 78.82 | 78.24 | 81.54 | 3.72 | 3.05 | 18.13 | 1.56 |
| 1991 | 6187.13 | 7155 | 890 | 78.61 | 80.42 | 79.36 | 81.68 | 2.75 | 2.28 | 17.30 | 1.82 |
| 1992 | 5956.55 | 7541 | 890 | 75.50 | 84.28 | 76.19 | 85.85 | 0.35 | 0.29 | 15.43 | 8.78 |
| 1993 | 6550.99 | 7442 | 890 | 84.08 | 84.08 | 84.03 | 84.95 | 1.93 | 1.66 | 14.26 | 0.01 |
| 1994 | 7006.49 | 8216 | 890 | 88.69 | 93.29 | 89.87 | 93.79 | 2.78 | 2.67 | 4.04 | 4.60 |
| 1995 | 6118.58 | 6947 | 890 | 77.09 | 77.14 | 78.48 | 79.30 | 3.77 | 3.02 | 19.84 | 0.05 |
| 1996 | 6349.81 | 7091 | 890 | 79.75 | 80.99 | 81.22 | 80.73 | 5.79 | 4.98 | 14.03 | 1.24 |
| 1997 | 6415.41 | 7153 | 890 | 81.14 | 81.56 | 82.29 | 81.66 | 4.22 | 3.60 | 14.84 | 0.42 |
| 1998 | 7781.11 | 8557 | 890 | 97.23 | 97.39 | 99.80 | 97.68 | 1.53 | 1.51 | 1.09 | 0.17 |
| 1999 | 6628.36 | 7427 | 890 | 82.72 | 85.28 | 85.02 | 84.78 | 1.07 | 0.92 | 13.79 | 2.57 |
| 2000 | 6618.56 | 7401 | 890 | 82.59 | 84.10 | 84.66 | 84.26 | 1.54 | 1.32 | 14.58 | 1.51 |
| 2001 | 6993.79 | 7729 | 890 | 87.34 | 99.36 | 89.71 | 88.23 | 0.61 | 0.61 | 0.02 | 12.02 |
| 2002 | 6639.81 | 7507 | 890 | 82.42 | 82.42 | 85.17 | 85.70 | 3.83 | 3.28 | 14.30 | 0.00 |
| 2003 | 6737.60 | 7549 | 890 | 85.15 | 86.59 | 86.42 | 86.18 | 2.29 | 2.03 | 11.38 | 1.44 |
| 2004 | 7882.97 | 8784 | 890 | 99.51 | 99.55 | 100.83 | 100.00 | 0.40 | 0.40 | 0.05 | 0.03 |
| 2005 | 6709.97 | 7656 | 890 | 85.07 | 85.47 | 86.06 | 87.40 | 4.44 | 3.97 | 10.56 | 0.40 |
| 2006 | 6928.78 | 7729 | 890 | 87.23 | 87.69 | 88.87 | 88.23 | 0.47 | 0.41 | 11.90 | 0.46 |
| 2007 | 7829.87 | 8631 | 890 | 98.32 | 98.32 | 100.43 | 98.53 | 1.61 | 1.61 | 0.07 | 0.00 |
| 2008 | 7280.02 | 8036 | 908 | 91.25 | 91.25 | 91.28 | 91.48 | 0.01 | 0.01 | 8.73 | 0.00 |
| 2009 | 7389.24 | 8074 | 921 | 91.55 | 91.78 | 91.59 | 92.17 | 0.03 | 0.03 | 8.19 | 0.23 |
| 2010 | 8056.90 | 8760 | 922 | 99.81 | 99.81 | 99.75 | 100.00 | 0.12 | 0.12 | 0.08 | 0.00 |
| 2011 | 6901.46 | 7581 | 922 | 85.49 | 85.49 | 85.45 | 86.54 | 5.00 | 4.50 | 10.01 | 0.00 |
| 2012 | 7185.04 | 7851 | 922 | 88.67 | 89.10 | 88.72 | 89.38 | 0.00 | 1.31 | 9.59 | 0.43 |
| 2013 | 8167.87 | 8728 | 928 | 99.38 | 99.86 | 100.47 | 99.63 | 0.00 | 0.00 | 0.14 | 0.48 |
| 2014 | 6708.52 | 7198 | 928 | 81.42 | 81.43 | 82.52 | 82.17 | 0.69 | 0.57 | 18.01 | 0.01 |
| 2015 | 6637.10 | 7048 | 938 | 80.35 | 80.35 | 80.77 | 80.46 | 5.93 | 11.85 | 7.80 | 0.00 |
| 2016 | 7944.16 | 8472 | 938 | 95.89 | 96.40 | 96.42 | 96.45 | 0.32 | 1.11 | 2.49 | 0.51 |
| 2017 | 6564.98 | 7021 | 938 | 79.64 | 79.64 | 79.90 | 80.15 | 0.85 | 8.54 | 11.82 | 0.00 |
| 2018 | 7556.50 | 8065 | 938 | 91.78 | 91.97 | 91.96 | 92.07 | 0.00 | 0.00 | 8.03 | 0.19 |
| 2019 | 7998.06 | 8507 | 938 | 96.81 | 96.81 | 97.34 | 97.11 | 0.00 | 0.00 | 3.19 | 0.00 |
| 2020 | 7156.32 | 7616 | 938 | 86.34 | 86.34 | 86.85 | 86.70 | 0.01 | 0.00 | 13.65 | 0.00 |
| 2021 | 7297.31 | 7783 | 938 | 88.38 | 88.38 | 88.81 | 88.85 | 0.01 | 0.01 | 11.61 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 8206.47 | 8731 | 938 | 99.55 | 99.94 | 99.87 | 99.67 | 0.00 | 0.00 | 0.06 | 0.39 |
| 2023 | 7300.69 | 7751 | 938 | 88.04 | 88.58 | 88.85 | 88.48 | 0.01 | 0.01 | 11.41 | 0.54 |

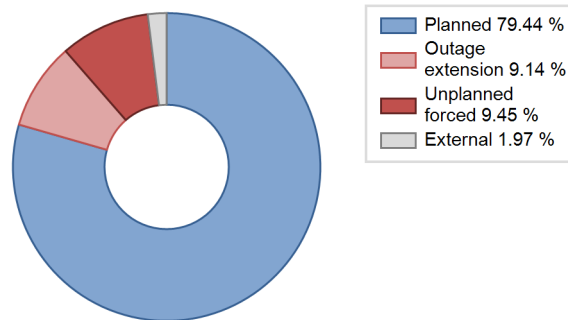
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 149 | |
| C. Inspection, maintenance or repair combined with refuelling | 972 | | | 823 | 2 | |
| D. Inspection, maintenance or repair without refuelling | | | | 8 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 29 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | 36 | | | 8 |
| Z. Other | | | | | 1 | |
| Subtotal | 972 | | 36 | 832 | 153 | 37 |
| Total | | 1008 | | | 1022 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 19 |
| 12. Reactor I&C Systems | | 29 |
| 13. Reactor Auxiliary Systems | | 3 |
| 15. Reactor Cooling Systems | | 23 |
| 16. Steam generation systems | | 5 |
| 31. Turbine and auxiliaries | | 13 |
| 32. Feedwater and Main Steam System | | 4 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 24 |
| 42. Electrical Power Supply Systems | | 58 |
| Total | | 182 |

Highlights (2023)

- 1.2023-04-01 04:17 unit off-line for EOC-27 refueling outage.
- 2.2023-10-04 23:21 Typhoon Strikes,unit shutdown.

2023 Operating Experience

UA-40 **KHMELNITSKI-1** **UKRAINE**

Status at end of year : **Operational**
 Operator : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Owner : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Reactor Supplier : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT
 ATOMMASH,VOLGODONSK,RUSSIA)
 Turbine Supplier : LMZ (JOINT-STOCK COMPANY "LENINGRADSKIY METALLICHESKIY ZAVOD")



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 1981-11-01 |
| Thermal power | : 3000 MWth | Grid Date | : 1987-12-31 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1988-08-13 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 36 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 16 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 322 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : DH |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

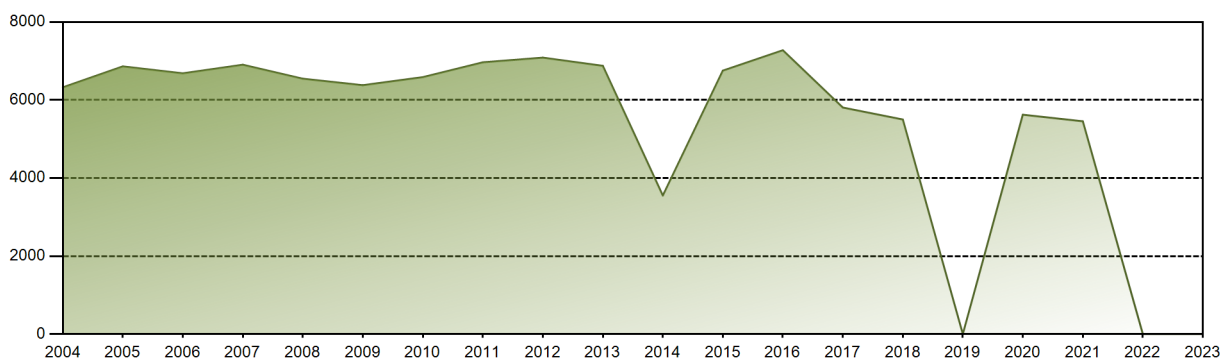
| Annual Summary | | | | | | | | | | | |
|----------------|--|--|--|--|--|--|--|--|--|--|--|
| No data found | | | | | | | | | | | |

| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

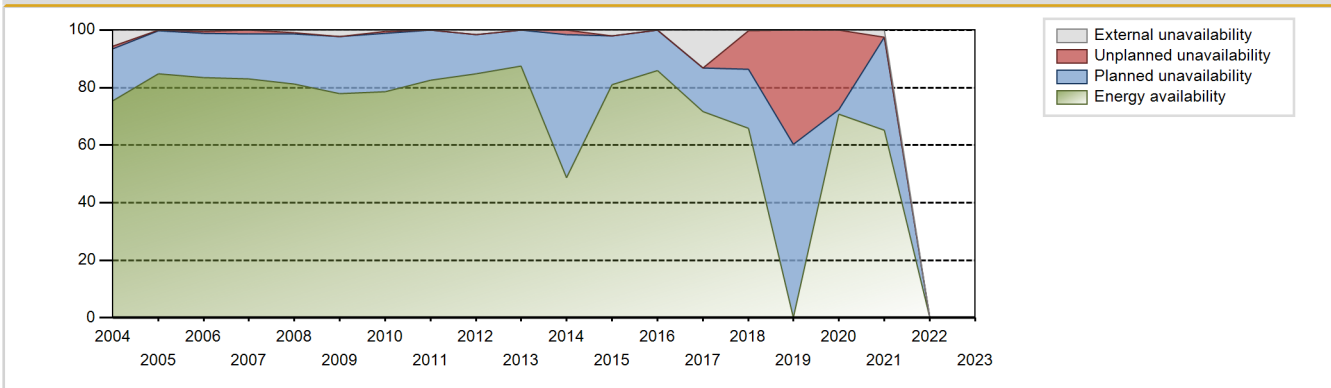
| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 3.39 % |
| Cumulative Energy Availability Factor (EAF) | : | 71.46 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 4.59 % |
| Cumulative Unit Capability Factor (UCF) | : | 72.69 % | Cumulative Planned Unavailability Factor (PUF) | : | 22.72 % |
| Cumulative Load Factor (LF) | : | 71.16 % | Cumulative Externally cause unavailability (XUF) | : | 1.23 % |
| Cumulative Operating Factor (OF) | : | 74.03 % | | | |

Electricity Production (net) [GWh]

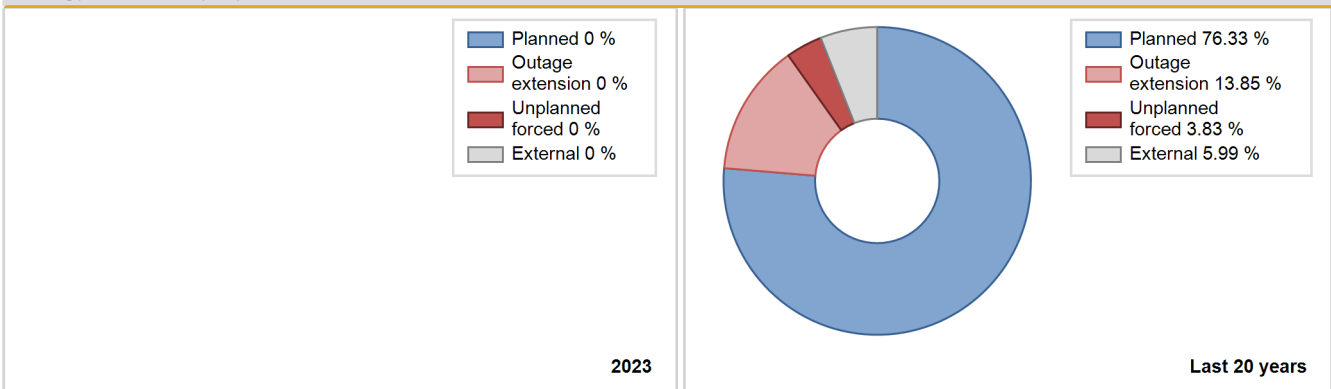


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 3578.19 | 5266 | 950 | 67.05 | 67.05 | 61.13 | 74.95 | 32.78 | 32.70 | 0.25 | 0.00 |
| 1989 | 5872.26 | 6295 | 950 | 70.62 | 70.68 | 70.56 | 71.86 | 6.04 | 4.54 | 24.78 | 0.06 |
| 1990 | 6498.57 | 6870 | 950 | 77.35 | 77.35 | 78.09 | 78.42 | 7.25 | 6.05 | 16.60 | 0.00 |
| 1991 | 5172.49 | 5551 | 950 | 61.23 | 61.23 | 62.15 | 63.37 | 11.34 | 7.83 | 30.94 | 0.00 |
| 1992 | 6075.13 | 6167 | 950 | 66.53 | 67.62 | 72.80 | 70.21 | 3.06 | 2.13 | 30.25 | 1.09 |
| 1993 | 5487.72 | 5782 | 950 | 65.22 | 65.22 | 65.94 | 66.00 | 7.10 | 4.98 | 29.79 | 0.00 |
| 1994 | 6303.41 | 6775 | 950 | 75.51 | 76.05 | 75.74 | 77.34 | 4.68 | 3.74 | 20.21 | 0.54 |
| 1995 | 5700.26 | 6014 | 950 | 67.98 | 68.00 | 68.50 | 68.65 | 2.15 | 1.49 | 30.51 | 0.02 |
| 1996 | 4497.91 | 4854 | 950 | 53.90 | 54.25 | 53.90 | 55.26 | 15.74 | 10.13 | 35.62 | 0.34 |
| 1997 | 6152.10 | 6415 | 950 | 72.56 | 72.78 | 73.93 | 73.23 | 7.87 | 6.21 | 21.01 | 0.22 |
| 1998 | 5499.20 | 5904 | 950 | 65.82 | 67.08 | 66.08 | 67.40 | 0.11 | 0.08 | 32.85 | 1.26 |
| 1999 | 5526.69 | 6506 | 950 | 66.37 | 66.77 | 66.41 | 74.27 | 1.38 | 0.94 | 32.30 | 0.39 |
| 2000 | 5899.61 | 6541 | 950 | 70.36 | 74.25 | 70.70 | 74.46 | 0.92 | 0.69 | 25.06 | 3.89 |
| 2001 | 6167.28 | 6781 | 950 | 73.63 | 76.47 | 73.91 | 77.20 | 4.40 | 3.52 | 20.01 | 2.84 |
| 2002 | 6730.45 | 7049 | 950 | 79.90 | 80.26 | 80.88 | 80.47 | 0.08 | 0.06 | 19.68 | 0.35 |
| 2003 | 7137.70 | 7512 | 950 | 84.89 | 85.42 | 85.77 | 85.75 | 0.42 | 0.36 | 14.23 | 0.52 |
| 2004 | 6325.09 | 6935 | 950 | 75.42 | 80.92 | 75.80 | 78.95 | 1.33 | 1.09 | 17.99 | 5.51 |
| 2005 | 6862.81 | 7433 | 950 | 84.80 | 84.86 | 82.47 | 84.85 | 0.29 | 0.24 | 14.89 | 0.06 |
| 2006 | 6684.91 | 7407 | 950 | 83.49 | 83.88 | 80.33 | 84.55 | 0.97 | 0.83 | 15.29 | 0.39 |
| 2007 | 6905.26 | 7297 | 950 | 83.01 | 83.11 | 82.98 | 83.30 | 0.30 | 1.17 | 15.72 | 0.10 |
| 2008 | 6547.17 | 7237 | 950 | 81.31 | 82.29 | 78.46 | 82.39 | 0.35 | 0.29 | 17.42 | 0.98 |
| 2009 | 6380.56 | 7031 | 950 | 77.84 | 80.05 | 76.67 | 80.26 | 0.19 | 0.15 | 19.81 | 2.20 |
| 2010 | 6587.15 | 6966 | 950 | 78.60 | 79.10 | 79.15 | 79.52 | 0.73 | 0.58 | 20.32 | 0.50 |
| 2011 | 6967.34 | 7253 | 950 | 82.61 | 82.63 | 83.72 | 82.80 | 0.00 | 0.00 | 17.37 | 0.02 |
| 2012 | 7087.23 | 7592 | 950 | 84.70 | 86.33 | 84.93 | 86.43 | 0.00 | 0.00 | 13.67 | 1.64 |
| 2013 | 6877.19 | 7681 | 950 | 87.43 | 87.47 | 82.64 | 87.68 | 0.00 | 0.00 | 12.53 | 0.04 |
| 2014 | 3551.74 | 5920 | 950 | 48.60 | 48.60 | 42.68 | 67.58 | 3.32 | 1.67 | 49.73 | 0.00 |
| 2015 | 6753.90 | 7307 | 950 | 80.97 | 83.01 | 81.16 | 83.41 | 0.09 | 0.08 | 16.91 | 2.04 |
| 2016 | 7276.34 | 7568 | 950 | 85.98 | 86.05 | 87.20 | 86.16 | 0.01 | 0.01 | 13.94 | 0.07 |
| 2017 | 5807.27 | 7443 | 950 | 71.65 | 84.94 | 69.78 | 84.97 | 0.00 | 0.00 | 15.06 | 13.30 |
| 2018 | 5501.15 | 5799 | 950 | 65.75 | 65.93 | 66.10 | 66.20 | 16.98 | 13.49 | 20.58 | 0.19 |
| 2019 | 0.00 | 0 | 950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 39.72 | 60.28 | 0.00 |
| 2020 | 5624.09 | 6255 | 950 | 70.86 | 70.86 | 67.40 | 71.21 | 0.22 | 27.58 | 1.56 | 0.01 |
| 2021 | 5455.12 | 5992 | 950 | 65.20 | 67.64 | 65.55 | 68.40 | 0.00 | 0.00 | 32.36 | 2.45 |
| 2022 | | | | Data not provided | | | | | | | |
| 2023 | | | | " | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 339 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1426 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 178 | | |
| E. Testing of plant systems or components | | | | 11 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 174 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 6 |
| L. Human factor related | | | | | 4 | |
| Z. Other | | | | | 1 | |
| Subtotal | | | | 1789 | 344 | 6 |
| Total | | 0 | | | 2139 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 17 |
| 13. Reactor Auxiliary Systems | | 7 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 14 |
| 16. Steam generation systems | | 5 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 15 |
| 32. Feedwater and Main Steam System | | 8 |
| 33. Circulating Water System | | 1 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 263 |
| 42. Electrical Power Supply Systems | | 3 |
| Total | | 337 |

2023 Operating Experience

UA-41 **KHMELNITSKI-2** **UKRAINE**

Status at end of year : **Operational**
 Operator : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Owner : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Reactor Supplier : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT ATOMMASH,VOLGODONSK,RUSSIA)
 Turbine Supplier : LMZ (JOINT-STOCK COMPANY "LENINGRADSKIY METALLICHESKIY ZAVOD")



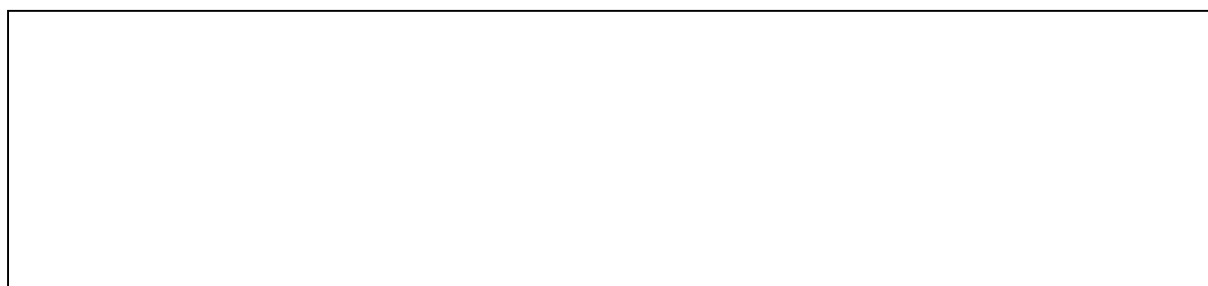
| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 1985-02-01 |
| Thermal power | : 3000 MWth | Grid Date | : 2004-08-07 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 2005-12-15 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 19 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 16 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 322 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : DH |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

No data found

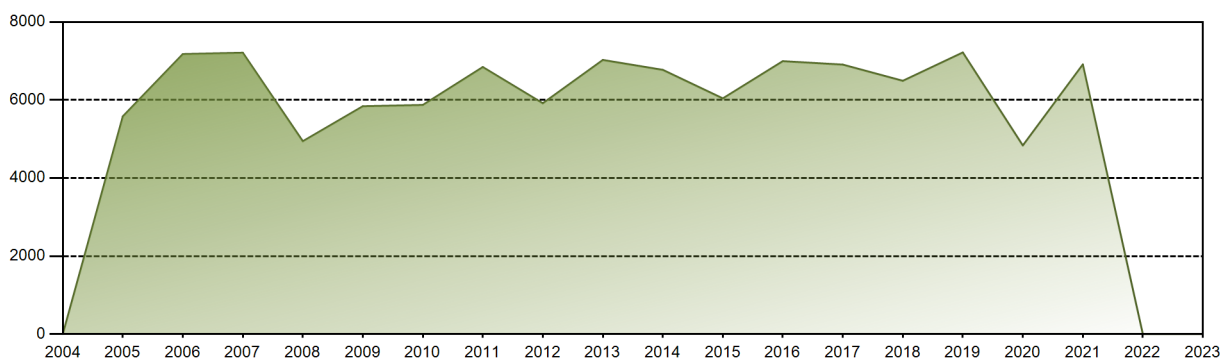


| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

| | | | |
|---|-------------|---|-----------|
| Lifetime energy generation | : 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.56 % |
| Cumulative Energy Availability Factor (EAF) | : 78.34 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.83 % |
| Cumulative Unit Capability Factor (UCF) | : 79.76 % | Cumulative Planned Unavailability Factor (PUF) | : 16.41 % |
| Cumulative Load Factor (LF) | : 77.11 % | Cumulative Externally cause unavailability (XUF) | : 1.43 % |
| Cumulative Operating Factor (OF) | : 79.78 % | | |

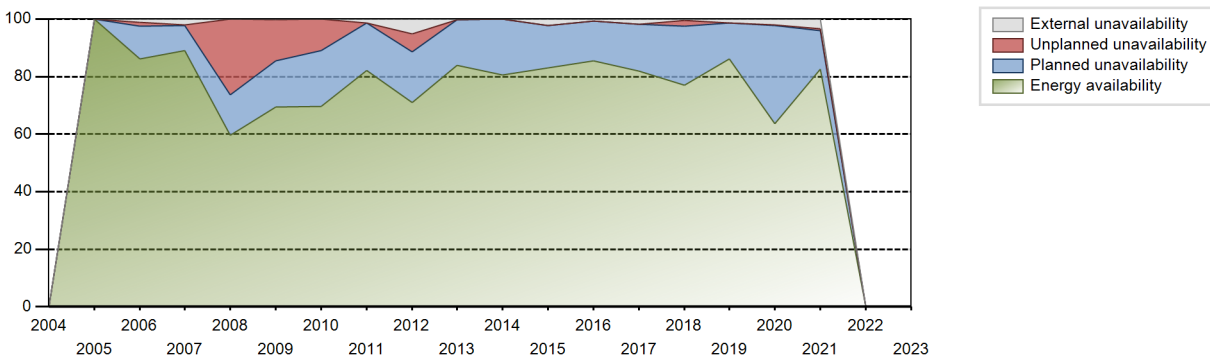
Electricity Production (net) [GWh]



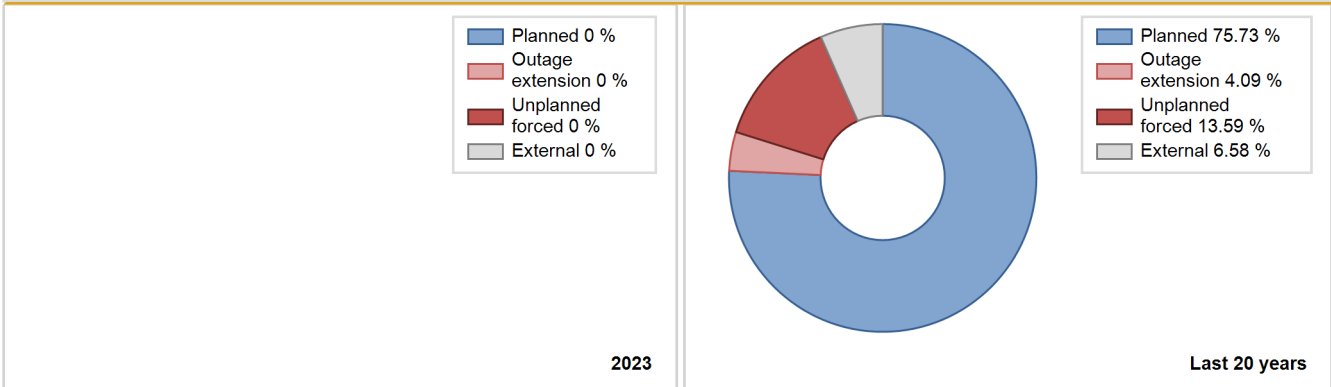
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF | | |
|------|------------------|------------------------|------------------------------|-------------------|--------|-------|-------|-------|-------|-------|------|--|--|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | | |
| 2005 | 5581.51 | 6376 | 950 | 100.00 | 100.00 | 36.98 | 39.78 | 0.00 | 0.00 | 0.00 | 0.00 | | |
| 2006 | 7178.29 | 7697 | 950 | 86.15 | 87.36 | 86.26 | 87.87 | 1.35 | 1.19 | 11.45 | 1.21 | | |
| 2007 | 7213.44 | 8008 | 950 | 89.11 | 91.23 | 86.68 | 91.42 | 0.09 | 0.08 | 8.69 | 2.11 | | |
| 2008 | 4944.85 | 5263 | 950 | 59.64 | 59.69 | 59.26 | 59.92 | 30.51 | 26.20 | 14.11 | 0.04 | | |
| 2009 | 5841.16 | 6126 | 950 | 69.50 | 69.76 | 70.19 | 69.93 | 0.09 | 14.33 | 15.91 | 0.26 | | |
| 2010 | 5873.72 | 6124 | 950 | 69.64 | 69.67 | 70.58 | 69.91 | 13.47 | 10.84 | 19.49 | 0.03 | | |
| 2011 | 6845.60 | 7333 | 950 | 82.13 | 83.51 | 82.26 | 83.71 | 0.00 | 0.00 | 16.49 | 1.38 | | |
| 2012 | 5917.74 | 6774 | 950 | 71.02 | 76.29 | 70.92 | 77.12 | 7.49 | 6.17 | 17.54 | 5.26 | | |
| 2013 | 7027.15 | 7391 | 950 | 83.99 | 84.26 | 84.44 | 84.37 | 0.00 | 0.00 | 15.74 | 0.27 | | |
| 2014 | 6773.28 | 7121 | 950 | 80.58 | 80.70 | 81.39 | 81.29 | 0.00 | 0.00 | 19.30 | 0.12 | | |
| 2015 | 6042.26 | 7523 | 950 | 83.04 | 85.31 | 72.61 | 85.88 | 0.00 | 0.00 | 14.69 | 2.27 | | |
| 2016 | 6996.59 | 7587 | 950 | 85.44 | 86.24 | 83.84 | 86.37 | 0.00 | 0.00 | 13.76 | 0.79 | | |
| 2017 | 6908.09 | 7354 | 950 | 81.91 | 83.75 | 83.01 | 83.95 | 0.00 | 0.00 | 16.25 | 1.84 | | |
| 2018 | 6493.12 | 6816 | 950 | 77.09 | 77.55 | 78.02 | 77.81 | 2.52 | 2.01 | 20.44 | 0.46 | | |
| 2019 | 7219.58 | 7679 | 950 | 86.17 | 87.54 | 86.75 | 87.66 | 0.05 | 0.04 | 12.42 | 1.36 | | |
| 2020 | 4835.27 | 5785 | 950 | 63.67 | 65.82 | 57.94 | 65.86 | 0.02 | 0.02 | 34.16 | 2.15 | | |
| 2021 | 6913.03 | 7619 | 950 | 82.52 | 85.89 | 83.07 | 86.97 | 0.78 | 0.68 | 13.43 | 3.36 | | |
| 2022 | | | | Data not provided | | | | | | | | | |
| 2023 | | | | | | | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2005 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 226 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1230 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 33 | | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant , spare part delivery problems etc.) | | | | | 69 | |
| Subtotal | | | | 1263 | 295 | |
| Total | | 0 | | | 1558 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2005 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 7 |
| 14. Safety Systems | | 4 |
| 16. Steam generation systems | | 0 |
| 31. Turbine and auxiliaries | | 1 |
| 32. Feedwater and Main Steam System | | 3 |
| 41. Main Generator Systems | | 211 |
| Total | | 226 |

2023 Operating Experience

UA-27

RIVNE-1

UKRAINE

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Owner | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Reactor Supplier | : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT ATOMMASH,VOLGODONSK,RUSSIA) |
| Turbine Supplier | : KTP (Kharkiv Turbine Plant "Turboatom") |



Reactor Unit Details

| | |
|----------------------------|--------------------|
| Reactor type and model | : PWR / VVER V-213 |
| Thermal power | : 1375 MWth |
| Gross electrical power | : 420 MWe |
| Reference unit power (net) | : 381 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 1973-08-01 |
| Grid Date | : 1980-12-22 |
| Commercial Date | : 1981-09-22 |
| Age at end of year | : 43 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : 12 |
| Part of the core refuelled [%] | : 25 |
| Average discharge burnup [MWd/t] | : 28600 |
| Active core diameter [m] | : 2.88 |
| Active core height/length [m] | : 2.5 |
| Number of fissile fuel assemblies/bundles | : 313 |
| Fuel linear heat generation rate [kW/m] | : 13.1 |
| Number of control rod assemblies | : 37 |
| Number of external reactor coolant loops | : 6 |
| Coolant type | : H2O |

| | |
|-----------------------------------|---------------|
| Operating coolant pressure [MPa] | : 12.3 |
| Reactor outlet temperature [°C] | : 296 |
| Number of SG | : 6 |
| Containment type | : Confinement |
| Containment design pressure [MPa] | : 5 |

Secondary systems

| | |
|--|------------------|
| Number of turbine-generators per unit/reactor | : 2 |
| Turbine speed [rpm] | : 3000 |
| Number of LP cylinders per turbine | : 2 |
| HP cylinder inlet steam pressure [MPa] | : 4.4 |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : Cooling Towers |
| Number of main condensate pumps | : 6 |
| Number of FW pumps for full power operation | : 4 |
| Number of on-site safety related diesel generators | : 3 |
| Non-electrical applications | : DH |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

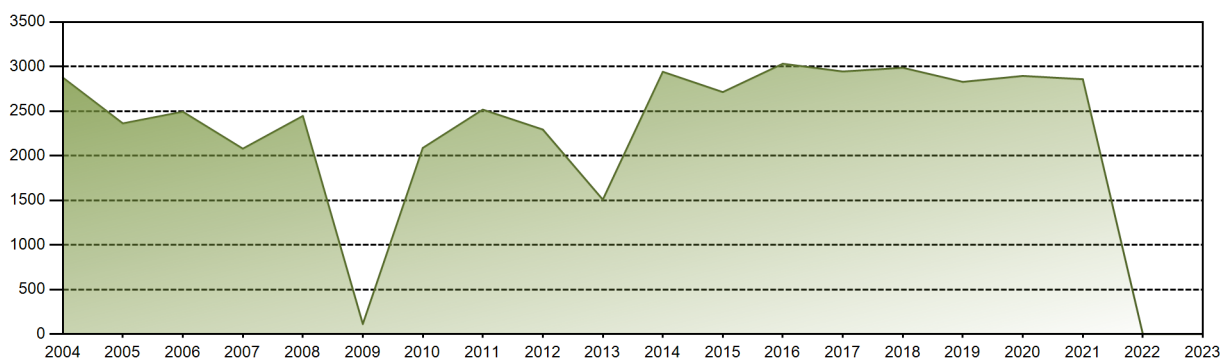
No data found

| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 2.69 % |
| Cumulative Energy Availability Factor (EAF) | : | 79.21 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 2.22 % |
| Cumulative Unit Capability Factor (UCF) | : | 79.98 % | Cumulative Planned Unavailability Factor (PUF) | : | 17.81 % |
| Cumulative Load Factor (LF) | : | 77.35 % | Cumulative Externally cause unavailability (XUF) | : | 0.77 % |
| Cumulative Operating Factor (OF) | : | 80.76 % | | | |

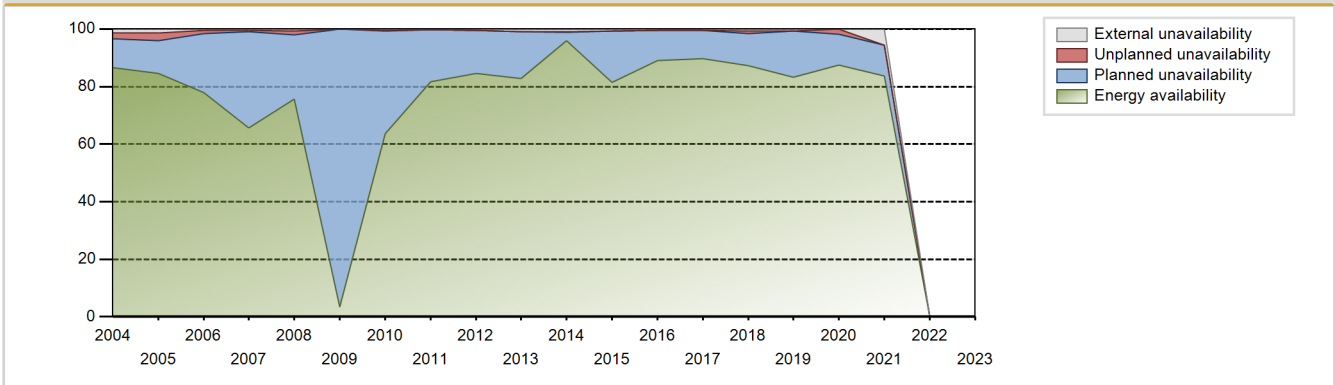
Electricity Production (net) [GWh]



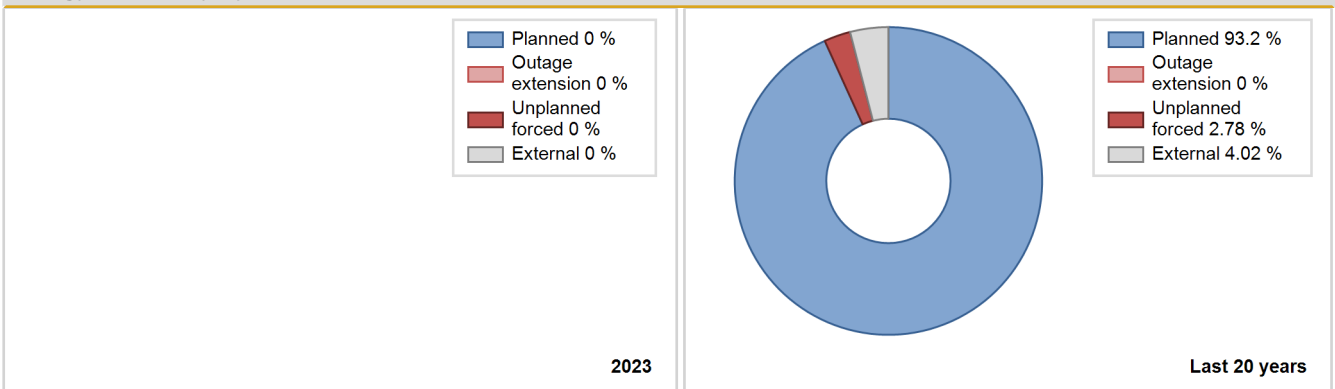
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 1685.10 | 6968 | 361 | 88.09 | 88.09 | 90.12 | 99.95 | 11.91 | 11.91 | 0.00 | 0.00 |
| 1982 | 1725.21 | 5498 | 361 | 51.94 | 51.94 | 54.55 | 62.76 | 13.79 | 8.31 | 39.75 | 0.00 |
| 1983 | 2036.59 | 6752 | 361 | 61.57 | 61.57 | 64.40 | 77.08 | 23.01 | 18.40 | 20.03 | 0.00 |
| 1984 | 2686.26 | 7782 | 361 | 82.48 | 82.48 | 84.71 | 88.59 | 6.69 | 5.92 | 11.60 | 0.00 |
| 1985 | 2664.82 | 7636 | 365 | 81.42 | 81.42 | 83.34 | 87.17 | 6.45 | 5.61 | 12.97 | 0.00 |
| 1986 | 2712.73 | 7606 | 361 | 77.54 | 77.54 | 85.78 | 86.83 | 10.18 | 8.79 | 13.67 | 0.00 |
| 1987 | 3040.76 | 7756 | 402 | 86.63 | 86.63 | 86.35 | 88.54 | 3.48 | 3.12 | 10.25 | 0.00 |
| 1988 | 2717.96 | 7877 | 361 | 86.02 | 86.02 | 85.71 | 89.67 | 3.35 | 2.98 | 11.00 | 0.00 |
| 1989 | 2823.85 | 7994 | 361 | 89.20 | 89.20 | 89.30 | 91.26 | 2.61 | 2.39 | 8.41 | 0.00 |
| 1990 | 2590.56 | 7265 | 361 | 79.27 | 79.27 | 81.92 | 82.93 | 4.30 | 3.57 | 17.17 | 0.00 |
| 1991 | 2640.06 | 7430 | 361 | 81.37 | 81.37 | 83.48 | 84.82 | 4.85 | 4.15 | 14.49 | 0.00 |
| 1992 | 3082.91 | 7989 | 403 | 87.29 | 88.47 | 87.00 | 90.95 | 1.66 | 1.49 | 10.04 | 1.18 |
| 1993 | 2584.41 | 7159 | 406 | 81.42 | 82.96 | 72.67 | 81.72 | 0.64 | 0.53 | 16.51 | 1.54 |
| 1994 | 2578.63 | 7378 | 361 | 81.70 | 81.75 | 81.54 | 84.22 | 0.81 | 0.67 | 17.59 | 0.05 |
| 1995 | 2747.40 | 7756 | 361 | 86.12 | 88.36 | 86.88 | 88.54 | 0.73 | 0.65 | 10.99 | 2.24 |
| 1996 | 2432.03 | 6960 | 361 | 76.70 | 78.99 | 76.70 | 79.23 | 1.97 | 1.59 | 19.42 | 2.29 |
| 1997 | 2701.14 | 7867 | 361 | 81.61 | 82.20 | 85.42 | 89.81 | 0.96 | 0.79 | 17.01 | 0.59 |
| 1998 | 2612.94 | 6912 | 361 | 77.76 | 78.11 | 82.63 | 78.90 | 1.39 | 1.10 | 20.79 | 0.35 |
| 1999 | 2240.49 | 6214 | 361 | 82.83 | 82.83 | 70.85 | 70.94 | 0.00 | 0.00 | 17.17 | 0.00 |
| 2000 | 2733.72 | 7580 | 361 | 82.63 | 85.70 | 86.21 | 86.29 | 2.16 | 1.89 | 12.41 | 3.06 |
| 2001 | 2753.81 | 7369 | 381 | 81.38 | 82.64 | 82.28 | 83.89 | 0.88 | 0.74 | 16.63 | 1.25 |
| 2002 | 2656.23 | 7242 | 381 | 79.91 | 81.04 | 79.59 | 82.67 | 2.33 | 1.93 | 17.02 | 1.14 |
| 2003 | 2816.14 | 7560 | 381 | 83.46 | 84.53 | 84.38 | 86.30 | 2.55 | 2.46 | 13.00 | 1.07 |
| 2004 | 2876.62 | 7914 | 381 | 86.54 | 87.91 | 85.95 | 90.10 | 2.25 | 2.02 | 10.06 | 1.37 |
| 2005 | 2362.64 | 7753 | 381 | 84.53 | 85.82 | 70.79 | 88.50 | 3.23 | 2.87 | 11.31 | 1.29 |
| 2006 | 2493.56 | 7012 | 381 | 77.99 | 78.43 | 74.71 | 80.05 | 1.38 | 1.10 | 20.47 | 0.44 |
| 2007 | 2079.02 | 5882 | 381 | 65.73 | 66.26 | 62.29 | 67.15 | 0.65 | 0.44 | 33.30 | 0.53 |
| 2008 | 2445.73 | 6815 | 381 | 75.60 | 76.22 | 73.08 | 77.58 | 1.76 | 1.36 | 22.42 | 0.62 |
| 2009 | 113.11 | 308 | 381 | 3.48 | 3.48 | 3.39 | 3.52 | 0.00 | 0.00 | 96.52 | 0.00 |
| 2010 | 2087.55 | 5572 | 381 | 63.70 | 64.20 | 62.55 | 63.61 | 0.33 | 0.21 | 35.59 | 0.49 |
| 2011 | 2517.09 | 6867 | 381 | 81.69 | 81.91 | 75.42 | 78.39 | 0.09 | 0.07 | 18.02 | 0.22 |
| 2012 | 2293.50 | 6596 | 381 | 84.59 | 85.11 | 68.53 | 75.09 | 0.00 | 0.00 | 14.89 | 0.53 |
| 2013 | 1507.59 | 4362 | 381 | 82.77 | 83.61 | 45.17 | 49.79 | 0.00 | 0.00 | 16.39 | 0.84 |
| 2014 | 2941.31 | 8052 | 381 | 95.95 | 96.88 | 88.13 | 91.92 | 0.24 | 0.24 | 2.88 | 0.94 |
| 2015 | 2713.77 | 7284 | 381 | 81.35 | 81.99 | 81.31 | 83.15 | 0.00 | 0.00 | 18.01 | 0.63 |
| 2016 | 3031.66 | 7918 | 381 | 89.07 | 89.60 | 90.59 | 90.14 | 0.00 | 0.00 | 10.40 | 0.53 |
| 2017 | 2944.90 | 7978 | 381 | 89.64 | 90.09 | 88.24 | 91.07 | 0.02 | 0.02 | 9.89 | 0.45 |

| | | | | | | | | | | | |
|------|-------------------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2018 | 2986.77 | 7778 | 381 | 87.24 | 87.99 | 89.49 | 88.79 | 1.00 | 0.89 | 11.12 | 0.75 |
| 2019 | 2828.40 | 7419 | 381 | 83.35 | 84.05 | 84.74 | 84.69 | 0.06 | 0.05 | 15.90 | 0.70 |
| 2020 | 2895.00 | 7773 | 381 | 87.57 | 87.57 | 86.50 | 88.49 | 1.91 | 1.71 | 10.72 | 0.00 |
| 2021 | 2858.07 | 7901 | 381 | 83.59 | 89.15 | 85.63 | 90.19 | 0.04 | 0.04 | 10.82 | 5.55 |
| 2022 | Data not provided | | | | | | | | | | |
| 2023 | " | | | | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 36 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1290 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 98 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 9 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 104 |
| L. Human factor related | | | | | 0 | |
| M. Governmental requirements or court decisions | | | | | 1 | |
| Subtotal | | | | 1388 | 37 | 113 |
| Total | | 0 | | | 1538 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 6 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 10 |
| 16. Steam generation systems | | 6 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 32. Feedwater and Main Steam System | | 0 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 5 |
| Total | | 35 |

2023 Operating Experience

UA-28

RIVNE-2

UKRAINE

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Owner | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Reactor Supplier | : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT ATOMMASH,VOLGODONSK,RUSSIA) |
| Turbine Supplier | : KTP (Kharkiv Turbine Plant "Turboatom") |



Reactor Unit Details

| | |
|----------------------------|--------------------|
| Reactor type and model | : PWR / VVER V-213 |
| Thermal power | : 1375 MWth |
| Gross electrical power | : 415 MWe |
| Reference unit power (net) | : 376 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 1973-10-01 |
| Grid Date | : 1981-12-22 |
| Commercial Date | : 1982-07-29 |
| Age at end of year | : 42 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : 12 |
| Part of the core refuelled [%] | : 25 |
| Average discharge burnup [MWd/t] | : 28600 |
| Active core diameter [m] | : 2.88 |
| Active core height/length [m] | : 2.5 |
| Number of fissile fuel assemblies/bundles | : 349 |
| Fuel linear heat generation rate [kW/m] | : 13.1 |
| Number of control rod assemblies | : 37 |
| Number of external reactor coolant loops | : 6 |
| Coolant type | : H2O |

| | |
|-----------------------------------|---------------|
| Operating coolant pressure [MPa] | : 12.3 |
| Reactor outlet temperature [°C] | : 296 |
| Number of SG | : 6 |
| Containment type | : Confinement |
| Containment design pressure [MPa] | : 5 |

Secondary systems

| | |
|--|------------------|
| Number of turbine-generators per unit/reactor | : 2 |
| Turbine speed [rpm] | : 3000 |
| Number of LP cylinders per turbine | : 2 |
| HP cylinder inlet steam pressure [MPa] | : 4.4 |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : Cooling Towers |
| Number of main condensate pumps | : 6 |
| Number of FW pumps for full power operation | : 4 |
| Number of on-site safety related diesel generators | : 3 |

| | |
|------------------------------------|------|
| Non-electrical applications | : DH |
|------------------------------------|------|

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

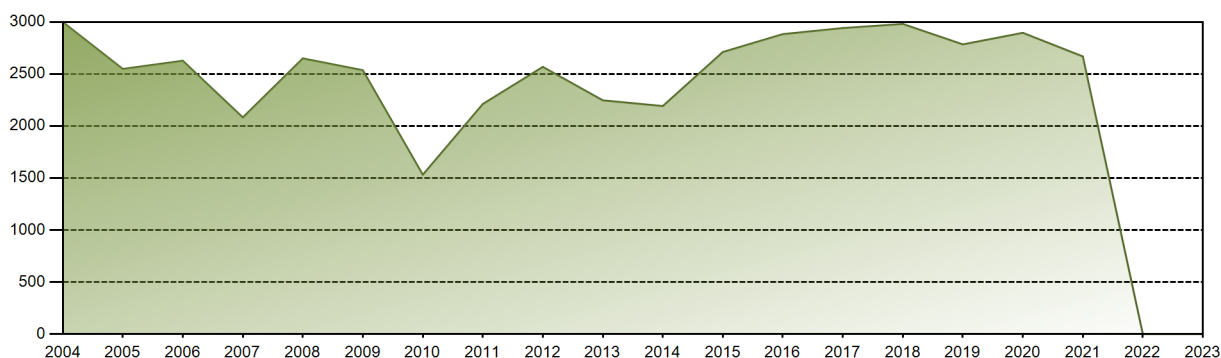
No data found

| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 3.24 % |
| Cumulative Energy Availability Factor (EAF) | : | 80.39 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 2.73 % |
| Cumulative Unit Capability Factor (UCF) | : | 81.51 % | Cumulative Planned Unavailability Factor (PUF) | : | 15.76 % |
| Cumulative Load Factor (LF) | : | 78.62 % | Cumulative Externally cause unavailability (XUF) | : | 1.12 % |
| Cumulative Operating Factor (OF) | : | 82.92 % | | | |

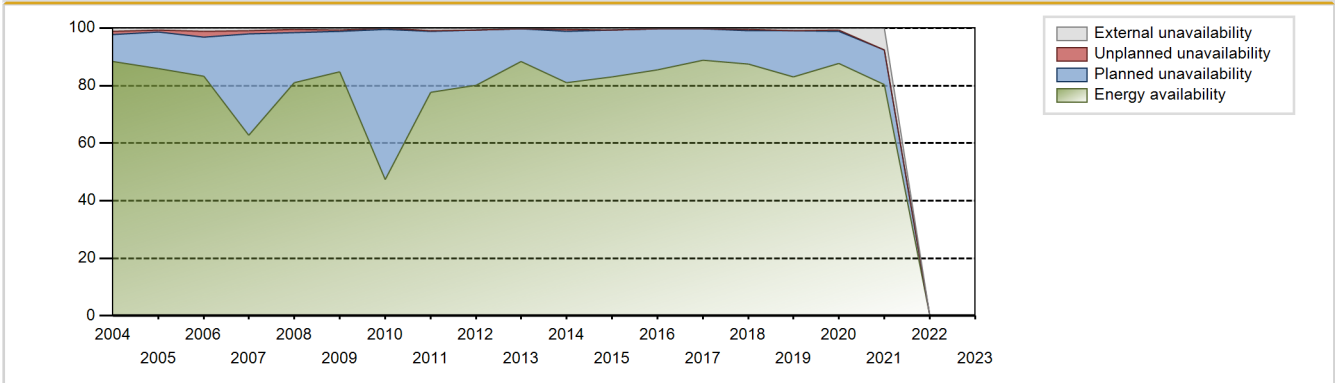
Electricity Production (net) [GWh]



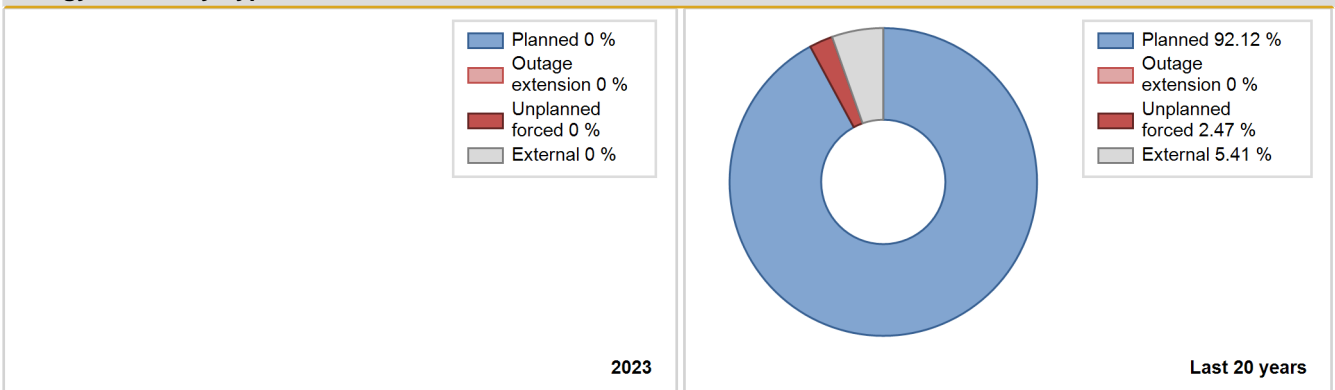
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1982 | 2062.20 | 8011 | 384 | 88.98 | 88.98 | 85.84 | 99.70 | 11.02 | 11.02 | 0.00 | 0.00 |
| 1983 | 1926.94 | 5572 | 384 | 58.00 | 58.00 | 57.28 | 63.61 | 9.34 | 5.98 | 36.02 | 0.00 |
| 1984 | 2808.20 | 7884 | 384 | 83.05 | 83.05 | 83.25 | 89.75 | 6.84 | 6.09 | 10.85 | 0.00 |
| 1985 | 2913.46 | 7994 | 384 | 86.04 | 86.04 | 86.61 | 91.26 | 6.57 | 6.05 | 7.91 | 0.00 |
| 1986 | 2891.75 | 7819 | 384 | 82.99 | 82.99 | 85.97 | 89.26 | 5.16 | 4.52 | 12.50 | 0.00 |
| 1987 | 3166.38 | 7649 | 416 | 86.26 | 86.26 | 86.89 | 87.32 | 1.88 | 1.65 | 12.09 | 0.00 |
| 1988 | 2778.30 | 7875 | 384 | 85.78 | 85.78 | 82.37 | 89.65 | 5.54 | 5.03 | 9.19 | 0.00 |
| 1989 | 2700.39 | 7989 | 384 | 86.27 | 86.27 | 80.28 | 91.20 | 4.14 | 3.73 | 10.01 | 0.00 |
| 1990 | 2798.97 | 7815 | 384 | 83.14 | 83.14 | 83.21 | 89.21 | 8.39 | 7.62 | 9.24 | 0.00 |
| 1991 | 2393.20 | 6560 | 384 | 70.99 | 70.99 | 71.14 | 74.89 | 5.07 | 3.79 | 25.22 | 0.00 |
| 1992 | 2983.74 | 7487 | 416 | 82.92 | 83.76 | 81.65 | 85.23 | 7.26 | 6.56 | 9.69 | 0.84 |
| 1993 | 2053.75 | 5981 | 406 | 64.35 | 66.00 | 57.75 | 68.28 | 24.88 | 21.86 | 12.14 | 1.65 |
| 1994 | 2690.67 | 7626 | 384 | 83.12 | 83.14 | 79.99 | 87.05 | 2.77 | 2.36 | 14.50 | 0.02 |
| 1995 | 2568.47 | 7215 | 384 | 76.36 | 79.58 | 76.36 | 82.36 | 0.86 | 0.69 | 19.72 | 3.23 |
| 1996 | 2783.13 | 7905 | 384 | 82.46 | 87.76 | 82.51 | 89.99 | 1.44 | 1.29 | 10.95 | 5.29 |
| 1997 | 2585.58 | 6847 | 384 | 76.50 | 77.60 | 76.86 | 78.16 | 3.29 | 2.64 | 19.76 | 1.10 |
| 1998 | 2739.64 | 7424 | 384 | 81.23 | 83.18 | 81.44 | 84.75 | 3.17 | 2.72 | 14.10 | 1.95 |
| 1999 | 2543.67 | 6958 | 384 | 75.47 | 77.96 | 75.62 | 79.43 | 2.35 | 1.88 | 20.16 | 2.49 |
| 2000 | 2718.18 | 7460 | 384 | 80.29 | 84.00 | 80.59 | 84.93 | 4.50 | 3.95 | 12.04 | 3.71 |
| 2001 | 2796.91 | 7691 | 376 | 83.23 | 86.63 | 84.68 | 87.56 | 1.38 | 1.21 | 12.16 | 3.40 |
| 2002 | 2861.82 | 7756 | 376 | 85.72 | 86.51 | 86.89 | 88.54 | 1.57 | 1.38 | 12.12 | 0.79 |
| 2003 | 2784.22 | 7376 | 376 | 81.60 | 82.65 | 84.53 | 84.20 | 1.55 | 1.30 | 16.06 | 1.04 |
| 2004 | 2999.69 | 8047 | 376 | 88.38 | 89.45 | 90.82 | 91.61 | 1.25 | 1.13 | 9.42 | 1.06 |
| 2005 | 2548.99 | 7527 | 376 | 85.95 | 86.54 | 77.39 | 85.92 | 0.98 | 0.85 | 12.60 | 0.59 |
| 2006 | 2627.46 | 7727 | 376 | 83.31 | 84.46 | 79.77 | 88.21 | 2.42 | 2.10 | 13.45 | 1.15 |
| 2007 | 2082.89 | 5672 | 376 | 62.75 | 63.70 | 63.24 | 64.75 | 1.59 | 1.03 | 35.28 | 0.94 |
| 2008 | 2650.26 | 7203 | 376 | 80.98 | 81.47 | 80.24 | 82.00 | 1.28 | 1.06 | 17.48 | 0.49 |
| 2009 | 2536.86 | 7603 | 376 | 84.82 | 85.56 | 77.02 | 86.79 | 0.54 | 0.46 | 13.97 | 0.74 |
| 2010 | 1531.71 | 4270 | 376 | 47.41 | 47.55 | 46.50 | 48.74 | 0.57 | 0.27 | 52.18 | 0.14 |
| 2011 | 2211.80 | 6632 | 376 | 77.68 | 78.67 | 67.15 | 75.71 | 0.27 | 0.22 | 21.11 | 0.99 |
| 2012 | 2568.64 | 7115 | 376 | 80.08 | 80.81 | 77.77 | 81.00 | 0.00 | 0.00 | 19.19 | 0.73 |
| 2013 | 2246.85 | 5886 | 376 | 88.35 | 88.63 | 68.22 | 67.19 | 0.00 | 0.00 | 11.37 | 0.28 |
| 2014 | 2192.26 | 6579 | 376 | 81.01 | 81.45 | 66.56 | 75.10 | 0.74 | 0.61 | 17.94 | 0.43 |
| 2015 | 2711.54 | 7363 | 376 | 83.05 | 83.71 | 82.32 | 84.05 | 0.00 | 0.00 | 16.29 | 0.66 |
| 2016 | 2883.55 | 7606 | 376 | 85.43 | 85.77 | 87.31 | 86.59 | 0.00 | 0.00 | 14.23 | 0.35 |
| 2017 | 2941.91 | 7890 | 376 | 88.88 | 89.15 | 89.32 | 90.07 | 0.01 | 0.01 | 10.84 | 0.27 |
| 2018 | 2981.26 | 7794 | 376 | 87.40 | 87.85 | 90.51 | 88.97 | 0.51 | 0.45 | 11.70 | 0.45 |

| | | | | | | | | | | | |
|------|-------------------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2019 | 2785.09 | 7395 | 376 | 83.01 | 83.84 | 84.56 | 84.42 | 0.00 | 0.00 | 16.16 | 0.82 |
| 2020 | 2896.19 | 7914 | 376 | 87.68 | 88.49 | 87.69 | 90.10 | 0.33 | 0.29 | 11.22 | 0.80 |
| 2021 | 2668.93 | 7788 | 376 | 80.28 | 87.95 | 81.03 | 88.90 | 0.00 | 0.00 | 12.05 | 7.68 |
| 2022 | Data not provided | | | | | | | | | | |
| 2023 | " | | | | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1982 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 94 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1071 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 153 | | |
| E. Testing of plant systems or components | | | | 0 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 9 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 63 |
| L. Human factor related | | | | | 1 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | 1 | |
| Z. Other | | | | 26 | | |
| Subtotal | | | | 1250 | 96 | 72 |
| Total | | 0 | | | 1418 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1982 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 11 |
| 13. Reactor Auxiliary Systems | | 2 |
| 15. Reactor Cooling Systems | | 5 |
| 16. Steam generation systems | | 57 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 0 |
| 32. Feedwater and Main Steam System | | 10 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 5 |
| Total | | 93 |

2023 Operating Experience

UA-29

RIVNE-3

UKRAINE

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Owner | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Reactor Supplier | : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT ATOMMASH,VOLGODONSK,RUSSIA) |
| Turbine Supplier | : LMZ (JOINT-STOCK COMPANY "LENINGRADSKIY METALLICHESKIY ZAVOD") |



Reactor Unit Details

| | |
|----------------------------|--------------------|
| Reactor type and model | : PWR / VVER V-320 |
| Thermal power | : 3000 MWth |
| Gross electrical power | : 1000 MWe |
| Reference unit power (net) | : 950 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 1980-02-01 |
| Grid Date | : 1986-12-21 |
| Commercial Date | : 1987-05-16 |
| Age at end of year | : 37 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : 12 |
| Part of the core refuelled [%] | : 25 |
| Average discharge burnup [MWd/t] | : 40000 |
| Active core diameter [m] | : 3.16 |
| Active core height/length [m] | : 3.53 |
| Number of fissile fuel assemblies/bundles | : 163 |
| Fuel linear heat generation rate [kW/m] | : 17.6 |
| Number of control rod assemblies | : 61 |
| Number of external reactor coolant loops | : 4 |
| Coolant type | : H2O |

| | |
|-----------------------------------|----------|
| Operating coolant pressure [MPa] | : 15.7 |
| Reactor outlet temperature [°C] | : 320 |
| Number of SG | : 4 |
| Containment type | : Single |
| Containment design pressure [MPa] | : 5 |

Secondary systems

| | |
|--|------------------|
| Number of turbine-generators per unit/reactor | : 1 |
| Turbine speed [rpm] | : 3000 |
| Number of LP cylinders per turbine | : 4 |
| HP cylinder inlet steam pressure [MPa] | : 6.4 |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : Cooling Towers |
| Number of main condensate pumps | : 8 |
| Number of FW pumps for full power operation | : 2 |
| Number of on-site safety related diesel generators | : 3 |

Non-electrical applications

| | |
|--|------|
| | : DH |
|--|------|

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

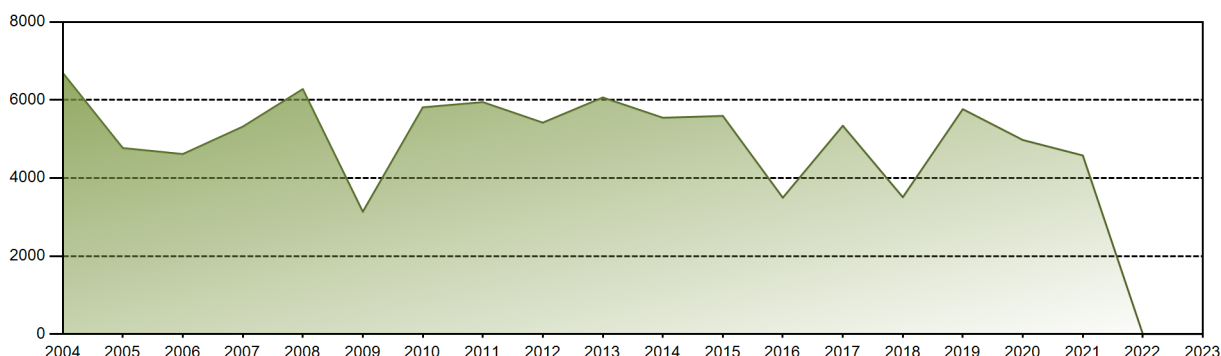
No data found

| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

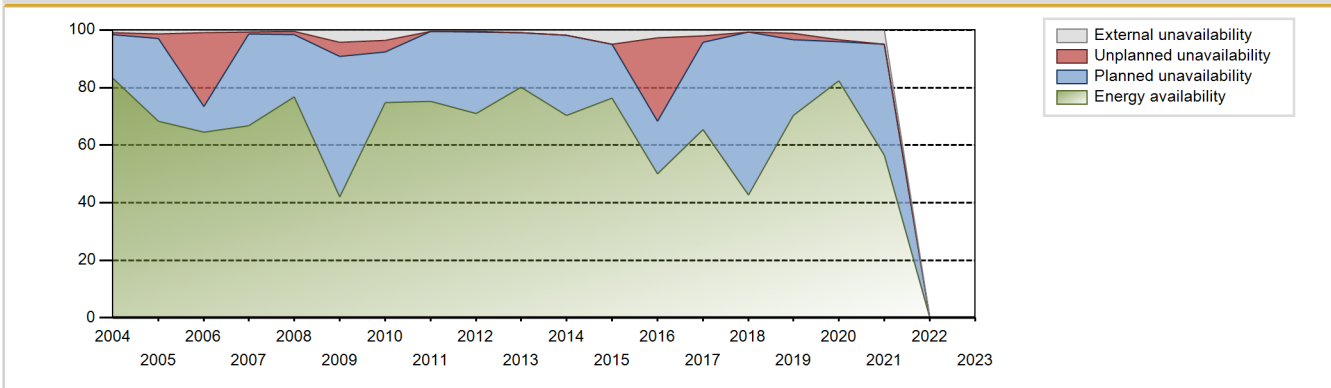
| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 5.77 % |
| Cumulative Energy Availability Factor (EAF) | : | 68.99 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 4.47 % |
| Cumulative Unit Capability Factor (UCF) | : | 70.98 % | Cumulative Planned Unavailability Factor (PUF) | : | 24.55 % |
| Cumulative Load Factor (LF) | : | 65.51 % | Cumulative Externally cause unavailability (XUF) | : | 1.99 % |
| Cumulative Operating Factor (OF) | : | 72.09 % | | | |

Electricity Production (net) [GWh]

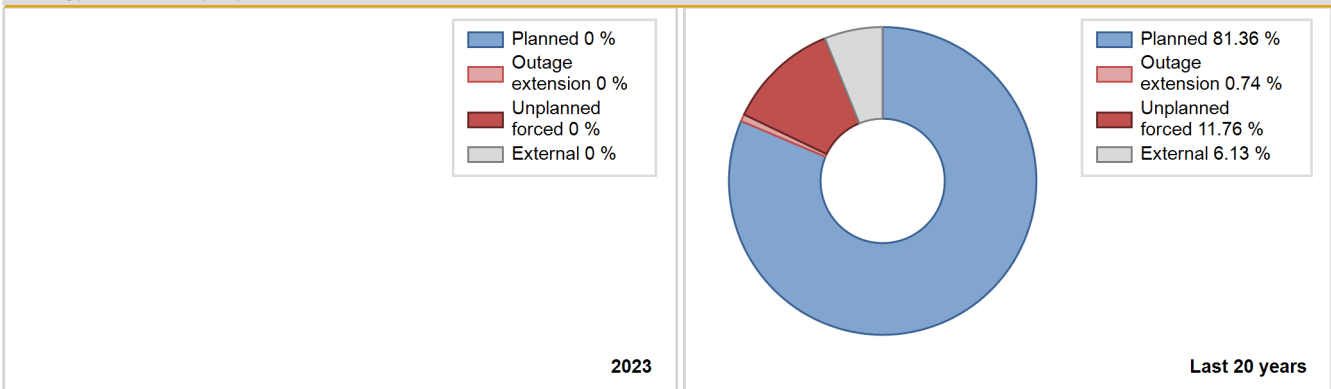


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 5202.19 | 6485 | 1000 | 82.32 | 82.32 | 70.62 | 79.97 | 13.74 | 13.11 | 4.57 | 0.00 |
| 1988 | 5661.32 | 6357 | 950 | 71.05 | 71.05 | 67.84 | 72.37 | 4.72 | 3.52 | 25.43 | 0.00 |
| 1989 | 6046.10 | 6771 | 950 | 75.08 | 75.08 | 72.65 | 77.29 | 8.99 | 7.42 | 17.50 | 0.00 |
| 1990 | 6360.06 | 6981 | 950 | 77.33 | 77.33 | 76.42 | 79.69 | 8.83 | 7.49 | 15.18 | 0.00 |
| 1991 | 5454.79 | 5971 | 950 | 66.02 | 66.02 | 65.55 | 68.16 | 4.54 | 3.14 | 30.84 | 0.00 |
| 1992 | 7084.94 | 7323 | 1000 | 82.18 | 82.20 | 80.66 | 83.37 | 5.22 | 4.53 | 13.27 | 0.02 |
| 1993 | 6195.07 | 6861 | 950 | 75.87 | 76.55 | 74.44 | 78.32 | 4.63 | 3.71 | 19.74 | 0.68 |
| 1994 | 5574.71 | 6042 | 950 | 67.67 | 67.67 | 66.99 | 68.97 | 0.88 | 0.60 | 31.73 | 0.01 |
| 1995 | 5018.27 | 5500 | 950 | 60.28 | 61.04 | 60.30 | 62.79 | 17.12 | 12.61 | 26.35 | 0.76 |
| 1996 | 5550.91 | 6064 | 950 | 66.52 | 66.77 | 66.52 | 69.03 | 10.54 | 7.87 | 25.36 | 0.26 |
| 1997 | 6249.62 | 6730 | 950 | 74.70 | 75.86 | 75.10 | 76.83 | 2.56 | 1.99 | 22.15 | 1.16 |
| 1998 | 5603.50 | 6036 | 950 | 67.32 | 68.22 | 67.33 | 68.90 | 1.01 | 0.70 | 31.08 | 0.90 |
| 1999 | 5303.46 | 6342 | 950 | 63.73 | 72.55 | 63.73 | 72.40 | 0.65 | 0.48 | 26.97 | 8.83 |
| 2000 | 4991.27 | 5641 | 950 | 59.81 | 72.39 | 59.81 | 64.22 | 14.22 | 12.00 | 15.61 | 12.58 |
| 2001 | 5783.63 | 6387 | 950 | 69.58 | 75.26 | 69.31 | 72.71 | 3.28 | 2.55 | 22.18 | 5.68 |
| 2002 | 5562.59 | 6320 | 950 | 68.37 | 69.77 | 66.84 | 72.15 | 2.05 | 1.46 | 28.77 | 1.40 |
| 2003 | 6250.46 | 6815 | 950 | 74.31 | 75.18 | 75.11 | 77.80 | 4.54 | 3.68 | 21.14 | 0.87 |
| 2004 | 6693.27 | 7321 | 950 | 83.21 | 84.16 | 80.21 | 83.34 | 0.79 | 0.67 | 15.17 | 0.95 |
| 2005 | 4768.06 | 6158 | 950 | 68.30 | 69.68 | 57.29 | 70.30 | 2.25 | 1.60 | 28.72 | 1.38 |
| 2006 | 4614.03 | 6777 | 950 | 64.56 | 65.57 | 55.44 | 77.36 | 28.11 | 25.64 | 8.79 | 1.01 |
| 2007 | 5317.21 | 6622 | 950 | 66.79 | 67.45 | 63.89 | 75.59 | 1.07 | 0.73 | 31.82 | 0.66 |
| 2008 | 6279.30 | 7097 | 950 | 76.83 | 77.28 | 75.25 | 80.79 | 1.36 | 1.06 | 21.65 | 0.45 |
| 2009 | 3134.99 | 4078 | 950 | 41.99 | 46.36 | 37.67 | 46.55 | 1.03 | 4.81 | 48.83 | 4.37 |
| 2010 | 5811.94 | 6731 | 950 | 74.80 | 78.49 | 69.84 | 76.84 | 4.76 | 3.92 | 17.59 | 3.69 |
| 2011 | 5945.19 | 7021 | 950 | 75.19 | 75.65 | 71.44 | 80.15 | 0.09 | 0.07 | 24.28 | 0.47 |
| 2012 | 5419.73 | 6665 | 950 | 71.01 | 71.40 | 64.95 | 75.88 | 0.40 | 0.29 | 28.31 | 0.39 |
| 2013 | 6064.61 | 7287 | 950 | 80.18 | 81.18 | 72.87 | 83.18 | 0.00 | 0.00 | 18.82 | 1.01 |
| 2014 | 5545.16 | 6863 | 950 | 70.34 | 72.09 | 66.63 | 78.34 | 0.00 | 0.00 | 27.91 | 1.76 |
| 2015 | 5591.79 | 7177 | 950 | 76.44 | 81.29 | 67.19 | 81.93 | 0.17 | 0.13 | 18.58 | 4.85 |
| 2016 | 3495.26 | 4654 | 950 | 50.00 | 52.72 | 41.89 | 52.98 | 35.38 | 28.87 | 18.41 | 2.72 |
| 2017 | 5339.44 | 6491 | 950 | 65.32 | 67.29 | 64.16 | 74.10 | 3.28 | 2.28 | 30.42 | 1.97 |
| 2018 | 3508.00 | 3886 | 950 | 42.77 | 43.40 | 42.15 | 44.36 | 0.00 | 0.00 | 56.60 | 0.63 |
| 2019 | 5764.88 | 6332 | 950 | 70.38 | 71.46 | 69.27 | 72.28 | 3.01 | 2.22 | 26.32 | 1.08 |
| 2020 | 4974.66 | 5791 | 950 | 82.41 | 85.86 | 59.61 | 65.93 | 0.65 | 0.56 | 13.57 | 3.46 |
| 2021 | 4578.27 | 5398 | 950 | 56.48 | 61.40 | 55.01 | 61.62 | 0.00 | 0.00 | 38.60 | 4.92 |
| 2022 | | | | Data not provided | | | | | | | |
| 2023 | | | | " | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 271 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1521 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 243 | | |
| E. Testing of plant systems or components | | | | 15 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 149 | | |
| H. Nuclear regulatory requirements | | | | | 10 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 62 |
| L. Human factor related | | | | | 5 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | | 5 |
| Z. Other | | | | | 2 | 20 |
| Subtotal | | | | 1928 | 288 | 91 |
| Total | | 0 | | | 2307 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 15 |
| 12. Reactor I&C Systems | | 22 |
| 13. Reactor Auxiliary Systems | | 12 |
| 15. Reactor Cooling Systems | | 15 |
| 16. Steam generation systems | | 18 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 26 |
| 32. Feedwater and Main Steam System | | 6 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 0 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 162 |
| 42. Electrical Power Supply Systems | | 24 |
| Total | | 304 |

2023 Operating Experience

UA-69

RIVNE-4

UKRAINE

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Owner | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Reactor Supplier | : PAA (PRODUCTION AMALGAMATION 'ATOMMASH', VOLGODONSK) |
| Turbine Supplier | : LMZ (JOINT-STOCK COMPANY "LENINGRADSKIY METALLICHESKIY ZAVOD") |



Reactor Unit Details

| | |
|----------------------------|--------------------|
| Reactor type and model | : PWR / VVER V-320 |
| Thermal power | : 3000 MWth |
| Gross electrical power | : 1000 MWe |
| Reference unit power (net) | : 950 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 1986-08-01 |
| Grid Date | : 2004-10-10 |
| Commercial Date | : 2006-04-06 |
| Age at end of year | : 19 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : 12 |
| Part of the core refuelled [%] | : 25 |
| Average discharge burnup [MWd/t] | : 40000 |
| Active core diameter [m] | : 3.16 |
| Active core height/length [m] | : 3.53 |
| Number of fissile fuel assemblies/bundles | : 163 |
| Fuel linear heat generation rate [kW/m] | : 17.6 |
| Number of control rod assemblies | : 61 |
| Number of external reactor coolant loops | : 4 |
| Coolant type | : H2O |

| | |
|-----------------------------------|----------|
| Operating coolant pressure [MPa] | : 15.7 |
| Reactor outlet temperature [°C] | : 320 |
| Number of SG | : 4 |
| Containment type | : Single |
| Containment design pressure [MPa] | : 5 |

Secondary systems

| | |
|--|------------------|
| Number of turbine-generators per unit/reactor | : 1 |
| Turbine speed [rpm] | : 3000 |
| Number of LP cylinders per turbine | : 4 |
| HP cylinder inlet steam pressure [MPa] | : 6.4 |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : Cooling Towers |
| Number of main condensate pumps | : 8 |
| Number of FW pumps for full power operation | : 2 |
| Number of on-site safety related diesel generators | : 3 |

Non-electrical applications

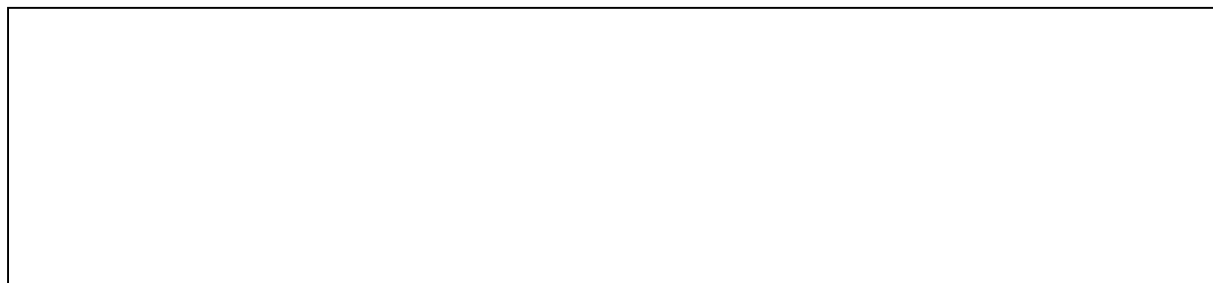
| | |
|--|------|
| | : DH |
|--|------|

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

No data found

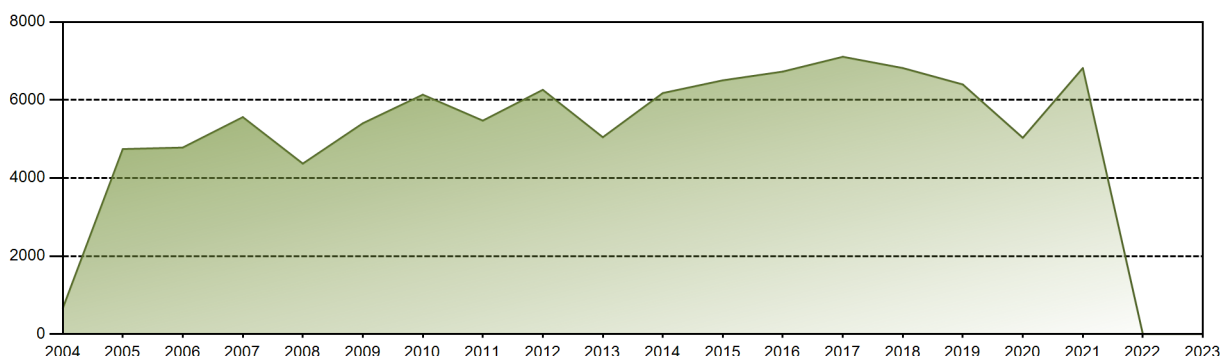


| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

| | | | |
|---|-------------|---|-----------|
| Lifetime energy generation | : 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.37 % |
| Cumulative Energy Availability Factor (EAF) | : 75.95 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.19 % |
| Cumulative Unit Capability Factor (UCF) | : 78.09 % | Cumulative Planned Unavailability Factor (PUF) | : 20.73 % |
| Cumulative Load Factor (LF) | : 70.95 % | Cumulative Externally cause unavailability (XUF) | : 2.14 % |
| Cumulative Operating Factor (OF) | : 81.97 % | | |

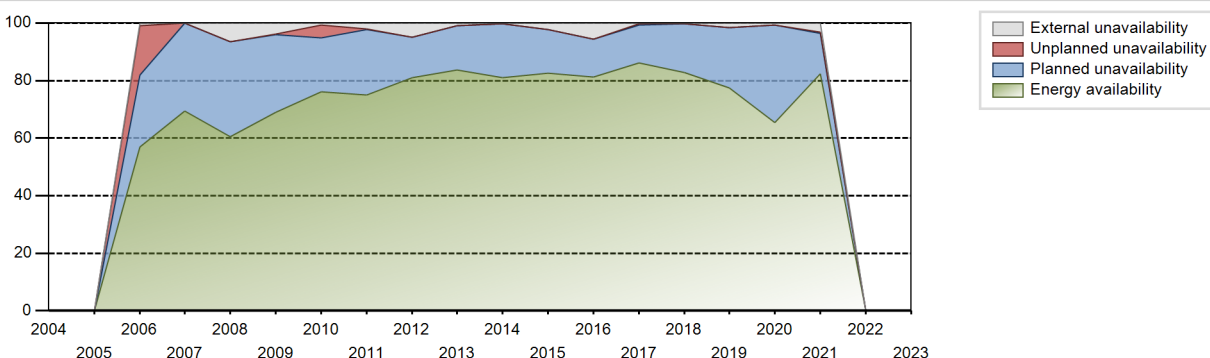
Electricity Production (net) [GWh]



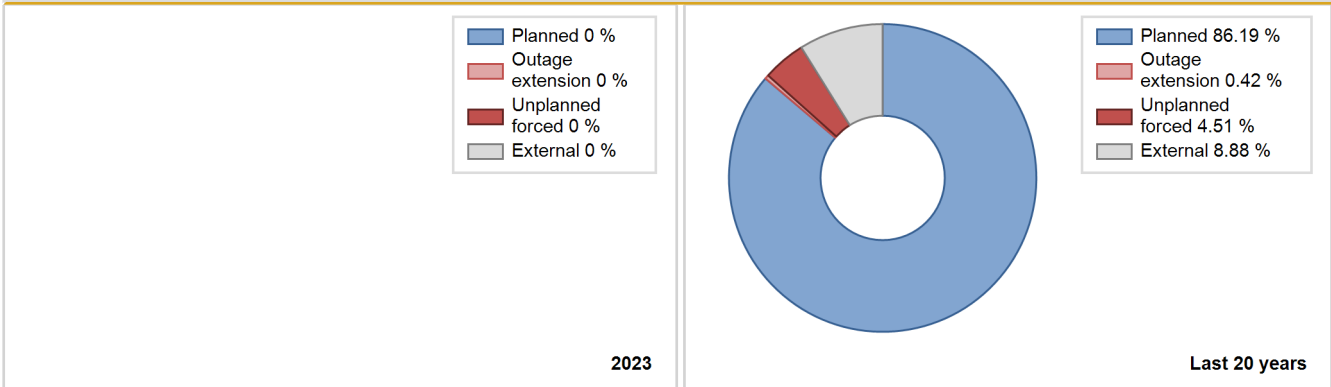
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF | | |
|------|------------------|---------------------------|---------------------------------|-------------------|-------|-------|-------|-------|-------|-------|------|--|--|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | | |
| 2006 | 4781.15 | 6030 | 950 | 57.03 | 57.93 | 51.75 | 65.55 | 22.84 | 17.15 | 24.92 | 0.90 | | |
| 2007 | 5560.92 | 7657 | 950 | 69.47 | 69.56 | 66.82 | 87.41 | 0.06 | 0.05 | 30.39 | 0.09 | | |
| 2008 | 4368.65 | 7058 | 950 | 60.44 | 66.88 | 52.35 | 80.35 | 0.03 | 0.02 | 33.10 | 6.43 | | |
| 2009 | 5402.74 | 8171 | 950 | 68.89 | 72.82 | 64.92 | 93.28 | 0.01 | 0.01 | 27.17 | 3.93 | | |
| 2010 | 6135.99 | 7001 | 950 | 76.13 | 76.78 | 73.73 | 79.92 | 3.68 | 4.52 | 18.70 | 0.65 | | |
| 2011 | 5471.04 | 6764 | 950 | 75.03 | 77.08 | 65.74 | 77.21 | 0.34 | 0.26 | 22.66 | 2.06 | | |
| 2012 | 6260.55 | 7558 | 950 | 80.98 | 85.81 | 75.02 | 86.04 | 0.00 | 0.00 | 14.19 | 4.84 | | |
| 2013 | 5045.41 | 7451 | 950 | 83.70 | 84.65 | 60.63 | 85.06 | 0.00 | 0.00 | 15.35 | 0.95 | | |
| 2014 | 6177.79 | 7076 | 950 | 81.10 | 81.44 | 74.23 | 80.78 | 0.00 | 0.00 | 18.56 | 0.34 | | |
| 2015 | 6503.98 | 7456 | 950 | 82.53 | 84.82 | 78.15 | 85.11 | 0.00 | 0.00 | 15.18 | 2.28 | | |
| 2016 | 6728.75 | 7643 | 950 | 81.15 | 86.72 | 80.63 | 87.01 | 0.00 | 0.00 | 13.28 | 5.56 | | |
| 2017 | 7107.65 | 7577 | 950 | 86.10 | 86.29 | 85.41 | 86.50 | 0.52 | 0.45 | 13.26 | 0.19 | | |
| 2018 | 6819.17 | 7282 | 950 | 82.74 | 83.00 | 81.94 | 83.13 | 0.00 | 0.00 | 17.00 | 0.26 | | |
| 2019 | 6398.38 | 6930 | 950 | 77.46 | 79.01 | 76.89 | 79.11 | 0.00 | 0.00 | 20.99 | 1.55 | | |
| 2020 | 5031.02 | 5698 | 950 | 65.39 | 66.07 | 60.29 | 64.87 | 0.00 | 0.00 | 33.93 | 0.68 | | |
| 2021 | 6818.65 | 7547 | 950 | 82.44 | 85.57 | 81.94 | 86.15 | 0.53 | 0.46 | 13.97 | 3.14 | | |
| 2022 | | | | Data not provided | | | | | | | | | |
| 2023 | | | | " | | | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2006 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 40 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1237 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 120 | | |
| H. Nuclear regulatory requirements | | | | | 8 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 23 |
| Subtotal | | | | 1357 | 48 | 24 |
| Total | | 0 | | | 1429 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2006 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 0 |
| 41. Main Generator Systems | | 36 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 39 |

2023 Operating Experience

UA-44 **SOUTH UKRAINE-1** **UKRAINE**

Status at end of year : **Operational**
 Operator : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Owner : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Reactor Supplier : PAA (PRODUCTION AMALGAMATION 'ATOMMASH', VOLGODONSK)
 Turbine Supplier : KTP (Kharkiv Turbine Plant "Turboatom")



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-302 | Construction Date | : 1976-08-01 |
| Thermal power | : 3000 MWth | Grid Date | : 1982-12-31 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1983-12-02 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 41 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 16 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 322 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 5 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : - | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 49 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : DH |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

No data found

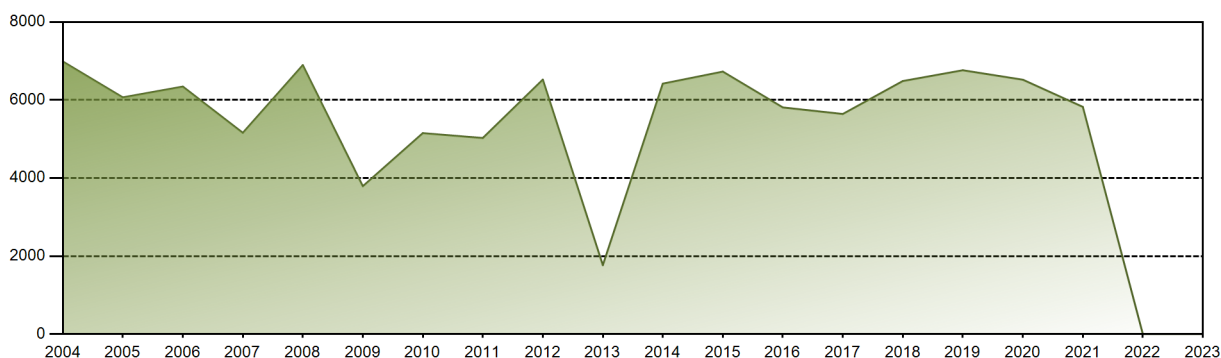


| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 5.55 % |
| Cumulative Energy Availability Factor (EAF) | : | 68.05 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 4.2 % |
| Cumulative Unit Capability Factor (UCF) | : | 70.37 % | Cumulative Planned Unavailability Factor (PUF) | : | 25.43 % |
| Cumulative Load Factor (LF) | : | 67.29 % | Cumulative Externally cause unavailability (XUF) | : | 2.32 % |
| Cumulative Operating Factor (OF) | : | 72.27 % | | | |

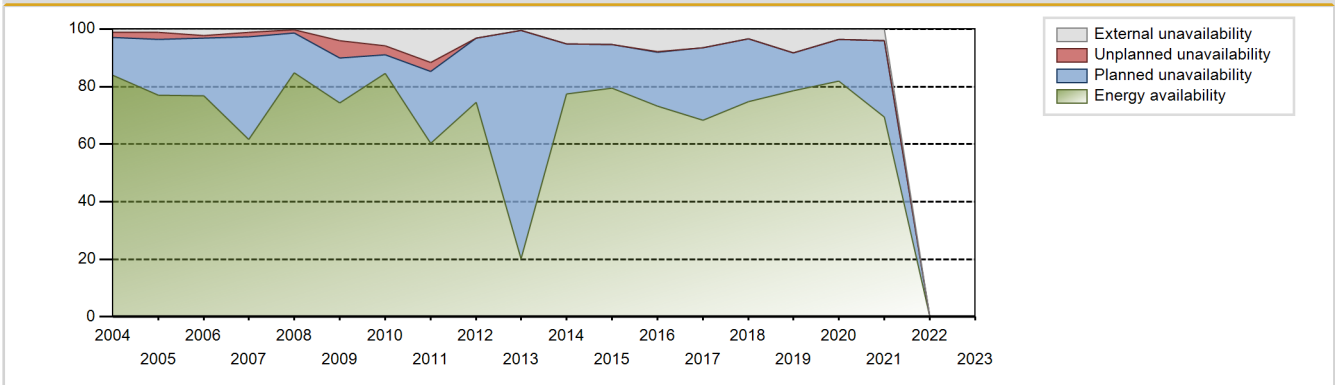
Electricity Production (net) [GWh]



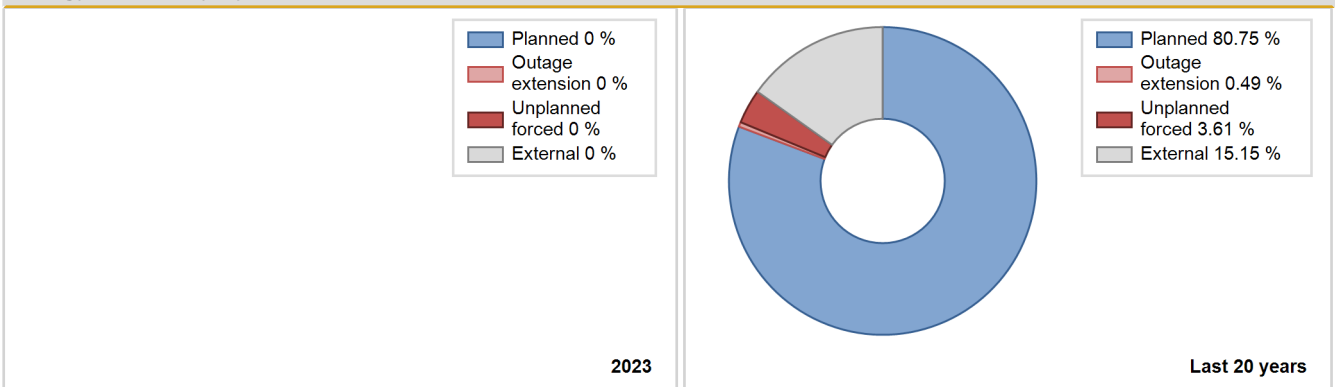
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 2558.83 | 3708 | 950 | 95.23 | 95.23 | 95.74 | 95.30 | 4.77 | 4.77 | 0.00 | 0.00 |
| 1984 | 6075.07 | 6364 | 950 | 71.66 | 71.66 | 72.80 | 72.45 | 11.12 | 8.97 | 19.38 | 0.00 |
| 1985 | 6939.15 | 7148 | 950 | 81.13 | 81.45 | 83.38 | 81.60 | 1.37 | 1.13 | 17.42 | 0.32 |
| 1986 | 6176.11 | 6735 | 950 | 73.47 | 74.05 | 74.21 | 76.88 | 14.47 | 12.53 | 13.42 | 0.58 |
| 1987 | 6385.87 | 6642 | 1000 | 75.58 | 75.58 | 72.90 | 75.82 | 5.05 | 4.02 | 20.40 | 0.00 |
| 1988 | 5467.47 | 6177 | 950 | 65.90 | 65.90 | 65.52 | 70.32 | 15.80 | 12.36 | 21.73 | 0.00 |
| 1989 | 2501.58 | 3321 | 950 | 30.85 | 30.85 | 30.06 | 37.91 | 42.57 | 22.87 | 46.29 | 0.00 |
| 1990 | 6174.36 | 7063 | 950 | 74.99 | 75.25 | 74.19 | 80.63 | 9.55 | 7.95 | 16.81 | 0.26 |
| 1991 | 3865.86 | 5532 | 950 | 46.47 | 46.47 | 46.45 | 63.14 | 28.83 | 18.83 | 34.70 | 0.00 |
| 1992 | 4946.83 | 6142 | 833 | 49.06 | 49.21 | 67.58 | 69.92 | 8.67 | 4.67 | 46.12 | 0.15 |
| 1993 | 5277.81 | 5650 | 950 | 61.36 | 62.30 | 63.42 | 64.50 | 7.30 | 4.91 | 32.80 | 0.93 |
| 1994 | 5117.43 | 5667 | 950 | 58.65 | 58.67 | 61.49 | 64.69 | 2.48 | 1.49 | 39.84 | 0.02 |
| 1995 | 5438.63 | 6212 | 950 | 65.35 | 66.10 | 65.35 | 70.91 | 3.84 | 2.64 | 31.25 | 0.75 |
| 1996 | 5138.24 | 5549 | 950 | 61.57 | 62.12 | 61.57 | 63.17 | 1.41 | 0.89 | 36.99 | 0.55 |
| 1997 | 6196.06 | 6416 | 950 | 72.47 | 73.01 | 74.45 | 73.24 | 1.18 | 0.87 | 26.12 | 0.53 |
| 1998 | 6164.95 | 6477 | 950 | 73.10 | 73.65 | 74.08 | 73.94 | 0.09 | 0.06 | 26.28 | 0.55 |
| 1999 | 5558.92 | 5920 | 950 | 66.55 | 67.14 | 66.80 | 67.58 | 0.16 | 0.11 | 32.75 | 0.59 |
| 2000 | 5203.05 | 5677 | 950 | 61.21 | 63.93 | 62.35 | 64.63 | 5.56 | 3.76 | 32.31 | 2.71 |
| 2001 | 5563.71 | 6015 | 950 | 66.58 | 68.32 | 66.67 | 68.48 | 4.66 | 3.34 | 28.34 | 1.74 |
| 2002 | 4254.82 | 4625 | 950 | 50.87 | 52.19 | 51.13 | 52.80 | 33.66 | 26.48 | 21.33 | 1.32 |
| 2003 | 6008.24 | 6612 | 950 | 72.58 | 74.23 | 72.20 | 75.48 | 1.58 | 1.19 | 24.58 | 1.65 |
| 2004 | 6988.95 | 7592 | 950 | 83.96 | 85.04 | 83.75 | 86.43 | 1.54 | 1.88 | 13.07 | 1.08 |
| 2005 | 6068.49 | 6926 | 950 | 77.06 | 78.26 | 72.92 | 79.06 | 0.66 | 2.40 | 19.34 | 1.19 |
| 2006 | 6345.12 | 6988 | 950 | 76.89 | 79.05 | 76.25 | 79.77 | 1.25 | 1.00 | 19.95 | 2.16 |
| 2007 | 5159.76 | 5562 | 950 | 61.58 | 62.75 | 62.00 | 63.49 | 2.25 | 1.44 | 35.81 | 1.17 |
| 2008 | 6895.39 | 7484 | 950 | 84.80 | 85.10 | 82.63 | 85.20 | 1.37 | 1.18 | 13.72 | 0.30 |
| 2009 | 3790.57 | 5368 | 950 | 74.25 | 78.30 | 45.55 | 61.28 | 7.22 | 6.10 | 15.60 | 4.06 |
| 2010 | 5151.44 | 6335 | 950 | 84.63 | 90.56 | 61.90 | 72.32 | 3.14 | 2.94 | 6.50 | 5.93 |
| 2011 | 5026.85 | 6632 | 950 | 60.33 | 72.00 | 60.40 | 75.71 | 4.16 | 3.13 | 24.87 | 11.66 |
| 2012 | 6524.13 | 7508 | 950 | 74.58 | 77.82 | 78.18 | 85.47 | 0.00 | 0.00 | 22.18 | 3.23 |
| 2013 | 1765.53 | 1987 | 950 | 20.15 | 20.63 | 21.22 | 22.68 | 0.00 | 0.00 | 79.37 | 0.48 |
| 2014 | 6420.56 | 7547 | 950 | 77.35 | 82.51 | 77.15 | 86.15 | 0.00 | 0.00 | 17.49 | 5.15 |
| 2015 | 6728.34 | 7777 | 950 | 79.55 | 84.90 | 80.85 | 88.78 | 0.11 | 0.09 | 15.01 | 5.35 |
| 2016 | 5810.19 | 7451 | 950 | 73.14 | 81.07 | 69.63 | 84.82 | 0.29 | 0.24 | 18.70 | 7.93 |
| 2017 | 5642.42 | 6828 | 950 | 68.27 | 74.69 | 67.80 | 77.95 | 0.00 | 0.00 | 25.31 | 6.42 |
| 2018 | 6487.01 | 6914 | 950 | 74.80 | 78.20 | 77.95 | 78.93 | 0.00 | 0.00 | 21.80 | 3.40 |
| 2019 | 6763.16 | 7700 | 950 | 78.59 | 86.81 | 81.27 | 87.90 | 0.00 | 0.00 | 13.19 | 8.22 |

| | | | | | | | | | | | |
|------|-------------------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2020 | 6521.17 | 7528 | 950 | 81.97 | 85.67 | 78.15 | 85.70 | 0.00 | 0.00 | 14.33 | 3.70 |
| 2021 | 5824.46 | 6517 | 950 | 69.42 | 73.54 | 69.99 | 74.39 | 0.06 | 0.04 | 26.42 | 4.12 |
| 2022 | Data not provided | | | | | | | | | | |
| 2023 | " | | | | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 289 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1647 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 261 | | |
| E. Testing of plant systems or components | | | | 7 | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 100 |
| L. Human factor related | | | | | 1 | |
| Z. Other | | | | | 26 | 1 |
| Subtotal | | | | 1915 | 317 | 102 |
| Total | | 0 | | | 2334 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 9 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 4 |
| 16. Steam generation systems | | 138 |
| 31. Turbine and auxiliaries | | 41 |
| 32. Feedwater and Main Steam System | | 5 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 81 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 284 |

2023 Operating Experience

| | | |
|--------------|------------------------|----------------|
| UA-45 | SOUTH UKRAINE-2 | UKRAINE |
|--------------|------------------------|----------------|

Status at end of year : **Operational**

Operator : NNEG (State Enterprise "National Nuclear Energy Generating Company 'Energoatom'")

Owner : NNEG (State Enterprise "National Nuclear Energy Generating Company 'Energoatom'")

Reactor Supplier : PAA (PRODUCTION AMALGAMATION 'ATOMMASH', VOLGODONSK)

Turbine Supplier : KTP (Kharkiv Turbine Plant "Turboatom")



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------|--------------------|------------|
| Reactor type and model | PWR / VVER V-338 | Construction Date | 1981-07-01 |
| Thermal power | 3000 MWth | Grid Date | 1985-01-06 |
| Gross electrical power | 1000 MWe | Commercial Date | 1985-04-06 |
| Reference unit power (net) | 950 MWe | Age at end of year | 38 years |

| Design Characteristics | | | |
|---|----------|--|---------------------|
| Primary Systems | | | |
| Reactor vessel centreline orientation | Vertical | Operating coolant pressure [MPa] | 16 |
| Fuel material | UO2 | Reactor outlet temperature [°C] | 322 |
| Refuelling type | OFF-line | Number of SG | 4 |
| Moderator material | H2O | Containment type | Single |
| Average fuel enrichment [% of U235] | - | Containment design pressure [MPa] | 5 |
| Refuelling frequency [month] | 12 | Secondary systems | |
| Part of the core refuelled [%] | 33 | Number of turbine-generators per unit/reactor | 1 |
| Average discharge burnup [MWd/t] | 40000 | Turbine speed [rpm] | 1500 |
| Active core diameter [m] | 3.16 | Number of LP cylinders per turbine | - |
| Active core height/length [m] | 3.53 | HP cylinder inlet steam pressure [MPa] | 6 |
| Number of fissile fuel assemblies/bundles | 163 | Output voltage [kV] | - |
| Fuel linear heat generation rate [kW/m] | 17.6 | Primary means of condenser cooling | Lake (once-through) |
| Number of control rod assemblies | 61 | Number of main condensate pumps | - |
| Number of external reactor coolant loops | 4 | Number of FW pumps for full power operation | 2 |
| Coolant type | H2O | Number of on-site safety related diesel generators | 3 |
| | | Non-electrical applications | |
| | | | DH |

| Annual Production Results (2023) | | | |
|----------------------------------|-----------|--|-------|
| Net Energy Production | 0 GW(e).h | Forced Loss Rate (FLR) | 0 % |
| Energy Availability Factor (EAF) | 0 % | Unplanned Capability Loss Factor (UCL) | 0 % |
| Unit Capability Factor (UCF) | 0 % | Planned Unavailability Factor (PUF) | 0 % |
| Load Factor (LF) | 0 % | Externally cause unavailability (XUF) | 0 % |
| Operating Factor (OF) | 0 % | Total off-line time | hours |

Annual Summary

No data found

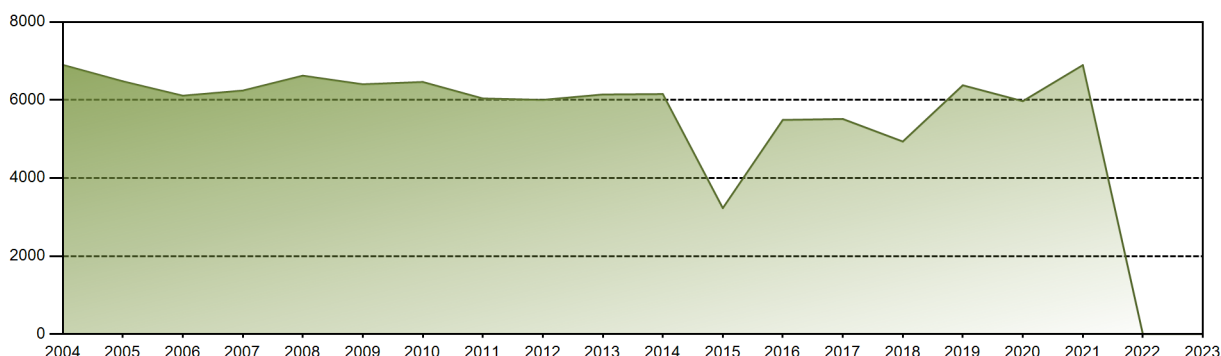


| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 11.61 % |
| Cumulative Energy Availability Factor (EAF) | : | 65.19 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 8.91 % |
| Cumulative Unit Capability Factor (UCF) | : | 67.56 % | Cumulative Planned Unavailability Factor (PUF) | : | 23.52 % |
| Cumulative Load Factor (LF) | : | 65.47 % | Cumulative Externally cause unavailability (XUF) | : | 2.38 % |
| Cumulative Operating Factor (OF) | : | 71.99 % | | | |

Electricity Production (net) [GWh]

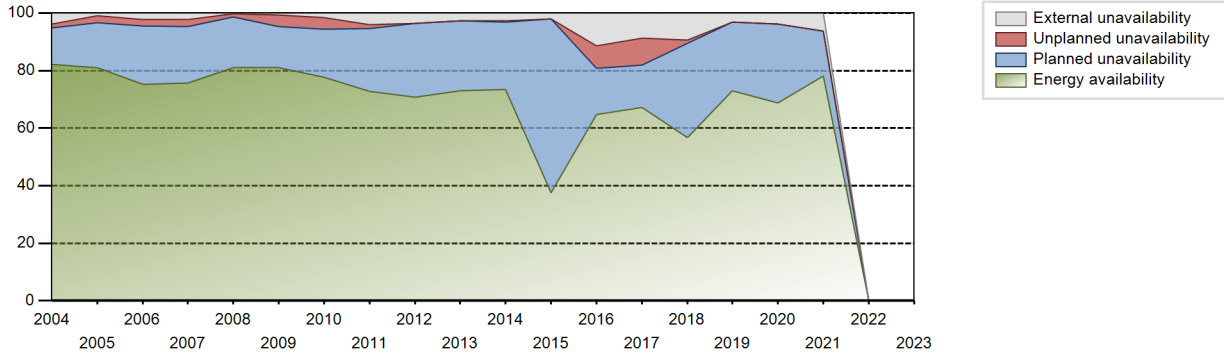


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 5603.65 | 6379 | 950 | 73.30 | 73.30 | 74.42 | 74.59 | 9.42 | 7.63 | 19.07 | 0.00 |
| 1986 | 5565.48 | 6315 | 950 | 66.25 | 67.00 | 66.88 | 72.09 | 10.56 | 7.91 | 25.09 | 0.75 |
| 1987 | 1641.67 | 1941 | 1000 | 22.04 | 22.04 | 18.74 | 22.16 | 77.96 | 77.96 | 0.00 | 0.00 |
| 1988 | 4850.58 | 5198 | 950 | 57.38 | 57.38 | 58.13 | 59.18 | 32.69 | 27.86 | 14.75 | 0.00 |
| 1989 | 4437.30 | 6674 | 950 | 54.29 | 54.29 | 53.32 | 76.19 | 32.49 | 26.12 | 19.59 | 0.00 |
| 1990 | 1768.96 | 4522 | 950 | 21.87 | 21.87 | 21.26 | 51.62 | 58.65 | 31.02 | 47.11 | 0.00 |
| 1991 | 6209.76 | 6722 | 950 | 72.04 | 72.04 | 74.62 | 76.74 | 9.16 | 7.26 | 20.70 | 0.00 |
| 1992 | 6412.13 | 6574 | 1000 | 71.66 | 72.91 | 73.00 | 74.84 | 4.84 | 3.71 | 23.38 | 1.25 |
| 1993 | 5204.03 | 6570 | 950 | 61.71 | 64.00 | 62.53 | 75.00 | 20.57 | 16.58 | 19.43 | 2.28 |
| 1994 | 3958.54 | 6471 | 950 | 46.86 | 47.32 | 47.57 | 73.87 | 34.13 | 24.52 | 28.16 | 0.46 |
| 1995 | 5429.43 | 6514 | 950 | 65.24 | 66.12 | 65.24 | 74.36 | 1.62 | 1.09 | 32.80 | 0.87 |
| 1996 | 4593.75 | 5590 | 950 | 55.05 | 55.43 | 55.05 | 63.64 | 22.85 | 16.42 | 28.15 | 0.38 |
| 1997 | 6326.54 | 7400 | 950 | 75.38 | 77.16 | 76.02 | 84.47 | 9.00 | 7.63 | 15.21 | 1.78 |
| 1998 | 4542.39 | 4867 | 950 | 53.97 | 55.15 | 54.58 | 55.56 | 1.29 | 0.72 | 44.13 | 1.18 |
| 1999 | 5537.94 | 6372 | 950 | 66.42 | 72.01 | 66.55 | 72.74 | 0.05 | 0.03 | 27.95 | 5.59 |
| 2000 | 4103.49 | 4486 | 950 | 49.17 | 50.04 | 49.17 | 51.07 | 34.95 | 26.88 | 23.08 | 0.86 |
| 2001 | 6206.51 | 6869 | 950 | 74.40 | 74.75 | 74.38 | 78.20 | 5.14 | 4.05 | 21.20 | 0.36 |
| 2002 | 6057.20 | 6565 | 950 | 72.65 | 74.16 | 72.79 | 74.94 | 0.54 | 0.40 | 25.44 | 1.51 |
| 2003 | 5507.74 | 5868 | 950 | 65.82 | 66.18 | 66.18 | 66.98 | 1.34 | 0.90 | 32.92 | 0.36 |
| 2004 | 6899.71 | 7647 | 950 | 82.23 | 86.14 | 82.68 | 87.06 | 1.32 | 1.15 | 12.71 | 3.92 |
| 2005 | 6479.16 | 7243 | 950 | 81.07 | 82.01 | 77.86 | 82.68 | 2.80 | 2.36 | 15.63 | 0.93 |
| 2006 | 6110.19 | 6847 | 950 | 75.28 | 77.53 | 73.42 | 78.16 | 2.94 | 2.35 | 20.12 | 2.25 |
| 2007 | 6241.70 | 6892 | 950 | 75.76 | 77.95 | 75.00 | 78.68 | 3.03 | 2.44 | 19.61 | 2.19 |
| 2008 | 6623.64 | 7248 | 950 | 81.11 | 81.38 | 79.37 | 82.51 | 1.25 | 1.03 | 17.59 | 0.27 |
| 2009 | 6402.79 | 7213 | 950 | 80.99 | 81.64 | 76.94 | 82.34 | 3.01 | 4.04 | 14.32 | 0.66 |
| 2010 | 6461.48 | 7326 | 950 | 77.75 | 79.43 | 77.64 | 83.63 | 4.79 | 4.00 | 16.57 | 1.69 |
| 2011 | 6039.15 | 7003 | 950 | 72.87 | 76.96 | 72.57 | 79.94 | 1.58 | 1.23 | 21.80 | 4.09 |
| 2012 | 6002.99 | 6723 | 950 | 70.69 | 74.30 | 71.94 | 76.54 | 0.00 | 0.00 | 25.70 | 3.61 |
| 2013 | 6141.18 | 7160 | 950 | 73.00 | 75.60 | 73.79 | 81.74 | 0.21 | 0.16 | 24.24 | 2.60 |
| 2014 | 6152.37 | 6846 | 950 | 73.46 | 76.22 | 73.93 | 78.15 | 0.47 | 0.36 | 23.42 | 2.76 |
| 2015 | 3228.28 | 3537 | 950 | 37.51 | 39.53 | 38.79 | 40.38 | 0.00 | 0.00 | 60.47 | 2.03 |
| 2016 | 5489.65 | 6776 | 950 | 64.76 | 76.28 | 65.79 | 77.14 | 9.18 | 7.71 | 16.02 | 11.51 |
| 2017 | 5513.69 | 6693 | 950 | 67.21 | 75.93 | 66.25 | 76.40 | 11.01 | 9.40 | 14.67 | 8.72 |
| 2018 | 4935.64 | 5822 | 950 | 56.71 | 66.11 | 59.31 | 66.46 | 1.68 | 1.13 | 32.76 | 9.40 |
| 2019 | 6377.49 | 6698 | 950 | 72.95 | 76.08 | 76.63 | 76.46 | 0.00 | 0.00 | 23.92 | 3.13 |
| 2020 | 5970.49 | 6393 | 950 | 68.83 | 72.63 | 71.55 | 72.78 | 0.00 | 0.00 | 27.37 | 3.80 |
| 2021 | 6894.09 | 7435 | 950 | 78.19 | 84.48 | 82.84 | 84.87 | 0.00 | 0.00 | 15.52 | 6.30 |

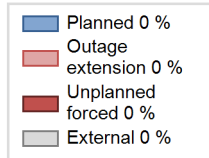
2022
2023

Data not provided
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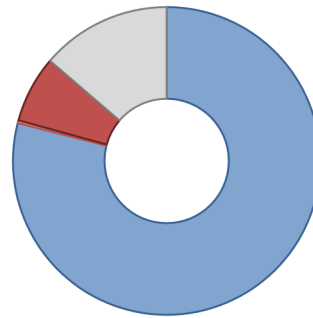
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 367 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1395 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 314 | | |
| E. Testing of plant systems or components | | | | 7 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 135 | | |
| H. Nuclear regulatory requirements | | | | | 4 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 4 |
| L. Human factor related | | | | | 1 | |
| Z. Other | | | | | 40 | |
| Subtotal | | | | 1851 | 412 | 4 |
| Total | | 0 | | | 2267 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 40 |
| 12. Reactor I&C Systems | | 6 |
| 14. Safety Systems | | 0 |
| 15. Reactor Cooling Systems | | 20 |
| 16. Steam generation systems | | 244 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 7 |
| 31. Turbine and auxiliaries | | 18 |
| 32. Feedwater and Main Steam System | | 22 |
| 34. Miscellaneous Systems | | 3 |
| 41. Main Generator Systems | | 43 |
| 42. Electrical Power Supply Systems | | 1 |
| Total | | 404 |

2023 Operating Experience

UA-48 **SOUTH UKRAINE-3** **UKRAINE**

Status at end of year : **Operational**
 Operator : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Owner : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Reactor Supplier : PAA (PRODUCTION AMALGAMATION 'ATOMMASH', VOLGODONSK)
 Turbine Supplier : LMZ (JOINT-STOCK COMPANY "LENINGRADSKIY METALLICHESKIY ZAVOD")



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 1984-11-01 |
| Thermal power | : 3000 MWth | Grid Date | : 1989-09-20 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1989-12-29 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 34 years |

Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|-----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 16 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 322 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 5 |
| Refuelling frequency [month] | : 12 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 40000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 3.16 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.53 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Number of fissile fuel assemblies/bundles | : 163 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Primary means of condenser cooling | : Lake (once-through) |
| Number of control rod assemblies | : 61 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 4 | Number of FW pumps for full power operation | : 2 |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : 3 |
| | | Non-electrical applications | : DH |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

No data found

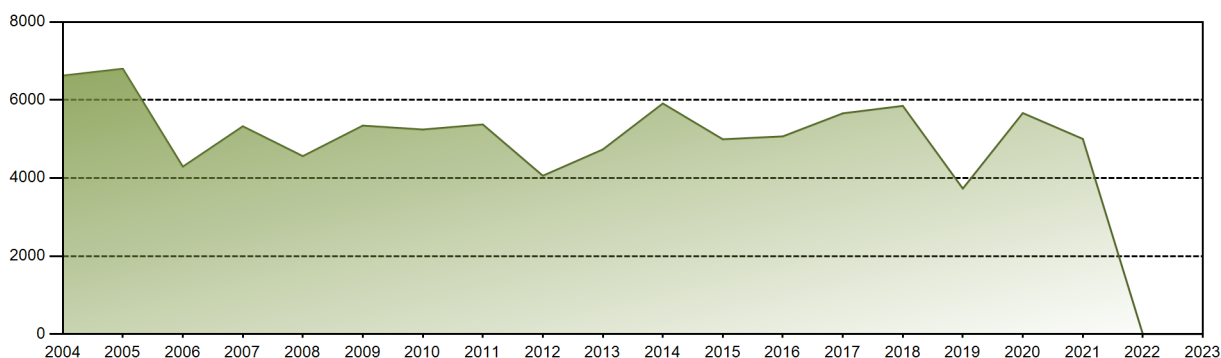


| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

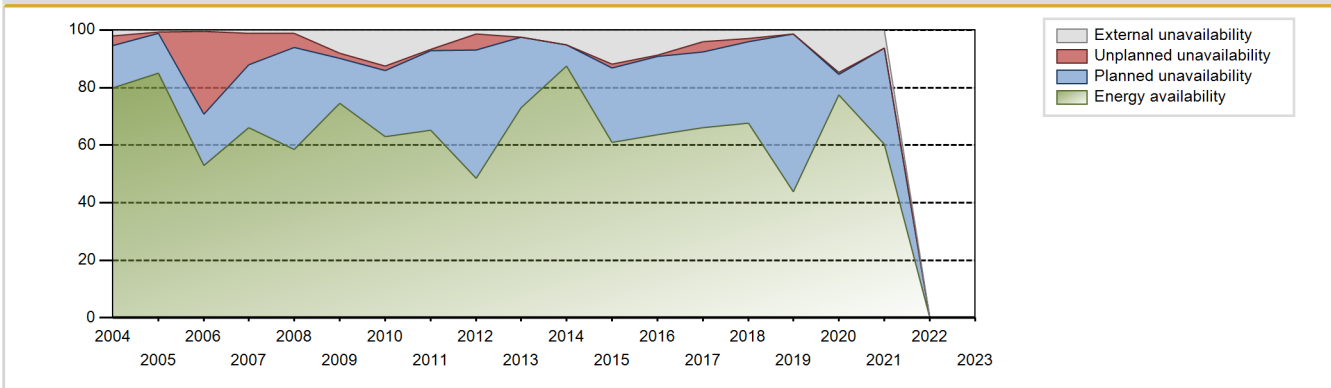
| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 4.95 % |
| Cumulative Energy Availability Factor (EAF) | : | 68.34 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 3.91 % |
| Cumulative Unit Capability Factor (UCF) | : | 71.76 % | Cumulative Planned Unavailability Factor (PUF) | : | 24.32 % |
| Cumulative Load Factor (LF) | : | 66.34 % | Cumulative Externally cause unavailability (XUF) | : | 3.42 % |
| Cumulative Operating Factor (OF) | : | 73.8 % | | | |

Electricity Production (net) [GWh]

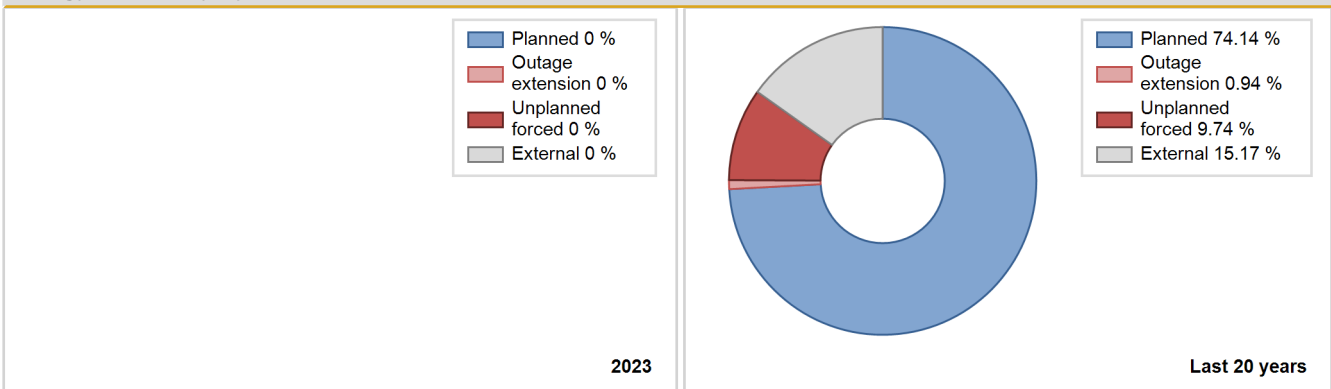


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 1299.66 | 1992 | 950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1990 | 5691.56 | 6408 | 950 | 69.37 | 69.37 | 68.39 | 73.15 | 13.24 | 10.58 | 20.05 | 0.00 |
| 1991 | 5762.83 | 6996 | 950 | 69.95 | 70.40 | 69.25 | 79.86 | 13.28 | 10.78 | 18.82 | 0.44 |
| 1992 | 6458.14 | 6646 | 1000 | 75.25 | 75.25 | 73.52 | 75.66 | 2.82 | 2.18 | 22.57 | 0.00 |
| 1993 | 6043.39 | 6527 | 950 | 71.69 | 72.78 | 72.62 | 74.51 | 7.90 | 6.24 | 20.98 | 1.08 |
| 1994 | 5565.05 | 6223 | 950 | 66.43 | 66.46 | 66.87 | 71.04 | 4.67 | 3.26 | 30.28 | 0.03 |
| 1995 | 4954.78 | 6300 | 950 | 59.54 | 60.17 | 59.54 | 71.92 | 0.37 | 0.22 | 39.61 | 0.63 |
| 1996 | 6155.02 | 7463 | 950 | 73.76 | 76.41 | 73.76 | 84.96 | 11.29 | 9.73 | 13.86 | 2.66 |
| 1997 | 6514.77 | 7079 | 950 | 77.70 | 79.75 | 78.28 | 80.81 | 0.61 | 0.49 | 19.76 | 2.05 |
| 1998 | 5850.99 | 6396 | 950 | 69.91 | 70.99 | 70.31 | 73.01 | 1.81 | 1.31 | 27.70 | 1.09 |
| 1999 | 5464.32 | 6244 | 950 | 65.51 | 67.19 | 65.66 | 71.28 | 0.00 | 0.00 | 32.81 | 1.68 |
| 2000 | 5909.66 | 6588 | 950 | 70.58 | 73.34 | 70.82 | 75.00 | 4.15 | 3.18 | 23.49 | 2.76 |
| 2001 | 6136.35 | 6985 | 950 | 73.71 | 76.29 | 73.53 | 79.52 | 8.00 | 6.64 | 17.08 | 2.58 |
| 2002 | 6335.16 | 7043 | 950 | 75.97 | 77.54 | 76.13 | 80.40 | 3.23 | 2.59 | 19.87 | 1.57 |
| 2003 | 6036.52 | 6680 | 950 | 73.11 | 74.31 | 72.54 | 76.26 | 4.34 | 3.37 | 22.32 | 1.20 |
| 2004 | 6625.11 | 7246 | 950 | 79.93 | 82.00 | 79.39 | 82.49 | 3.82 | 3.26 | 14.74 | 2.07 |
| 2005 | 6801.04 | 7548 | 950 | 84.99 | 85.73 | 81.72 | 86.16 | 0.47 | 0.40 | 13.87 | 0.73 |
| 2006 | 4290.89 | 4734 | 950 | 53.02 | 53.61 | 51.56 | 54.04 | 34.76 | 28.57 | 17.83 | 0.59 |
| 2007 | 5326.10 | 5978 | 950 | 66.13 | 67.27 | 64.00 | 68.24 | 14.05 | 11.00 | 21.73 | 1.14 |
| 2008 | 4560.77 | 5961 | 950 | 58.58 | 59.66 | 54.65 | 67.86 | 7.69 | 4.97 | 35.37 | 1.08 |
| 2009 | 5343.14 | 7024 | 950 | 74.56 | 82.64 | 64.20 | 80.18 | 2.09 | 1.76 | 15.60 | 8.08 |
| 2010 | 5243.17 | 6778 | 950 | 62.88 | 75.43 | 63.00 | 77.37 | 2.05 | 1.58 | 22.99 | 12.54 |
| 2011 | 5372.61 | 6404 | 950 | 65.16 | 71.95 | 64.56 | 73.11 | 0.63 | 0.46 | 27.59 | 6.80 |
| 2012 | 4058.36 | 4448 | 950 | 48.46 | 49.74 | 48.63 | 50.64 | 0.00 | 5.68 | 44.58 | 1.28 |
| 2013 | 4731.07 | 6704 | 950 | 73.05 | 75.60 | 56.85 | 76.53 | 0.00 | 0.00 | 24.40 | 2.55 |
| 2014 | 5911.15 | 6781 | 950 | 87.39 | 92.52 | 71.03 | 77.41 | 0.00 | 0.00 | 7.48 | 5.13 |
| 2015 | 4993.40 | 6481 | 950 | 60.94 | 72.89 | 60.00 | 73.98 | 1.58 | 1.17 | 25.95 | 11.95 |
| 2016 | 5067.23 | 6445 | 950 | 63.58 | 72.23 | 60.72 | 73.37 | 0.71 | 0.52 | 27.26 | 8.65 |
| 2017 | 5657.50 | 6219 | 950 | 66.08 | 70.15 | 67.98 | 70.99 | 4.71 | 3.47 | 26.38 | 4.07 |
| 2018 | 5849.13 | 6260 | 950 | 67.57 | 70.40 | 70.29 | 71.46 | 1.81 | 1.30 | 28.30 | 2.83 |
| 2019 | 3729.04 | 4031 | 950 | 43.76 | 45.05 | 44.81 | 46.02 | 0.00 | 0.00 | 54.95 | 1.29 |
| 2020 | 5664.51 | 8490 | 950 | 77.55 | 92.38 | 67.88 | 96.65 | 0.69 | 0.64 | 6.97 | 14.84 |
| 2021 | 5003.02 | 5913 | 950 | 60.35 | 66.68 | 60.12 | 67.50 | 0.00 | 0.00 | 33.32 | 6.33 |
| 2022 | | | | Data not provided | | | | | | | |
| 2023 | | | | " | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 194 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1671 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 207 | | |
| E. Testing of plant systems or components | | | | 12 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 61 |
| L. Human factor related | | | | | 0 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 15 | |
| Subtotal | | | | 1890 | 209 | 61 |
| Total | | 0 | | | 2160 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 2 |
| 13. Reactor Auxiliary Systems | | 0 |
| 15. Reactor Cooling Systems | | 1 |
| 16. Steam generation systems | | 5 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 18 |
| 32. Feedwater and Main Steam System | | 1 |
| 33. Circulating Water System | | 0 |
| 34. Miscellaneous Systems | | 2 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 159 |
| 42. Electrical Power Supply Systems | | 1 |
| Total | | 194 |

2023 Operating Experience

UA-54

ZAPOROZHYE-1

UKRAINE

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Owner | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Reactor Supplier | : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT ATOMMASH,VOLGODONSK,RUSSIA) |
| Turbine Supplier | : KTP (Kharkiv Turbine Plant "Turboatom") |



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 1980-04-01 |
| Thermal power | : 3000 MWth | Grid Date | : 1984-12-10 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1985-12-25 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 39 years |

Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|-----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 16 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 322 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 5 |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : DH |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

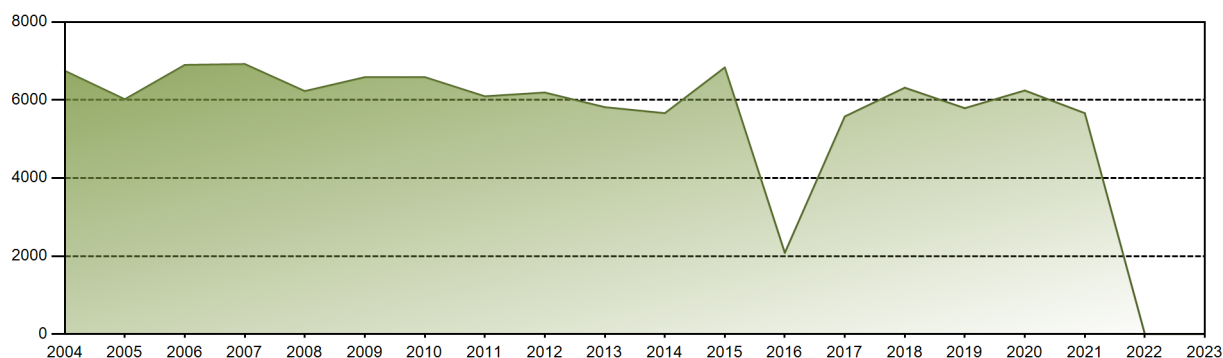
No data found

| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 5.93 % |
| Cumulative Energy Availability Factor (EAF) | : | 66.74 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 5.26 % |
| Cumulative Unit Capability Factor (UCF) | : | 68.94 % | Cumulative Planned Unavailability Factor (PUF) | : | 25.81 % |
| Cumulative Load Factor (LF) | : | 65.24 % | Cumulative Externally cause unavailability (XUF) | : | 2.2 % |
| Cumulative Operating Factor (OF) | : | 71.11 % | | | |

Electricity Production (net) [GWh]

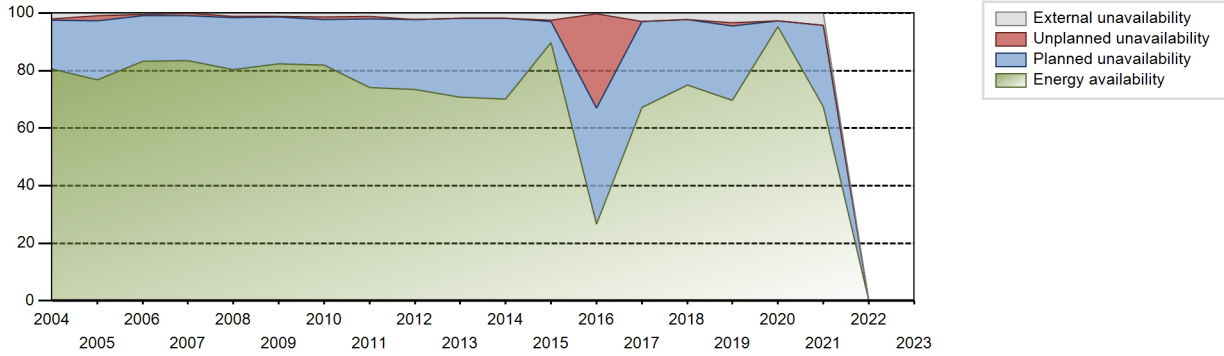


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|--------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 4051.06 | 5893 | 950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1986 | 4826.26 | 5580 | 950 | 58.26 | 61.54 | 57.99 | 63.70 | 19.03 | 14.46 | 24.00 | 3.28 |
| 1987 | 6720.93 | 7205 | 1000 | 80.82 | 80.82 | 76.72 | 82.25 | 8.64 | 7.64 | 11.54 | 0.00 |
| 1988 | 5170.41 | 6225 | 950 | 67.21 | 67.37 | 61.96 | 70.87 | 18.83 | 15.63 | 17.00 | 0.17 |
| 1989 | 0.00 | 0 | 950 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 9.86 | 90.14 | 0.00 |
| 1990 | 4668.70 | 5684 | 950 | 56.40 | 58.79 | 56.10 | 64.89 | 20.08 | 14.77 | 26.45 | 2.39 |
| 1991 | 5332.22 | 6343 | 950 | 64.25 | 68.51 | 64.07 | 72.41 | 10.27 | 7.84 | 23.65 | 4.27 |
| 1992 | 6103.50 | 6739 | 950 | 67.84 | 70.30 | 73.14 | 76.72 | 7.99 | 6.10 | 23.60 | 2.46 |
| 1993 | 4209.71 | 6591 | 950 | 52.14 | 53.46 | 50.59 | 75.24 | 39.69 | 35.18 | 11.36 | 1.32 |
| 1994 | 3770.96 | 5062 | 950 | 45.49 | 45.50 | 45.31 | 57.79 | 26.88 | 16.73 | 37.77 | 0.01 |
| 1995 | 3557.27 | 4213 | 950 | 42.75 | 44.87 | 42.75 | 48.09 | 3.78 | 1.76 | 53.37 | 2.13 |
| 1996 | 4299.48 | 5224 | 950 | 51.52 | 53.54 | 51.52 | 59.47 | 11.20 | 6.75 | 39.71 | 2.02 |
| 1997 | 4070.63 | 5531 | 950 | 48.91 | 53.86 | 48.91 | 63.14 | 2.16 | 1.19 | 44.95 | 4.94 |
| 1998 | 5517.47 | 6122 | 950 | 66.28 | 68.73 | 66.30 | 69.89 | 2.70 | 1.90 | 29.37 | 2.45 |
| 1999 | 5992.45 | 7422 | 950 | 72.01 | 84.01 | 72.01 | 84.73 | 1.25 | 1.06 | 14.93 | 12.01 |
| 2000 | 4222.71 | 4589 | 950 | 50.26 | 52.04 | 50.60 | 52.24 | 6.12 | 3.39 | 44.57 | 1.78 |
| 2001 | 5847.06 | 6434 | 950 | 69.93 | 71.84 | 70.07 | 73.25 | 1.17 | 0.85 | 27.30 | 1.92 |
| 2002 | 6734.96 | 7334 | 950 | 80.57 | 83.21 | 80.93 | 83.72 | 1.80 | 1.52 | 15.26 | 2.64 |
| 2003 | 6596.43 | 7223 | 950 | 78.96 | 81.85 | 79.26 | 82.45 | 2.33 | 1.95 | 16.20 | 2.89 |
| 2004 | 6748.27 | 7290 | 950 | 80.60 | 82.64 | 80.87 | 82.99 | 0.50 | 0.42 | 16.94 | 2.04 |
| 2005 | 6018.79 | 6823 | 950 | 76.81 | 77.76 | 72.32 | 77.89 | 2.21 | 1.75 | 20.49 | 0.95 |
| 2006 | 6899.02 | 7380 | 950 | 83.32 | 83.75 | 82.90 | 84.25 | 0.48 | 0.40 | 15.85 | 0.43 |
| 2007 | 6921.01 | 7406 | 950 | 83.51 | 83.61 | 83.17 | 84.54 | 0.97 | 0.82 | 15.57 | 0.10 |
| 2008 | 6227.72 | 6748 | 950 | 80.28 | 81.37 | 74.63 | 76.82 | 0.64 | 0.53 | 18.10 | 1.09 |
| 2009 | 6584.42 | 7174 | 950 | 82.38 | 83.43 | 79.12 | 81.89 | 0.45 | 0.38 | 16.19 | 1.06 |
| 2010 | 6586.76 | 7396 | 950 | 81.88 | 83.27 | 79.15 | 84.43 | 1.13 | 0.95 | 15.78 | 1.38 |
| 2011 | 6095.13 | 6702 | 950 | 74.11 | 75.35 | 73.24 | 76.51 | 1.02 | 0.78 | 23.88 | 1.24 |
| 2012 | 6191.10 | 6765 | 950 | 73.43 | 75.59 | 74.19 | 77.02 | 0.00 | 0.00 | 24.41 | 2.15 |
| 2013 | 5816.74 | 6585 | 950 | 70.70 | 72.48 | 69.90 | 75.17 | 0.00 | 0.00 | 27.52 | 1.78 |
| 2014 | 5661.63 | 6397 | 950 | 70.17 | 72.02 | 68.03 | 73.03 | 0.00 | 0.00 | 27.98 | 1.85 |
| 2015 | 6835.34 | 8147 | 950 | 89.73 | 92.17 | 82.14 | 93.00 | 0.58 | 0.53 | 7.29 | 2.44 |
| 2016 | 2082.50 | 2431 | 950 | 26.65 | 27.02 | 24.96 | 27.68 | 0.01 | 32.72 | 40.26 | 0.37 |
| 2017 | 5577.73 | 6302 | 950 | 67.23 | 70.21 | 67.02 | 71.94 | 0.00 | 0.00 | 29.79 | 2.98 |
| 2018 | 6314.69 | 7144 | 950 | 75.10 | 77.32 | 75.88 | 81.55 | 0.00 | 0.00 | 22.68 | 2.22 |
| 2019 | 5790.20 | 6601 | 950 | 69.55 | 72.98 | 69.58 | 75.35 | 1.55 | 1.15 | 25.87 | 3.43 |
| 2020 | 6243.86 | 7106 | 950 | 95.29 | 98.09 | 74.82 | 80.90 | 0.00 | 0.00 | 1.91 | 2.80 |
| 2021 | 5662.83 | 6491 | 950 | 67.46 | 71.81 | 68.05 | 74.10 | 0.00 | 0.00 | 28.19 | 4.35 |

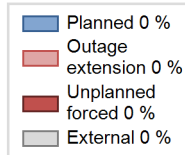
2022
2023

Data not provided
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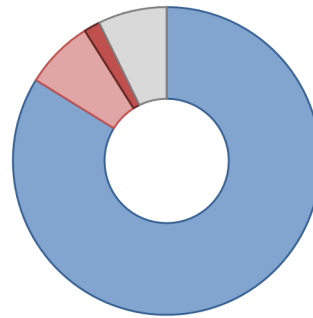
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 208 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1495 | 21 | |
| D. Inspection, maintenance or repair without refuelling | | | | 449 | | |
| E. Testing of plant systems or components | | | | 4 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 100 | 76 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 66 |
| L. Human factor related | | | | | 7 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 5 |
| Z. Other | | | | | 2 | |
| Subtotal | | | | 2048 | 314 | 71 |
| Total | | 0 | | | 2433 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 29 |
| 15. Reactor Cooling Systems | | 21 |
| 16. Steam generation systems | | 55 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 5 |
| 31. Turbine and auxiliaries | | 34 |
| 32. Feedwater and Main Steam System | | 22 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 9 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 23 |
| 42. Electrical Power Supply Systems | | 9 |
| Total | | 211 |

2023 Operating Experience

UA-56

ZAPOROZHYE-2

UKRAINE

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Owner | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Reactor Supplier | : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT ATOMMASH,VOLGODONSK,RUSSIA) |
| Turbine Supplier | : KTP (Kharkiv Turbine Plant "Turboatom") |



Reactor Unit Details

| | |
|----------------------------|--------------------|
| Reactor type and model | : PWR / VVER V-320 |
| Thermal power | : 3000 MWth |
| Gross electrical power | : 1000 MWe |
| Reference unit power (net) | : 950 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 1981-01-01 |
| Grid Date | : 1985-07-22 |
| Commercial Date | : 1986-02-15 |
| Age at end of year | : 38 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : 12 |
| Part of the core refuelled [%] | : 33 |
| Average discharge burnup [MWd/t] | : 40000 |
| Active core diameter [m] | : 3.16 |
| Active core height/length [m] | : 3.53 |
| Number of fissile fuel assemblies/bundles | : 163 |
| Fuel linear heat generation rate [kW/m] | : 17.6 |
| Number of control rod assemblies | : 61 |
| Number of external reactor coolant loops | : 4 |
| Coolant type | : H2O |

| | |
|-----------------------------------|----------|
| Operating coolant pressure [MPa] | : 16 |
| Reactor outlet temperature [°C] | : 322 |
| Number of SG | : 4 |
| Containment type | : Single |
| Containment design pressure [MPa] | : 5 |

Secondary systems

| | |
|--|-----------------------|
| Number of turbine-generators per unit/reactor | : 1 |
| Turbine speed [rpm] | : 1500 |
| Number of LP cylinders per turbine | : - |
| HP cylinder inlet steam pressure [MPa] | : 6 |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : Lake (once-through) |
| Number of main condensate pumps | : - |
| Number of FW pumps for full power operation | : 2 |
| Number of on-site safety related diesel generators | : 3 |
| Non-electrical applications | : DH |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

No data found

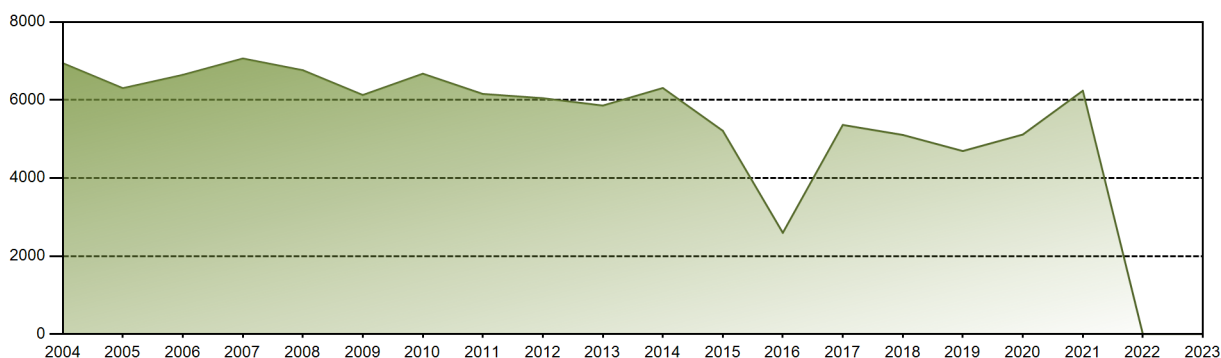


| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 3.82 % |
| Cumulative Energy Availability Factor (EAF) | : | 68.49 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 3.9 % |
| Cumulative Unit Capability Factor (UCF) | : | 71.03 % | Cumulative Planned Unavailability Factor (PUF) | : | 25.07 % |
| Cumulative Load Factor (LF) | : | 66.21 % | Cumulative Externally cause unavailability (XUF) | : | 2.54 % |
| Cumulative Operating Factor (OF) | : | 72.63 % | | | |

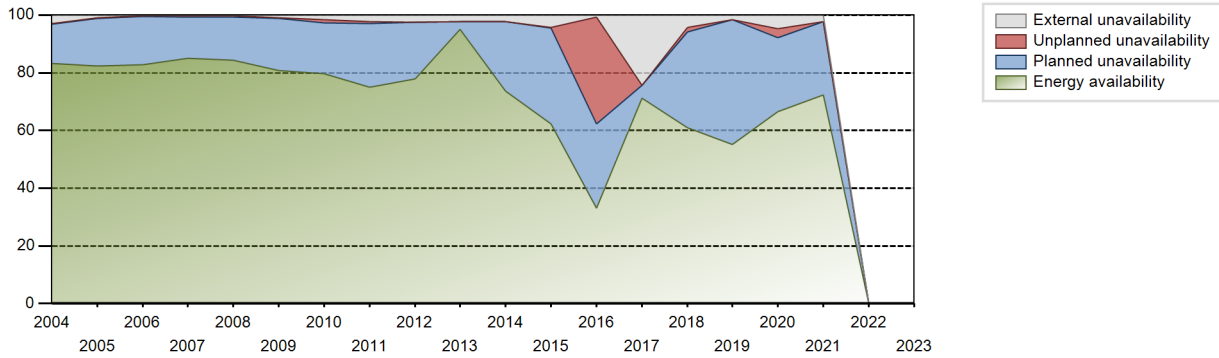
Electricity Production (net) [GWh]



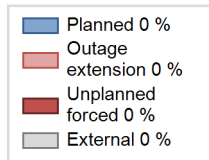
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 5651.61 | 6417 | 950 | 65.51 | 68.22 | 65.41 | 70.29 | 13.53 | 10.68 | 21.10 | 2.72 |
| 1987 | 6058.32 | 6675 | 1000 | 76.04 | 76.04 | 69.16 | 76.20 | 13.47 | 11.84 | 12.12 | 0.00 |
| 1988 | 6088.56 | 7253 | 950 | 81.18 | 81.18 | 72.96 | 82.57 | 7.45 | 6.53 | 12.29 | 0.00 |
| 1989 | 3050.89 | 3393 | 950 | 45.14 | 45.14 | 36.66 | 38.73 | 7.00 | 3.40 | 51.47 | 0.00 |
| 1990 | 1869.06 | 2165 | 950 | 22.35 | 22.55 | 22.46 | 24.71 | 8.56 | 2.11 | 75.34 | 0.21 |
| 1991 | 4583.92 | 5112 | 950 | 55.40 | 56.13 | 55.08 | 58.36 | 17.35 | 11.78 | 32.09 | 0.73 |
| 1992 | 6551.69 | 7016 | 950 | 76.24 | 77.66 | 78.51 | 79.87 | 5.49 | 4.51 | 17.84 | 1.42 |
| 1993 | 4386.11 | 6194 | 950 | 53.80 | 56.55 | 52.71 | 70.71 | 27.05 | 20.97 | 22.48 | 2.75 |
| 1994 | 4103.48 | 5924 | 950 | 49.83 | 49.93 | 49.31 | 67.63 | 8.00 | 4.34 | 45.73 | 0.10 |
| 1995 | 5051.78 | 7329 | 950 | 60.70 | 63.47 | 60.70 | 83.66 | 15.01 | 11.21 | 25.32 | 2.76 |
| 1996 | 5373.03 | 6247 | 950 | 64.39 | 67.53 | 64.39 | 71.12 | 5.44 | 3.88 | 28.59 | 3.14 |
| 1997 | 6081.68 | 6745 | 950 | 73.01 | 76.47 | 73.08 | 77.00 | 0.35 | 0.27 | 23.26 | 3.46 |
| 1998 | 4922.76 | 5601 | 950 | 58.97 | 62.95 | 59.15 | 63.94 | 1.01 | 0.64 | 36.41 | 3.98 |
| 1999 | 5476.01 | 5887 | 950 | 65.68 | 66.94 | 65.80 | 67.20 | 0.00 | 0.00 | 33.06 | 1.26 |
| 2000 | 5626.40 | 6281 | 950 | 67.42 | 70.74 | 67.42 | 71.51 | 1.31 | 0.94 | 28.33 | 3.31 |
| 2001 | 5867.65 | 6422 | 950 | 70.59 | 72.47 | 70.31 | 73.11 | 1.37 | 1.01 | 26.52 | 1.88 |
| 2002 | 6315.64 | 6834 | 950 | 75.87 | 78.84 | 75.89 | 78.01 | 0.78 | 0.62 | 20.54 | 2.97 |
| 2003 | 6742.38 | 7387 | 950 | 80.89 | 83.75 | 81.02 | 84.33 | 0.33 | 0.28 | 15.97 | 2.86 |
| 2004 | 6944.29 | 7531 | 950 | 83.15 | 85.99 | 83.22 | 85.74 | 0.39 | 0.33 | 13.68 | 2.85 |
| 2005 | 6303.15 | 7332 | 950 | 82.41 | 83.38 | 75.74 | 83.70 | 0.35 | 0.29 | 16.33 | 0.97 |
| 2006 | 6644.71 | 7297 | 950 | 82.82 | 83.03 | 79.85 | 83.30 | 0.38 | 0.31 | 16.66 | 0.21 |
| 2007 | 7064.48 | 7528 | 950 | 85.13 | 85.34 | 84.89 | 85.94 | 0.60 | 0.51 | 14.15 | 0.21 |
| 2008 | 6763.54 | 7470 | 950 | 84.26 | 84.58 | 81.05 | 85.04 | 0.36 | 0.31 | 15.11 | 0.33 |
| 2009 | 6127.91 | 7206 | 950 | 80.90 | 81.79 | 73.64 | 82.26 | 0.35 | 0.29 | 17.92 | 0.89 |
| 2010 | 6674.39 | 7180 | 950 | 79.78 | 81.39 | 80.20 | 81.96 | 1.25 | 1.03 | 17.58 | 1.61 |
| 2011 | 6155.30 | 6881 | 950 | 75.09 | 77.42 | 73.96 | 78.55 | 0.82 | 0.64 | 21.94 | 2.33 |
| 2012 | 6046.81 | 7202 | 950 | 77.80 | 80.19 | 72.46 | 81.99 | 0.00 | 0.00 | 19.81 | 2.39 |
| 2013 | 5857.28 | 7464 | 950 | 95.09 | 97.30 | 70.38 | 85.21 | 0.00 | 0.00 | 2.70 | 2.22 |
| 2014 | 6307.66 | 6811 | 950 | 73.55 | 75.75 | 75.80 | 77.75 | 0.12 | 0.09 | 24.16 | 2.19 |
| 2015 | 5210.05 | 5982 | 950 | 62.35 | 66.53 | 62.61 | 68.29 | 0.53 | 0.36 | 33.11 | 4.18 |
| 2016 | 2595.13 | 3041 | 950 | 33.12 | 33.78 | 31.10 | 34.62 | 3.99 | 37.03 | 29.19 | 0.65 |
| 2017 | 5361.20 | 8387 | 950 | 71.31 | 95.66 | 64.42 | 95.74 | 0.00 | 0.00 | 4.34 | 24.35 |
| 2018 | 5104.80 | 5883 | 950 | 61.06 | 65.34 | 61.34 | 67.16 | 2.42 | 1.62 | 33.04 | 4.28 |
| 2019 | 4691.92 | 5002 | 950 | 55.07 | 56.59 | 56.38 | 57.10 | 0.00 | 0.00 | 43.41 | 1.52 |
| 2020 | 5114.55 | 5783 | 950 | 66.52 | 71.24 | 61.29 | 65.84 | 0.13 | 3.07 | 25.70 | 4.71 |
| 2021 | 6238.32 | 6587 | 950 | 72.36 | 74.57 | 74.96 | 75.19 | 0.18 | 0.13 | 25.29 | 2.22 |
| 2022 | | | | | | | | | | | |

Data not provided

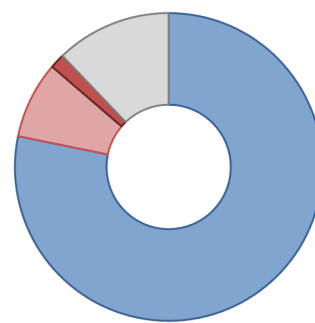
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 257 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1483 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 315 | | |
| E. Testing of plant systems or components | | | | 3 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 66 | 83 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 53 |
| L. Human factor related | | | | | 2 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| Z. Other | | | | | 2 | |
| Subtotal | | | | 1867 | 344 | 57 |
| Total | | 0 | | | 2268 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 0 |
| 14. Safety Systems | | 7 |
| 15. Reactor Cooling Systems | | 12 |
| 16. Steam generation systems | | 146 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 31. Turbine and auxiliaries | | 23 |
| 32. Feedwater and Main Steam System | | 5 |
| 34. Miscellaneous Systems | | 6 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 40 |
| 42. Electrical Power Supply Systems | | 7 |
| Total | | 261 |

2023 Operating Experience

UA-78

ZAPOROZHYE-3

UKRAINE

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Owner | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Reactor Supplier | : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT ATOMMASH,VOLGODONSK,RUSSIA) |
| Turbine Supplier | : KTP (Kharkiv Turbine Plant "Turboatom") |



Reactor Unit Details

| | |
|----------------------------|--------------------|
| Reactor type and model | : PWR / VVER V-320 |
| Thermal power | : 3000 MWth |
| Gross electrical power | : 1000 MWe |
| Reference unit power (net) | : 950 MWe |

Key Dates

| | |
|--------------------|--------------|
| Construction Date | : 1982-04-01 |
| Grid Date | : 1986-12-10 |
| Commercial Date | : 1987-03-05 |
| Age at end of year | : 37 years |

Design Characteristics

Primary Systems

| | |
|---|------------|
| Reactor vessel centreline orientation | : Vertical |
| Fuel material | : UO2 |
| Refuelling type | : OFF-line |
| Moderator material | : H2O |
| Average fuel enrichment [% of U235] | : - |
| Refuelling frequency [month] | : 12 |
| Part of the core refuelled [%] | : 33 |
| Average discharge burnup [MWd/t] | : 40000 |
| Active core diameter [m] | : 3.16 |
| Active core height/length [m] | : 3.53 |
| Number of fissile fuel assemblies/bundles | : 163 |
| Fuel linear heat generation rate [kW/m] | : 17.6 |
| Number of control rod assemblies | : 61 |
| Number of external reactor coolant loops | : 4 |
| Coolant type | : H2O |

| | |
|-----------------------------------|----------|
| Operating coolant pressure [MPa] | : 16 |
| Reactor outlet temperature [°C] | : 322 |
| Number of SG | : 4 |
| Containment type | : Single |
| Containment design pressure [MPa] | : 5 |

Secondary systems

| | |
|--|-----------------------|
| Number of turbine-generators per unit/reactor | : 1 |
| Turbine speed [rpm] | : 1500 |
| Number of LP cylinders per turbine | : - |
| HP cylinder inlet steam pressure [MPa] | : 6 |
| Output voltage [kV] | : - |
| Primary means of condenser cooling | : Lake (once-through) |
| Number of main condensate pumps | : - |
| Number of FW pumps for full power operation | : 2 |
| Number of on-site safety related diesel generators | : 3 |
| Non-electrical applications | : DH |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

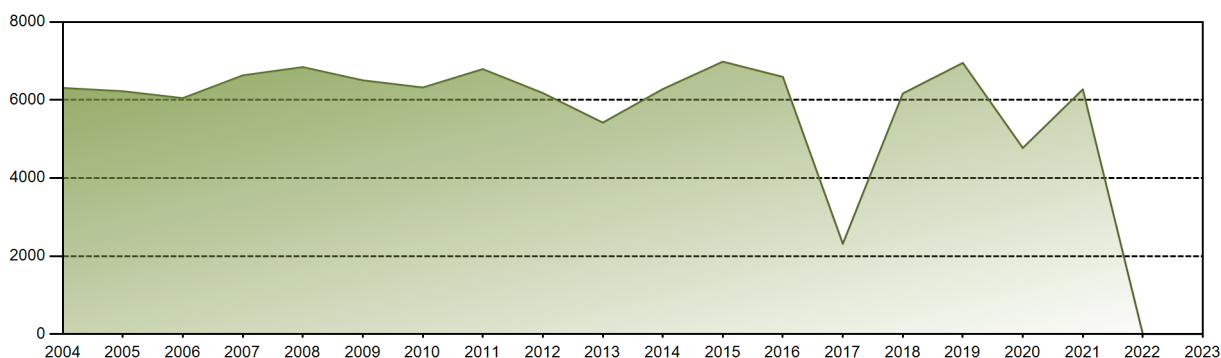
No data found

| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

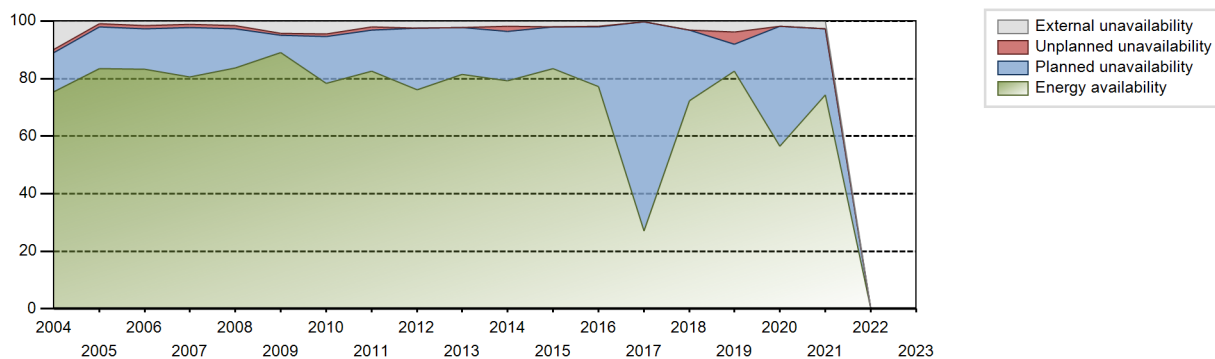
| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 3.32 % |
| Cumulative Energy Availability Factor (EAF) | : | 71.38 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 2.54 % |
| Cumulative Unit Capability Factor (UCF) | : | 74.09 % | Cumulative Planned Unavailability Factor (PUF) | : | 23.37 % |
| Cumulative Load Factor (LF) | : | 69.64 % | Cumulative Externally cause unavailability (XUF) | : | 2.71 % |
| Cumulative Operating Factor (OF) | : | 76.51 % | | | |

Electricity Production (net) [GWh]

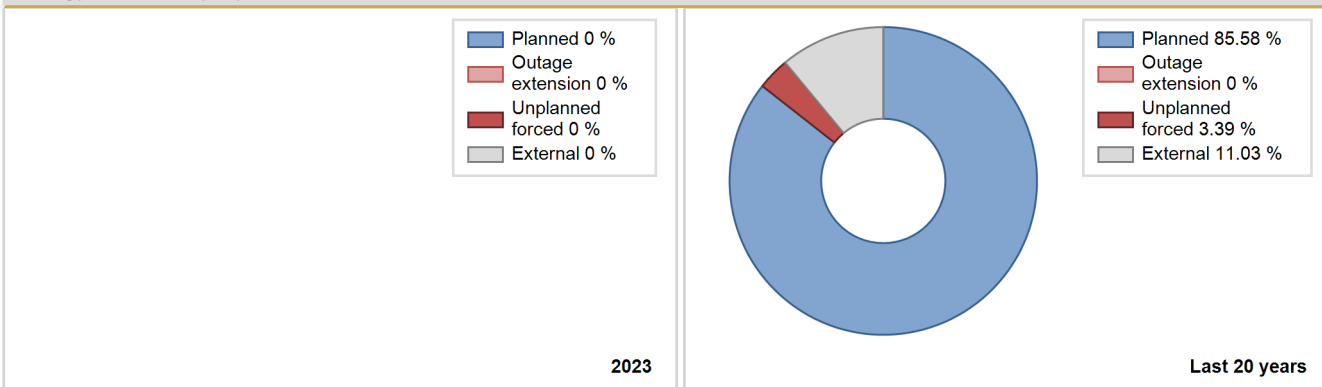


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 6690.98 | 7222 | 1000 | 80.32 | 80.32 | 78.39 | 80.15 | 4.02 | 3.37 | 16.31 | 0.00 |
| 1988 | 6414.29 | 7077 | 950 | 81.35 | 81.35 | 76.87 | 80.57 | 5.32 | 4.57 | 14.08 | 0.00 |
| 1989 | 6614.43 | 7373 | 950 | 80.85 | 80.85 | 79.48 | 84.17 | 3.97 | 3.34 | 15.80 | 0.00 |
| 1990 | 5625.32 | 6166 | 950 | 67.66 | 68.10 | 67.60 | 70.39 | 15.26 | 12.26 | 19.64 | 0.44 |
| 1991 | 4958.75 | 5877 | 950 | 59.91 | 61.09 | 59.59 | 67.09 | 11.90 | 8.25 | 30.66 | 1.18 |
| 1992 | 4140.90 | 5274 | 950 | 50.54 | 53.97 | 49.62 | 60.04 | 9.62 | 5.74 | 40.28 | 3.43 |
| 1993 | 5416.55 | 7263 | 950 | 66.01 | 67.60 | 65.09 | 82.91 | 19.21 | 16.08 | 16.32 | 1.59 |
| 1994 | 4273.71 | 6068 | 950 | 52.51 | 52.53 | 51.35 | 69.27 | 4.07 | 2.23 | 45.24 | 0.02 |
| 1995 | 4027.80 | 5804 | 950 | 48.38 | 49.72 | 48.40 | 66.26 | 1.31 | 0.66 | 49.62 | 1.35 |
| 1996 | 4940.20 | 6096 | 950 | 59.20 | 62.34 | 59.20 | 69.40 | 6.67 | 4.45 | 33.21 | 3.14 |
| 1997 | 4869.79 | 6544 | 950 | 58.52 | 70.09 | 58.52 | 74.70 | 3.99 | 2.91 | 27.00 | 11.57 |
| 1998 | 4953.19 | 6316 | 950 | 59.52 | 63.14 | 59.52 | 72.10 | 2.25 | 1.45 | 35.41 | 3.62 |
| 1999 | 5114.49 | 6162 | 950 | 61.46 | 64.75 | 61.46 | 70.34 | 5.25 | 3.59 | 31.66 | 3.29 |
| 2000 | 6123.23 | 6875 | 950 | 73.01 | 76.56 | 73.38 | 78.27 | 1.98 | 1.55 | 21.89 | 3.56 |
| 2001 | 6307.79 | 7027 | 950 | 75.72 | 80.85 | 75.59 | 80.00 | 2.63 | 2.18 | 16.97 | 5.13 |
| 2002 | 6602.04 | 7470 | 950 | 79.17 | 84.44 | 79.33 | 85.27 | 1.52 | 1.30 | 14.25 | 5.27 |
| 2003 | 6588.92 | 7236 | 950 | 79.01 | 81.93 | 79.17 | 82.60 | 0.63 | 0.52 | 17.55 | 2.92 |
| 2004 | 6308.69 | 7371 | 950 | 75.50 | 85.42 | 75.60 | 83.91 | 1.34 | 1.16 | 13.43 | 9.91 |
| 2005 | 6224.11 | 7229 | 950 | 83.55 | 84.38 | 74.79 | 82.52 | 1.30 | 1.11 | 14.51 | 0.83 |
| 2006 | 6048.05 | 7031 | 950 | 83.30 | 84.83 | 72.68 | 80.26 | 1.41 | 1.21 | 13.95 | 1.53 |
| 2007 | 6631.37 | 7268 | 950 | 80.48 | 81.72 | 79.68 | 82.97 | 1.34 | 1.11 | 17.17 | 1.24 |
| 2008 | 6843.24 | 7589 | 950 | 83.67 | 85.31 | 82.01 | 86.40 | 1.12 | 0.97 | 13.72 | 1.64 |
| 2009 | 6504.34 | 7996 | 950 | 88.93 | 93.15 | 78.16 | 91.28 | 0.85 | 0.80 | 6.05 | 4.22 |
| 2010 | 6319.92 | 7341 | 950 | 78.31 | 82.70 | 75.93 | 83.79 | 1.12 | 0.94 | 16.36 | 4.38 |
| 2011 | 6791.75 | 7569 | 950 | 82.59 | 84.71 | 81.61 | 86.40 | 1.27 | 1.09 | 14.20 | 2.12 |
| 2012 | 6178.42 | 6984 | 950 | 76.02 | 78.41 | 74.04 | 79.51 | 0.00 | 0.00 | 21.59 | 2.39 |
| 2013 | 5420.54 | 6518 | 950 | 81.45 | 83.61 | 65.14 | 74.41 | 0.00 | 0.00 | 16.39 | 2.16 |
| 2014 | 6279.95 | 7159 | 950 | 79.18 | 80.92 | 75.46 | 81.72 | 2.36 | 1.95 | 17.13 | 1.74 |
| 2015 | 6983.04 | 7557 | 950 | 83.36 | 85.40 | 83.91 | 86.27 | 0.08 | 0.07 | 14.53 | 2.04 |
| 2016 | 6593.10 | 7004 | 950 | 77.21 | 79.08 | 79.01 | 79.74 | 0.24 | 0.19 | 20.73 | 1.87 |
| 2017 | 2314.02 | 2440 | 950 | 27.17 | 27.49 | 27.81 | 27.85 | 0.00 | 0.00 | 72.51 | 0.32 |
| 2018 | 6166.88 | 6623 | 950 | 72.39 | 75.52 | 74.10 | 75.61 | 0.00 | 0.00 | 24.48 | 3.13 |
| 2019 | 6950.92 | 7590 | 950 | 82.52 | 86.42 | 83.52 | 86.64 | 4.52 | 4.09 | 9.49 | 3.90 |
| 2020 | 4771.20 | 5136 | 950 | 56.51 | 58.30 | 57.18 | 58.47 | 0.00 | 0.00 | 41.70 | 1.80 |
| 2021 | 6271.69 | 6748 | 950 | 74.25 | 76.86 | 75.36 | 77.03 | 0.00 | 0.00 | 23.14 | 2.61 |
| 2022 | | | | Data not provided | | | | | | | |
| 2023 | | | | | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 69 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1470 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 137 | | |
| E. Testing of plant systems or components | | | | 12 | 2 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 172 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 7 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 52 |
| L. Human factor related | | | | | 5 | |
| R. External restrictions on supply and services (lack of funds due to delayed payments from customers, disputes in fuel industries, fuel-rationing, labour strike outside the plant, spare part delivery problems etc.) | | | | | | 7 |
| Z. Other | | | | 1 | 3 | |
| Subtotal | | | | 1792 | 79 | 66 |
| Total | | 0 | | | 1937 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 3 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 5 |
| 15. Reactor Cooling Systems | | 1 |
| 16. Steam generation systems | | 9 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 31. Turbine and auxiliaries | | 3 |
| 32. Feedwater and Main Steam System | | 8 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 5 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 27 |
| 42. Electrical Power Supply Systems | | 10 |
| Total | | 75 |

2023 Operating Experience

UA-79

ZAPOROZHYE-4

UKRAINE

| | |
|-----------------------|---|
| Status at end of year | : Operational |
| Operator | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Owner | : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom") |
| Reactor Supplier | : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT ATOMMASH,VOLGODONSK,RUSSIA) |
| Turbine Supplier | : KTP (Kharkiv Turbine Plant "Turboatom") |



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 1983-04-01 |
| Thermal power | : 3000 MWth | Grid Date | : 1987-12-18 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1988-04-14 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 36 years |

Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|-----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 16 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 322 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 5 |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : DH |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

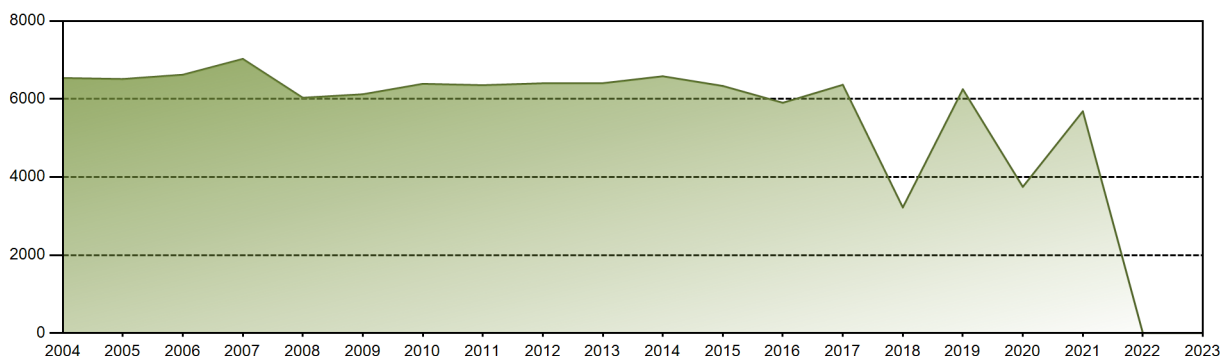
No data found

| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 2.84 % |
| Cumulative Energy Availability Factor (EAF) | : | 72.95 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 2.22 % |
| Cumulative Unit Capability Factor (UCF) | : | 75.23 % | Cumulative Planned Unavailability Factor (PUF) | : | 22.54 % |
| Cumulative Load Factor (LF) | : | 71.45 % | Cumulative Externally cause unavailability (XUF) | : | 2.28 % |
| Cumulative Operating Factor (OF) | : | 76.34 % | | | |

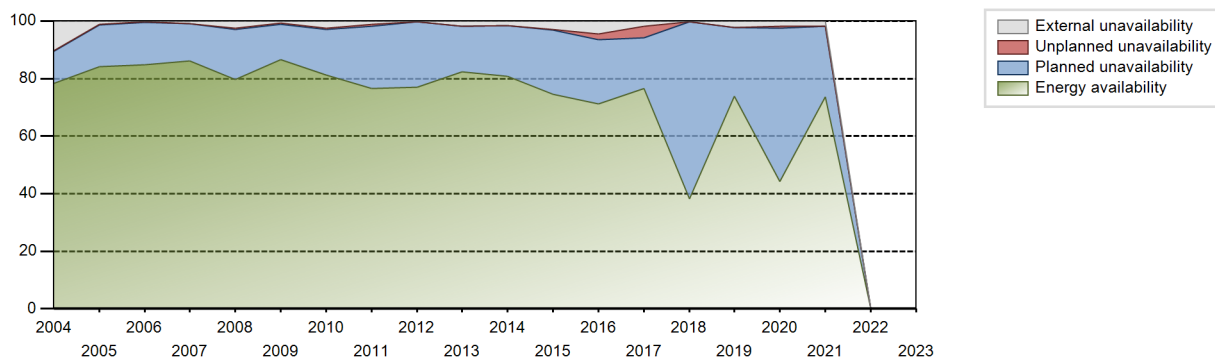
Electricity Production (net) [GWh]



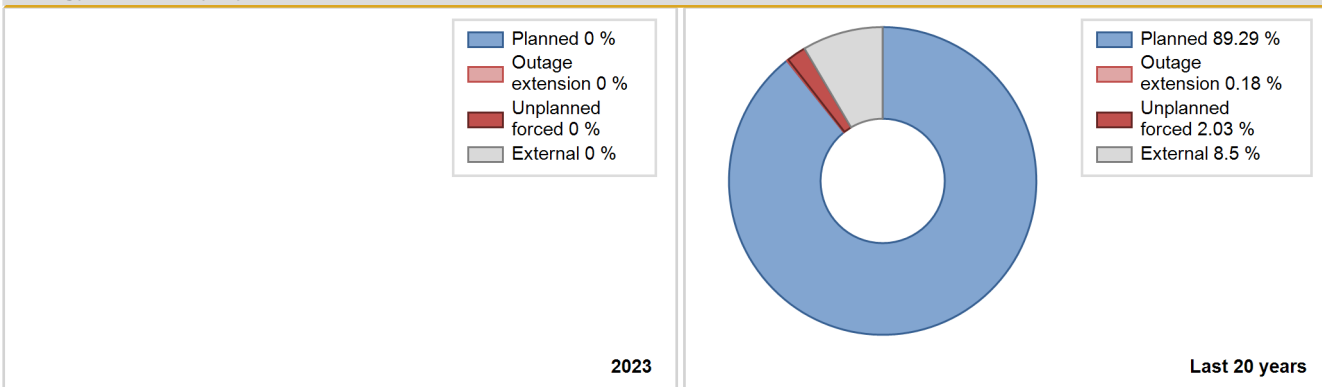
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|-------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 6431.44 | 7143 | 950 | 79.07 | 79.07 | 76.53 | 79.96 | 6.22 | 5.25 | 15.68 | 0.00 |
| 1989 | 5828.07 | 6613 | 950 | 73.08 | 73.08 | 70.03 | 75.49 | 10.85 | 8.90 | 18.02 | 0.00 |
| 1990 | 6637.35 | 7393 | 950 | 78.86 | 79.78 | 79.76 | 84.39 | 8.99 | 7.88 | 12.34 | 0.92 |
| 1991 | 4259.50 | 5114 | 950 | 51.08 | 51.25 | 51.18 | 58.38 | 23.69 | 15.91 | 32.84 | 0.17 |
| 1992 | 6962.30 | 6961 | 1000 | 78.56 | 78.81 | 79.26 | 79.25 | 2.75 | 2.23 | 18.96 | 0.25 |
| 1993 | 6118.75 | 6821 | 950 | 73.37 | 74.09 | 73.53 | 77.87 | 12.30 | 10.39 | 15.52 | 0.72 |
| 1994 | 5888.70 | 6718 | 950 | 71.28 | 71.41 | 70.76 | 76.69 | 2.19 | 1.60 | 26.99 | 0.13 |
| 1995 | 4717.10 | 5902 | 950 | 56.68 | 58.41 | 56.68 | 67.37 | 5.56 | 3.44 | 38.15 | 1.73 |
| 1996 | 5372.18 | 6372 | 950 | 64.38 | 66.26 | 64.38 | 72.54 | 6.81 | 4.84 | 28.89 | 1.89 |
| 1997 | 6284.42 | 7060 | 950 | 75.52 | 79.93 | 75.52 | 80.59 | 2.47 | 2.03 | 18.04 | 4.42 |
| 1998 | 6022.02 | 6839 | 950 | 72.36 | 74.04 | 72.36 | 78.07 | 3.06 | 2.33 | 23.62 | 1.68 |
| 1999 | 3921.35 | 4630 | 950 | 47.12 | 49.83 | 47.12 | 52.85 | 0.58 | 0.29 | 49.88 | 2.71 |
| 2000 | 6708.40 | 7423 | 950 | 80.29 | 83.81 | 80.39 | 84.51 | 0.90 | 0.77 | 15.42 | 3.52 |
| 2001 | 6091.25 | 7884 | 950 | 73.15 | 89.85 | 72.99 | 89.75 | 0.42 | 0.38 | 9.77 | 16.70 |
| 2002 | 6337.06 | 6895 | 950 | 76.15 | 78.53 | 76.15 | 78.71 | 0.05 | 0.04 | 21.43 | 2.38 |
| 2003 | 6736.32 | 7248 | 950 | 80.87 | 82.45 | 80.95 | 82.74 | 0.04 | 0.04 | 17.52 | 1.58 |
| 2004 | 6537.56 | 7247 | 950 | 78.27 | 88.49 | 78.34 | 82.50 | 0.21 | 0.19 | 11.32 | 10.22 |
| 2005 | 6511.87 | 7498 | 950 | 84.10 | 85.13 | 78.25 | 85.59 | 0.36 | 0.30 | 14.56 | 1.04 |
| 2006 | 6621.84 | 7186 | 950 | 84.82 | 85.16 | 79.57 | 82.03 | 0.25 | 0.21 | 14.63 | 0.34 |
| 2007 | 7027.84 | 7645 | 950 | 86.22 | 87.10 | 84.45 | 87.27 | 0.02 | 0.02 | 12.88 | 0.88 |
| 2008 | 6031.59 | 7265 | 950 | 79.65 | 82.20 | 72.28 | 82.71 | 0.56 | 0.46 | 17.34 | 2.55 |
| 2009 | 6121.29 | 7111 | 950 | 86.67 | 87.28 | 73.56 | 81.18 | 0.52 | 0.46 | 12.27 | 0.61 |
| 2010 | 6388.85 | 7086 | 950 | 81.31 | 83.77 | 76.77 | 80.89 | 0.60 | 0.51 | 15.72 | 2.46 |
| 2011 | 6353.81 | 6892 | 950 | 76.58 | 77.65 | 76.35 | 78.68 | 1.01 | 0.80 | 21.56 | 1.06 |
| 2012 | 6403.06 | 6941 | 950 | 77.11 | 77.44 | 76.73 | 79.02 | 0.00 | 0.00 | 22.56 | 0.33 |
| 2013 | 6404.96 | 7580 | 950 | 82.40 | 84.16 | 76.96 | 86.53 | 0.00 | 0.00 | 15.84 | 1.76 |
| 2014 | 6582.83 | 7375 | 950 | 80.89 | 82.57 | 79.10 | 84.19 | 0.00 | 0.00 | 17.43 | 1.68 |
| 2015 | 6334.43 | 6921 | 950 | 74.46 | 77.41 | 76.12 | 79.01 | 0.18 | 0.14 | 22.45 | 2.95 |
| 2016 | 5903.10 | 6670 | 950 | 71.13 | 75.53 | 70.74 | 75.93 | 2.66 | 2.07 | 22.40 | 4.40 |
| 2017 | 6363.95 | 7006 | 950 | 76.50 | 78.35 | 76.47 | 79.98 | 4.79 | 3.94 | 17.71 | 1.84 |
| 2018 | 3220.41 | 3407 | 950 | 38.17 | 38.54 | 38.70 | 38.89 | 0.00 | 0.00 | 61.46 | 0.37 |
| 2019 | 6249.05 | 6673 | 950 | 73.81 | 75.98 | 75.09 | 76.18 | 0.00 | 0.00 | 24.02 | 2.17 |
| 2020 | 3748.24 | 4055 | 950 | 44.18 | 45.91 | 44.92 | 46.16 | 0.00 | 0.82 | 53.27 | 1.74 |
| 2021 | 5685.03 | 6170 | 950 | 73.58 | 75.41 | 68.31 | 70.43 | 0.10 | 0.08 | 24.51 | 1.83 |
| 2022 | Data not provided | | | | | | | | | | |
| 2023 | " | | | | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 103 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1400 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 364 | | |
| E. Testing of plant systems or components | | | | 10 | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 64 |
| L. Human factor related | | | | | 18 | |
| Subtotal | | | | 1774 | 121 | 64 |
| Total | | 0 | | | 1959 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 19 |
| 12. Reactor I&C Systems | | 6 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 3 |
| 15. Reactor Cooling Systems | | 7 |
| 16. Steam generation systems | | 12 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 7 |
| 32. Feedwater and Main Steam System | | 4 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 53 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | | 120 |

2023 Operating Experience

UA-126

ZAPOROZHYE-5

UKRAINE

Status at end of year : **Operational**
 Operator : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Owner : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Reactor Supplier : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT
 ATOMMASH,VOLGODONSK,RUSSIA)
 Turbine Supplier : KTP (Kharkiv Turbine Plant "Turboatom")



Reactor Unit Details

Reactor type and model : PWR / VVER V-320
 Thermal power : 3000 MWth
 Gross electrical power : 1000 MWe
 Reference unit power (net) : 950 MWe

Key Dates

Construction Date : 1985-11-01
 Grid Date : 1989-08-14
 Commercial Date : 1989-10-27
 Age at end of year : 34 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 12
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 40000
 Active core diameter [m] : 3.16
 Active core height/length [m] : 3.53
 Number of fissile fuel assemblies/bundles : 163
 Fuel linear heat generation rate [kW/m] : 17.6
 Number of control rod assemblies : 61
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 16
 Reactor outlet temperature [°C] : 322
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 5

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 3

Non-electrical applications : DH

Annual Production Results (2023)

Net Energy Production : 0 GW(e).h
 Energy Availability Factor (EAF) : 0 %
 Unit Capability Factor (UCF) : 0 %
 Load Factor (LF) : 0 %
 Operating Factor (OF) : 0 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : hours

Annual Summary

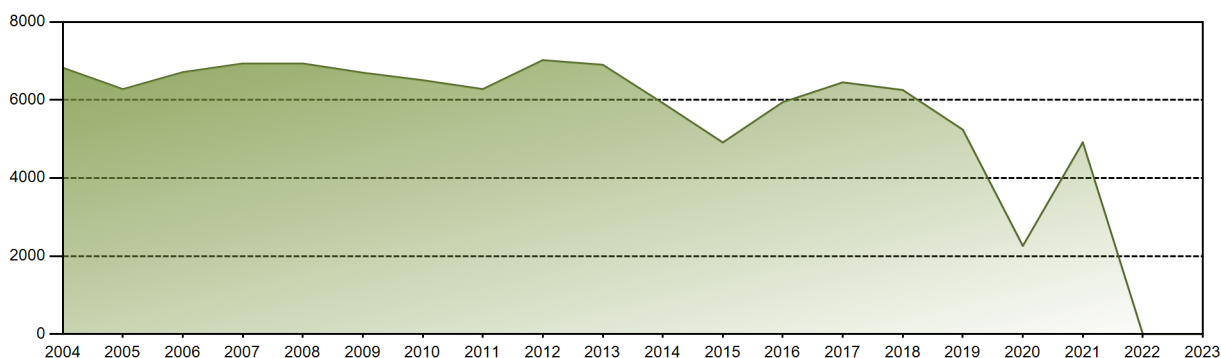
No data found

| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

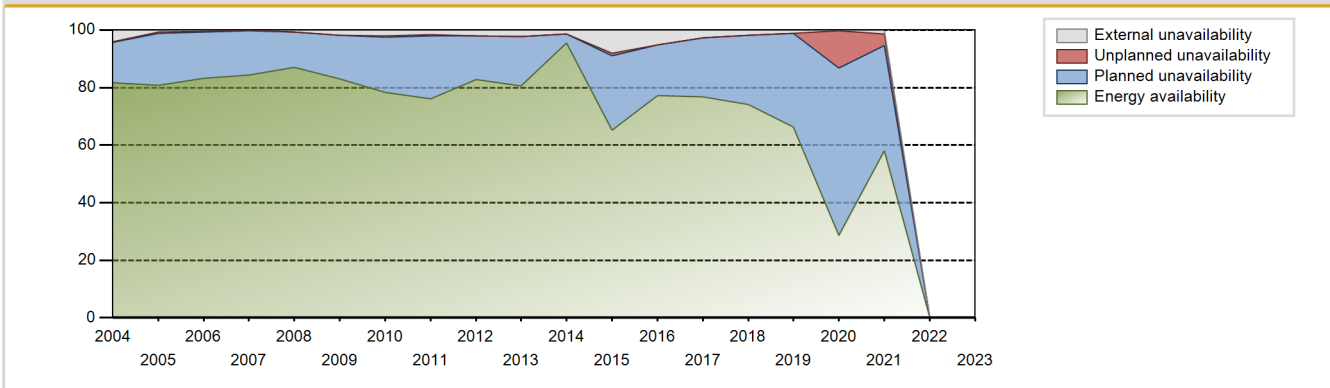
| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 2.95 % |
| Cumulative Energy Availability Factor (EAF) | : | 73.35 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 2.82 % |
| Cumulative Unit Capability Factor (UCF) | : | 75.31 % | Cumulative Planned Unavailability Factor (PUF) | : | 21.87 % |
| Cumulative Load Factor (LF) | : | 71.77 % | Cumulative Externally cause unavailability (XUF) | : | 1.96 % |
| Cumulative Operating Factor (OF) | : | 76.95 % | | | |

Electricity Production (net) [GWh]

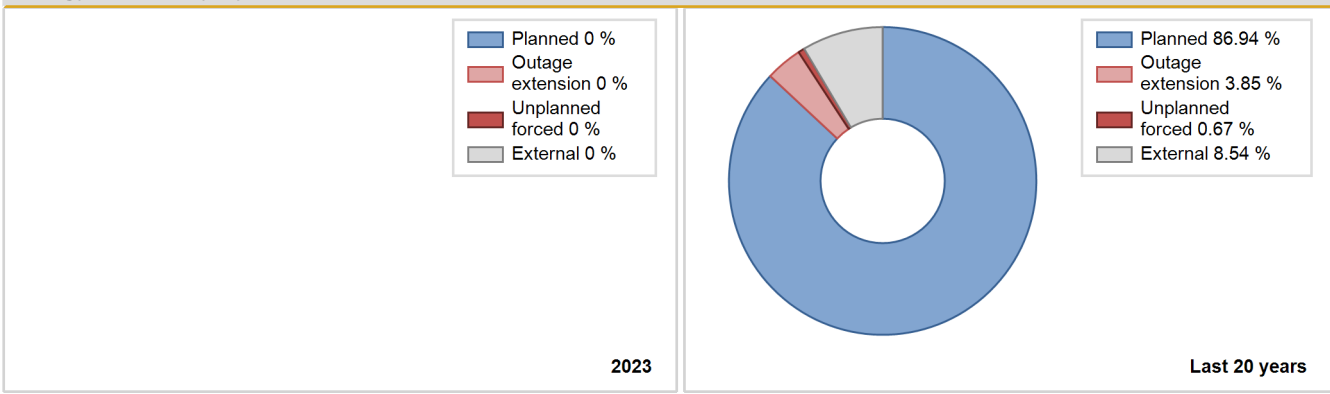


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 2147.46 | 2938 | 950 | 85.59 | 85.59 | 80.54 | 86.20 | 10.02 | 9.54 | 4.88 | 0.00 |
| 1990 | 4678.67 | 6002 | 950 | 56.65 | 57.92 | 56.22 | 68.52 | 20.69 | 15.11 | 26.98 | 1.27 |
| 1991 | 6554.93 | 7319 | 950 | 78.38 | 79.49 | 78.77 | 83.55 | 8.70 | 7.57 | 12.94 | 1.11 |
| 1992 | 6898.80 | 7032 | 1000 | 79.16 | 80.12 | 78.54 | 80.05 | 2.62 | 2.15 | 17.73 | 0.95 |
| 1993 | 5661.77 | 6735 | 950 | 68.26 | 68.92 | 68.03 | 76.88 | 13.97 | 11.19 | 19.88 | 0.66 |
| 1994 | 4858.94 | 6779 | 950 | 59.12 | 59.13 | 58.39 | 77.39 | 20.05 | 14.83 | 26.04 | 0.02 |
| 1995 | 5391.90 | 6506 | 950 | 64.73 | 66.00 | 64.79 | 74.27 | 4.95 | 3.44 | 30.56 | 1.27 |
| 1996 | 6126.05 | 6799 | 950 | 73.41 | 74.14 | 73.41 | 77.40 | 2.38 | 1.81 | 24.05 | 0.73 |
| 1997 | 6381.48 | 6705 | 950 | 75.77 | 76.23 | 76.68 | 76.54 | 2.33 | 1.82 | 21.95 | 0.46 |
| 1998 | 5856.23 | 6249 | 950 | 70.12 | 70.72 | 70.37 | 71.34 | 1.34 | 0.96 | 28.31 | 0.60 |
| 1999 | 5070.20 | 5525 | 950 | 60.60 | 62.96 | 60.93 | 63.07 | 0.00 | 0.00 | 37.04 | 2.36 |
| 2000 | 6286.64 | 6928 | 950 | 74.89 | 77.87 | 75.34 | 78.87 | 1.02 | 0.80 | 21.34 | 2.97 |
| 2001 | 5890.83 | 6751 | 950 | 70.66 | 76.19 | 70.59 | 76.86 | 1.90 | 1.48 | 22.33 | 5.54 |
| 2002 | 6222.49 | 6983 | 950 | 74.55 | 80.79 | 74.77 | 79.71 | 1.22 | 0.99 | 18.21 | 6.25 |
| 2003 | 6585.47 | 7107 | 950 | 79.00 | 80.20 | 79.13 | 81.13 | 8.06 | 7.03 | 12.77 | 1.20 |
| 2004 | 6826.67 | 7551 | 950 | 81.62 | 85.58 | 81.81 | 85.96 | 0.28 | 0.24 | 14.18 | 3.97 |
| 2005 | 6278.94 | 6975 | 950 | 80.79 | 81.48 | 75.45 | 79.62 | 0.66 | 0.54 | 17.98 | 0.69 |
| 2006 | 6713.60 | 7297 | 950 | 83.28 | 83.72 | 80.67 | 83.30 | 0.24 | 0.20 | 16.08 | 0.44 |
| 2007 | 6936.51 | 7408 | 950 | 84.26 | 84.29 | 83.35 | 84.57 | 0.18 | 0.15 | 15.56 | 0.03 |
| 2008 | 6935.93 | 7708 | 950 | 86.95 | 87.59 | 83.12 | 87.75 | 0.06 | 0.06 | 12.35 | 0.64 |
| 2009 | 6700.77 | 7445 | 950 | 83.02 | 84.88 | 80.52 | 84.99 | 0.01 | 0.01 | 15.11 | 1.86 |
| 2010 | 6507.63 | 7081 | 950 | 78.30 | 80.42 | 78.20 | 80.83 | 0.36 | 0.29 | 19.29 | 2.13 |
| 2011 | 6280.40 | 6861 | 950 | 76.04 | 77.71 | 75.47 | 78.32 | 0.41 | 0.32 | 21.97 | 1.67 |
| 2012 | 7022.33 | 7545 | 950 | 82.91 | 84.95 | 84.15 | 85.89 | 0.00 | 0.00 | 15.05 | 2.04 |
| 2013 | 6903.10 | 7381 | 950 | 80.66 | 82.98 | 82.95 | 84.26 | 0.00 | 0.00 | 17.02 | 2.31 |
| 2014 | 5920.96 | 7601 | 950 | 95.58 | 97.01 | 71.15 | 86.77 | 0.00 | 0.00 | 2.99 | 1.44 |
| 2015 | 4911.23 | 6519 | 950 | 65.24 | 73.21 | 59.01 | 74.41 | 1.31 | 0.97 | 25.82 | 7.96 |
| 2016 | 5945.32 | 7345 | 950 | 77.23 | 82.48 | 71.25 | 83.62 | 0.00 | 0.00 | 17.52 | 5.26 |
| 2017 | 6452.82 | 7052 | 950 | 76.79 | 79.39 | 77.54 | 80.50 | 0.00 | 0.00 | 20.61 | 2.60 |
| 2018 | 6256.59 | 6742 | 950 | 74.12 | 75.95 | 75.18 | 76.96 | 0.00 | 0.00 | 24.05 | 1.83 |
| 2019 | 5239.69 | 5999 | 950 | 66.35 | 67.56 | 62.96 | 68.48 | 0.00 | 0.00 | 32.44 | 1.21 |
| 2020 | 2261.14 | 2546 | 950 | 28.52 | 28.71 | 27.10 | 28.98 | 0.00 | 13.11 | 58.18 | 0.18 |
| 2021 | 4915.79 | 5255 | 950 | 58.02 | 59.36 | 59.07 | 59.99 | 0.27 | 4.00 | 36.64 | 1.34 |
| 2022 | | | | Data not provided | | | | | | | |
| 2023 | | | | | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 100 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1427 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 142 | | |
| E. Testing of plant systems or components | | | | 14 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 149 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 42 |
| L. Human factor related | | | | | 5 | |
| Z. Other | | | | | 1 | |
| Subtotal | | | | 1732 | 106 | 42 |
| Total | | 0 | | | 1880 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 5 |
| 14. Safety Systems | | 34 |
| 15. Reactor Cooling Systems | | 8 |
| 16. Steam generation systems | | 35 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 5 |
| 32. Feedwater and Main Steam System | | 4 |
| 41. Main Generator Systems | | 5 |
| 42. Electrical Power Supply Systems | | 5 |
| Total | | 102 |

2023 Operating Experience

UA-127

ZAPOROZHYE-6

UKRAINE

Status at end of year : **Operational**
 Operator : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Owner : NNEGC (State Enterprise "National Nuclear Energy Generating Company 'Energoatom")
 Reactor Supplier : PAIP (PRODUCTION AMALGAMATION IZHORSKY PLANT
 ATOMMASH,VOLGODONSK,RUSSIA)
 Turbine Supplier : KTP (Kharkiv Turbine Plant "Turboatom")



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------|--------------------|--------------|
| Reactor type and model | : PWR / VVER V-320 | Construction Date | : 1986-06-01 |
| Thermal power | : 3000 MWth | Grid Date | : 1995-10-19 |
| Gross electrical power | : 1000 MWe | Commercial Date | : 1996-09-17 |
| Reference unit power (net) | : 950 MWe | Age at end of year | : 28 years |

Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|-----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 16 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 322 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : Single |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 5 |
| Refuelling frequency [month] | : 12 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : - | Turbine speed [rpm] | : 1500 |
| Average discharge burnup [MWd/t] | : 40000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.16 | HP cylinder inlet steam pressure [MPa] | : 6 |
| Active core height/length [m] | : 3.53 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 163 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.6 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 61 | Number of FW pumps for full power operation | : 2 |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 3 |
| Coolant type | : H2O | Non-electrical applications | : DH |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------|--|---------|
| Net Energy Production | : 0 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 0 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 0 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 0 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 0 % | Total off-line time | : hours |

Annual Summary

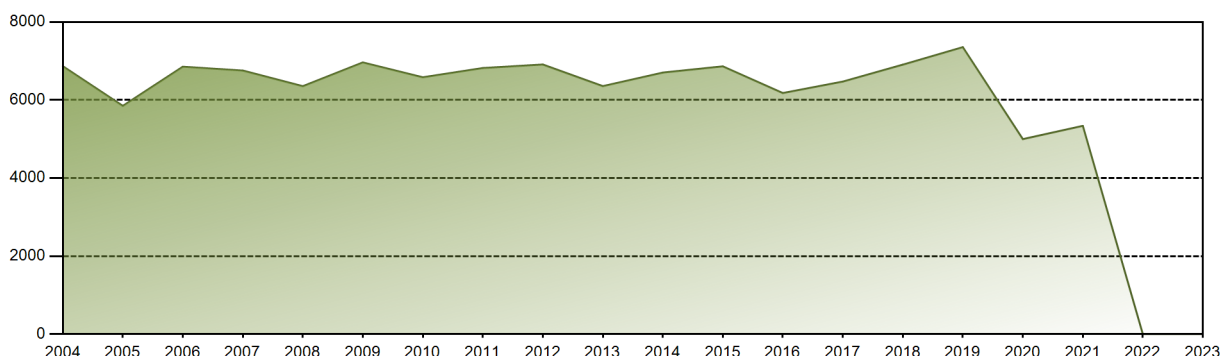
No data found

| | Jan | Oct | Nov | Dec | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| GW(e)-h | | | | | | | | | | | | |
| EAF [%] | | | | | | | | | | | | |
| UCF [%] | | | | | | | | | | | | |
| LF [%] | | | | | | | | | | | | |
| OF [%] | | | | | | | | | | | | |
| FLR [%] | | | | | | | | | | | | |
| UCL [%] | | | | | | | | | | | | |
| PUF [%] | | | | | | | | | | | | |
| XUF [%] | | | | | | | | | | | | |

Historical Summary

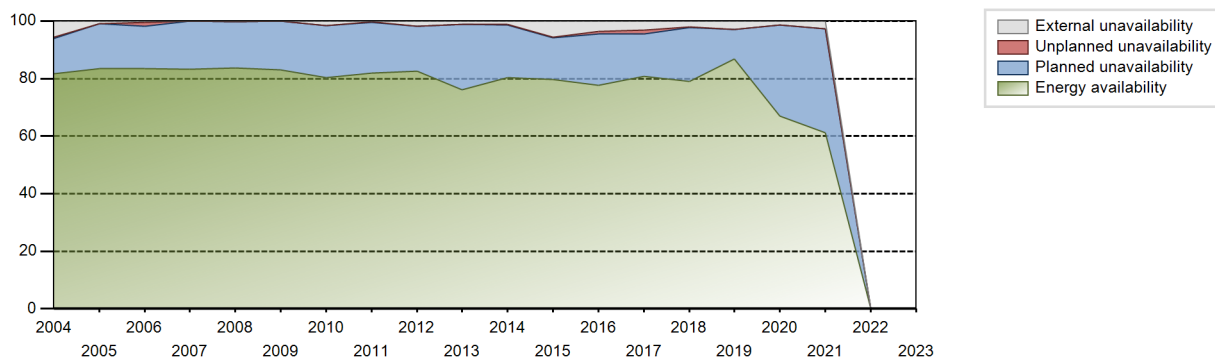
| | | | | | |
|---|---|-----------|---|---|---------|
| Lifetime energy generation | : | 0 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 0.53 % |
| Cumulative Energy Availability Factor (EAF) | : | 78.62 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 0.43 % |
| Cumulative Unit Capability Factor (UCF) | : | 80.73 % | Cumulative Planned Unavailability Factor (PUF) | : | 18.84 % |
| Cumulative Load Factor (LF) | : | 77.76 % | Cumulative Externally cause unavailability (XUF) | : | 2.11 % |
| Cumulative Operating Factor (OF) | : | 80.51 % | | | |

Electricity Production (net) [GWh]

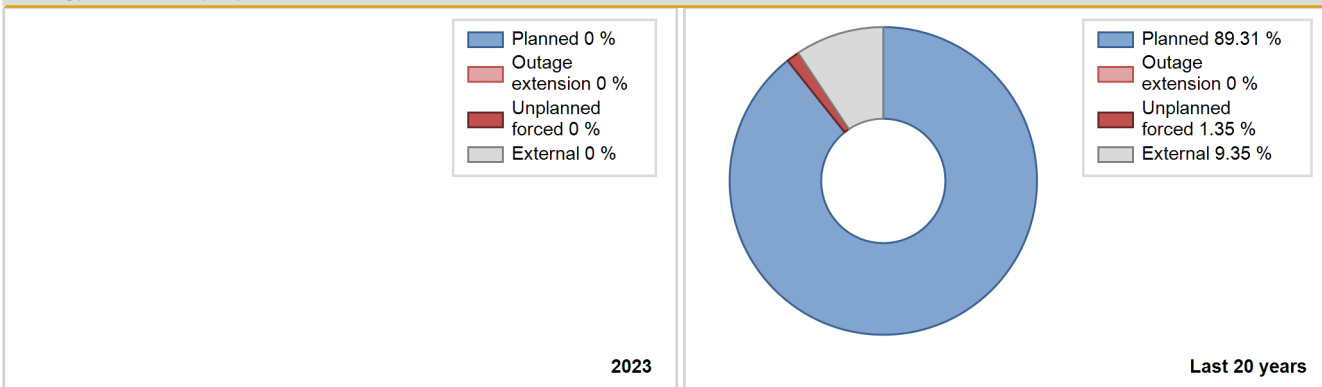


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1996 | 6403.54 | 7871 | 950 | 85.50 | 87.53 | 85.50 | 87.87 | 0.00 | 0.00 | 12.47 | 2.02 |
| 1997 | 6332.68 | 6640 | 950 | 75.18 | 75.50 | 76.10 | 75.80 | 0.96 | 0.73 | 23.77 | 0.32 |
| 1998 | 6132.18 | 6766 | 950 | 73.41 | 76.19 | 73.69 | 77.24 | 1.09 | 0.84 | 22.97 | 2.78 |
| 1999 | 6165.39 | 6934 | 950 | 74.09 | 78.37 | 74.09 | 79.16 | 0.42 | 0.33 | 21.30 | 4.28 |
| 2000 | 5844.18 | 6191 | 950 | 69.29 | 70.13 | 70.03 | 70.48 | 1.55 | 1.11 | 28.76 | 0.84 |
| 2001 | 6336.18 | 7118 | 950 | 75.23 | 80.10 | 75.93 | 81.03 | 1.51 | 1.23 | 18.68 | 4.86 |
| 2002 | 6790.62 | 7393 | 950 | 80.96 | 83.41 | 81.60 | 84.39 | 1.54 | 1.31 | 15.28 | 2.46 |
| 2003 | 7006.44 | 7590 | 950 | 83.47 | 86.29 | 84.19 | 86.64 | 0.40 | 0.35 | 13.37 | 2.82 |
| 2004 | 6867.82 | 7715 | 950 | 81.73 | 87.35 | 82.30 | 87.83 | 0.43 | 0.38 | 12.27 | 5.62 |
| 2005 | 5850.74 | 6557 | 950 | 83.53 | 84.47 | 70.30 | 74.85 | 0.00 | 0.00 | 15.53 | 0.95 |
| 2006 | 6855.00 | 7317 | 950 | 83.56 | 84.01 | 82.37 | 83.53 | 1.49 | 1.27 | 14.73 | 0.45 |
| 2007 | 6756.35 | 7275 | 950 | 83.33 | 83.35 | 81.19 | 83.05 | 0.09 | 0.08 | 16.57 | 0.02 |
| 2008 | 6355.28 | 6888 | 950 | 83.70 | 83.85 | 76.16 | 78.42 | 0.00 | 0.00 | 16.15 | 0.15 |
| 2009 | 6964.63 | 7285 | 950 | 82.94 | 82.98 | 83.69 | 83.16 | 0.01 | 0.01 | 17.01 | 0.04 |
| 2010 | 6583.55 | 7181 | 950 | 80.27 | 81.80 | 79.11 | 81.97 | 0.09 | 0.08 | 18.12 | 1.53 |
| 2011 | 6820.92 | 7254 | 950 | 81.91 | 82.14 | 81.96 | 82.81 | 0.20 | 0.17 | 17.70 | 0.22 |
| 2012 | 6911.00 | 7496 | 950 | 82.65 | 84.48 | 82.82 | 85.34 | 0.00 | 0.00 | 15.52 | 1.82 |
| 2013 | 6356.96 | 6819 | 950 | 76.01 | 77.15 | 76.39 | 77.84 | 0.00 | 0.00 | 22.85 | 1.14 |
| 2014 | 6704.13 | 7217 | 950 | 80.32 | 81.47 | 80.56 | 82.39 | 0.38 | 0.31 | 18.22 | 1.14 |
| 2015 | 6863.82 | 7601 | 950 | 79.76 | 85.37 | 82.48 | 86.77 | 0.29 | 0.24 | 14.38 | 5.61 |
| 2016 | 6179.42 | 7225 | 950 | 77.58 | 81.27 | 74.05 | 82.25 | 0.86 | 0.71 | 18.02 | 3.70 |
| 2017 | 6473.26 | 7450 | 950 | 80.76 | 83.98 | 77.78 | 85.05 | 1.60 | 1.37 | 14.65 | 3.22 |
| 2018 | 6907.39 | 7188 | 950 | 79.07 | 81.03 | 83.00 | 82.05 | 0.37 | 0.30 | 18.67 | 1.95 |
| 2019 | 7356.44 | 8015 | 950 | 86.83 | 89.70 | 88.40 | 91.50 | 0.04 | 0.04 | 10.26 | 2.86 |
| 2020 | 4998.20 | 5492 | 950 | 67.05 | 68.32 | 59.90 | 62.52 | 0.00 | 0.00 | 31.68 | 1.27 |
| 2021 | 5338.28 | 5693 | 950 | 61.27 | 63.92 | 64.15 | 64.99 | 0.00 | 0.00 | 36.08 | 2.65 |
| 2022 | | | | Data not provided | | | | | | | |
| 2023 | | | | " | | | | | | | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1996 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 27 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1434 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 60 | | |
| E. Testing of plant systems or components | | | | 17 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 72 |
| Subtotal | | | | 1511 | 27 | 72 |
| Total | | 0 | | | 1610 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1996 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 1 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 5 |
| 16. Steam generation systems | | 7 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 5 |
| 32. Feedwater and Main Steam System | | 0 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 3 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 27 |

2023 Operating Experience

AE-01

BARAKAH-1

UNITED ARAB EMIRATES

Status at end of year : **Operational**
 Operator : NAWAH (Nawah Energy Company)
 Owner : ENEC (Emirates Nuclear Energy Corporation)
 Reactor Supplier : KEPCO (Korea Electric Power Corporation)
 Turbine Supplier : KEPCO (Korea Electric Power Corporation)



Reactor Unit Details

Reactor type and model : PWR / APR-1400
 Thermal power : 3983 MWth
 Gross electrical power : 1417 MWe
 Reference unit power (net) : 1337 MWe

Key Dates

Construction Date : 2012-07-19
 Grid Date : 2020-08-19
 Commercial Date : 2021-04-01
 Age at end of year : 3 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.66
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 28914
 Active core diameter [m] : 3.647
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 241
 Fuel linear heat generation rate [kW/m] : 47.572
 Number of control rod assemblies : 81
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.513
 Reactor outlet temperature [°C] : 323.9
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.414

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.629
 Output voltage [kV] : 27
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 3
 Number of on-site safety related diesel generators : 2

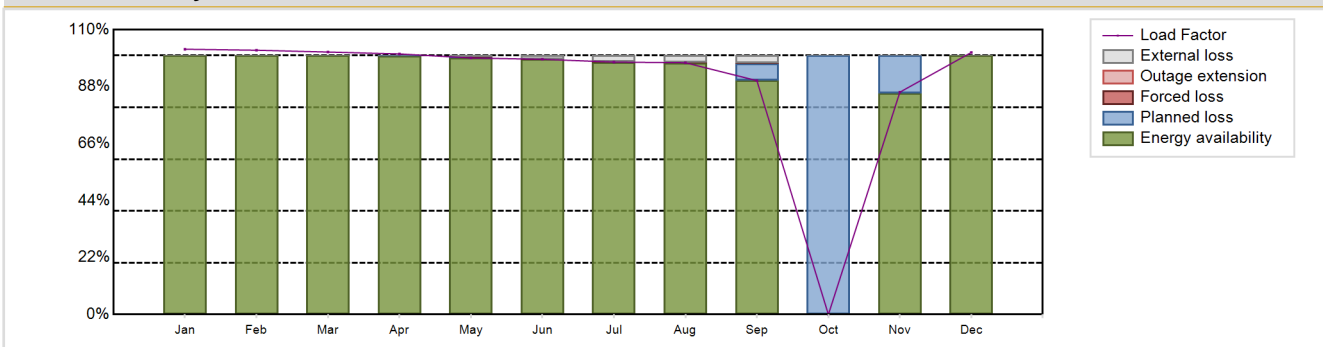
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 10488.13 GW(e).h
 Energy Availability Factor (EAF) : 88.87 %
 Unit Capability Factor (UCF) : 89.66 %
 Load Factor (LF) : 89.55 %
 Operating Factor (OF) : 90.25 %
 Forced Loss Rate (FLR) : 0.06 %
 Unplanned Capability Loss Factor (UCL) : 0.05 %
 Planned Unavailability Factor (PUF) : 10.29 %
 Externally cause unavailability (XUF) : 0.79 %
 Total off-line time : 854 hours

Annual Summary

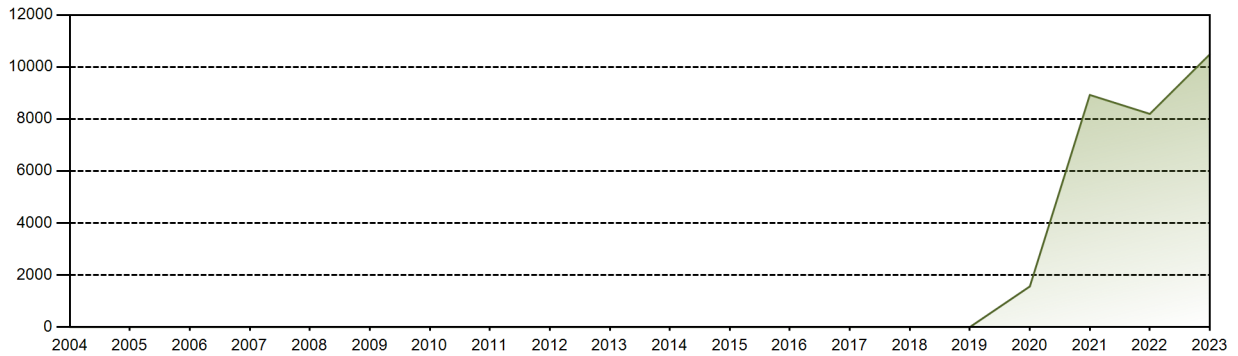


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|---------|--------|---------|--------|--------|--------|--------|--------|--------|--------|--------|---------|----------|
| GW(e)-h | 1019.19 | 917.05 | 1008.43 | 968.90 | 985.59 | 948.84 | 969.77 | 967.32 | 869.56 | 0.00 | 826.71 | 1006.78 | 10488.13 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 99.98 | 99.08 | 98.57 | 97.49 | 97.24 | 90.33 | 0.00 | 85.42 | 100.00 | 88.87 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 99.98 | 99.40 | 99.99 | 99.91 | 99.80 | 93.09 | 0.00 | 85.42 | 100.00 | 89.66 |
| LF [%] | 102.46 | 102.07 | 101.38 | 100.65 | 99.08 | 98.57 | 97.49 | 97.24 | 90.33 | 0.00 | 85.88 | 101.21 | 89.55 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.61 | 0.00 | 91.11 | 100.00 | 90.25 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.01 | 0.09 | 0.20 | 0.27 | 0.00 | 0.00 | 0.00 | 0.06 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.01 | 0.09 | 0.20 | 0.25 | 0.00 | 0.00 | 0.00 | 0.05 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.02 | 0.54 | 0.00 | 0.00 | 0.00 | 6.65 | 100.00 | 14.58 | 0.00 | 10.29 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 | 1.43 | 2.42 | 2.56 | 2.76 | 0.00 | 0.00 | 0.00 | 0.79 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 29172.82 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.66 % |
| Cumulative Energy Availability Factor (EAF) | : 81.11 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.81 % |
| Cumulative Unit Capability Factor (UCF) | : 81.65 % | Cumulative Planned Unavailability Factor (PUF) | : 11.53 % |
| Cumulative Load Factor (LF) | : 81.4 % | Cumulative Externally cause unavailability (XUF) | : 0.54 % |
| Cumulative Operating Factor (OF) | : 83.88 % | | |

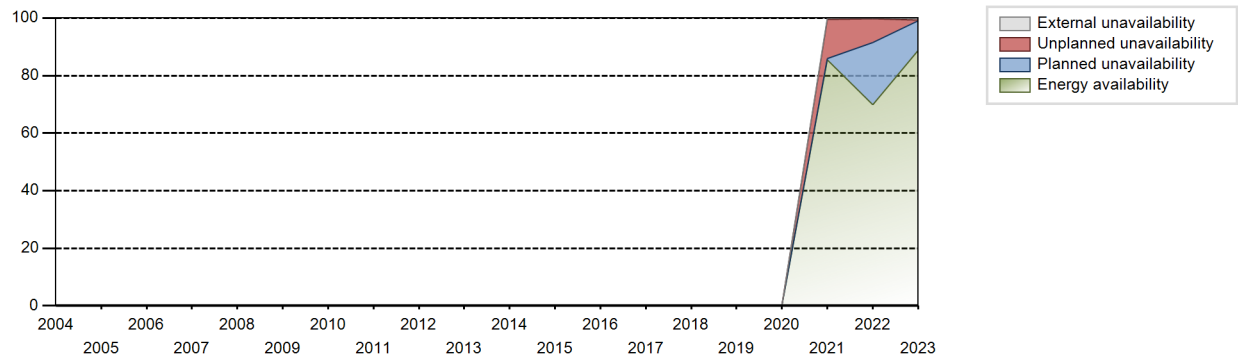
Electricity Production (net) [GWh]



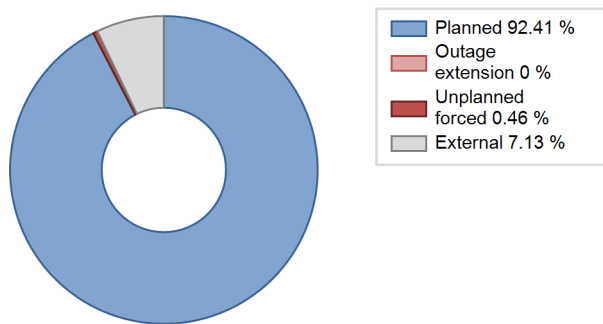
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2021 | 8926.09 | 6763 | 1417 | 85.44 | 85.98 | 85.49 | 91.77 | 13.54 | 13.47 | 0.55 | 0.54 |
| 2022 | 8196.79 | 6269 | 1337 | 69.89 | 70.18 | 69.99 | 71.56 | 0.53 | 8.26 | 21.55 | 0.30 |
| 2023 | 10488.13 | 7906 | 1337 | 88.87 | 89.66 | 89.55 | 90.25 | 0.06 | 0.05 | 10.29 | 0.79 |

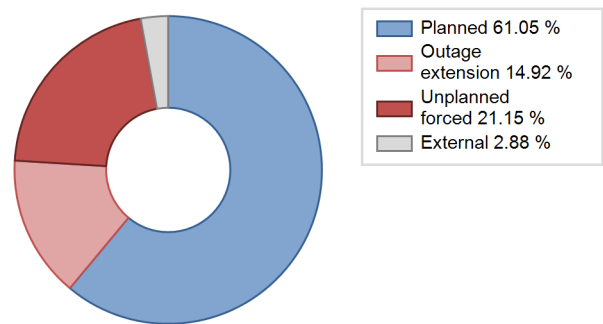
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2021 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 302 | |
| C. Inspection, maintenance or repair combined with refuelling | 854 | | | 835 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 441 | | |
| Z. Other | | | | | 463 | |
| Subtotal | 854 | | | 1276 | 765 | |
| Total | | 854 | | | 2041 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2021 to 2023 | |
|------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 12. Reactor I&C Systems | | | | 154 |
| 33. Circulating Water System | | | | 123 |
| Total | | | | 277 |

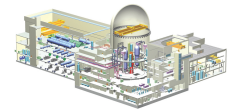
2023 Operating Experience

AE-02

BARAKAH-2

UNITED ARAB EMIRATES

Status at end of year : **Operational**
 Operator : NAWAH (Nawah Energy Company)
 Owner : ENEC (Emirates Nuclear Energy Corporation)
 Reactor Supplier : KEPCO (Korea Electric Power Corporation)
 Turbine Supplier : KEPCO (Korea Electric Power Corporation)



Reactor Unit Details

Reactor type and model : PWR / APR-1400
 Thermal power : 3983 MWth
 Gross electrical power : 1417 MWe
 Reference unit power (net) : 1337 MWe

Key Dates

Construction Date : 2013-04-15
 Grid Date : 2021-09-14
 Commercial Date : 2022-03-24
 Age at end of year : 2 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : 2.66
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 28914
 Active core diameter [m] : 3.647
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 241
 Fuel linear heat generation rate [kW/m] : 17.9
 Number of control rod assemblies : 81
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.513
 Reactor outlet temperature [°C] : 323.9
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : 0.414

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.629
 Output voltage [kV] : 27
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 3
 Number of FW pumps for full power operation : 2
 Number of on-site safety related diesel generators : 2

Non-electrical applications

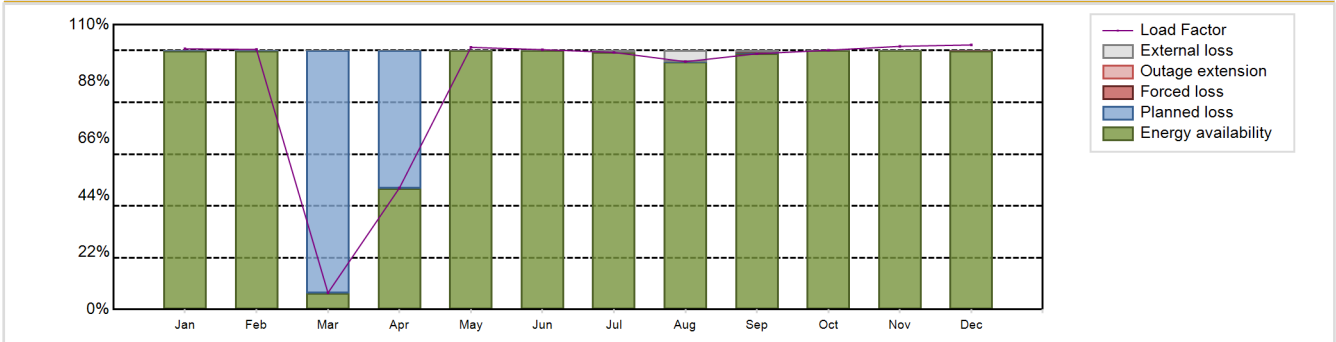
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 10274.57 GW(e).h
 Energy Availability Factor (EAF) : 87.12 %
 Unit Capability Factor (UCF) : 87.59 %
 Load Factor (LF) : 87.73 %
 Operating Factor (OF) : 88.16 %

Forced Loss Rate (FLR) : 0.02 %
 Unplanned Capability Loss Factor (UCL) : 0.02 %
 Planned Unavailability Factor (PUF) : 12.39 %
 Externally cause unavailability (XUF) : 0.48 %
 Total off-line time : 1037 hours

Annual Summary

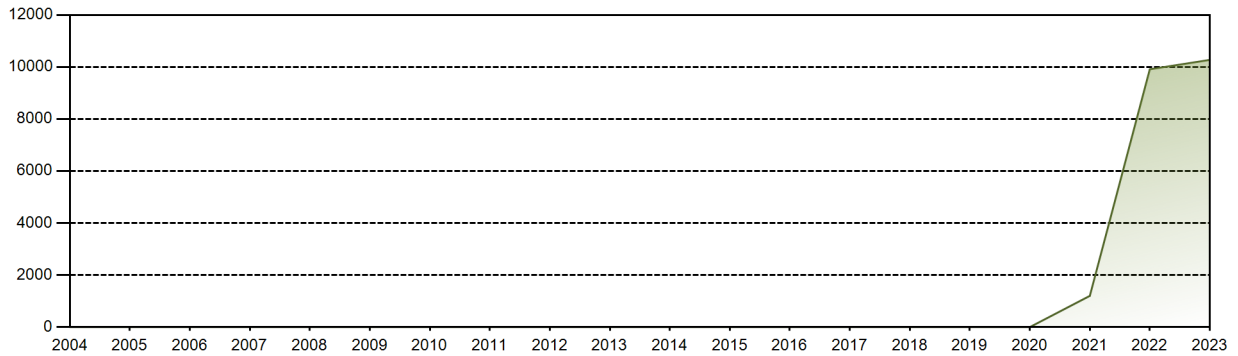


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|---------|--------|-------|--------|---------|--------|--------|--------|--------|--------|--------|---------|----------|
| GW(e)-h | 1001.43 | 902.30 | 64.06 | 452.11 | 1007.13 | 966.08 | 987.66 | 952.15 | 950.77 | 995.98 | 978.47 | 1016.44 | 10274.57 |
| EAF [%] | 99.97 | 99.91 | 6.41 | 46.69 | 100.00 | 100.00 | 99.29 | 95.72 | 98.77 | 100.00 | 100.00 | 99.80 | 87.12 |
| UCF [%] | 99.97 | 99.91 | 6.41 | 46.69 | 100.00 | 100.00 | 100.00 | 99.96 | 99.44 | 100.00 | 100.00 | 99.80 | 87.59 |
| LF [%] | 100.67 | 100.43 | 6.44 | 46.97 | 101.25 | 100.36 | 99.29 | 95.72 | 98.77 | 100.13 | 101.64 | 102.18 | 87.73 |
| OF [%] | 100.00 | 100.00 | 6.85 | 52.22 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.16 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.02 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.02 |
| PUF [%] | 0.03 | 0.09 | 93.59 | 53.31 | 0.00 | 0.00 | 0.00 | 0.04 | 0.56 | 0.00 | 0.00 | 0.00 | 12.39 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 4.24 | 0.67 | 0.00 | 0.00 | 0.00 | 0.48 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 21388.89 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.29 % |
| Cumulative Energy Availability Factor (EAF) | : 91.98 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.27 % |
| Cumulative Unit Capability Factor (UCF) | : 92.54 % | Cumulative Planned Unavailability Factor (PUF) | : 7.19 % |
| Cumulative Load Factor (LF) | : 92.19 % | Cumulative Externally cause unavailability (XUF) | : 0.56 % |
| Cumulative Operating Factor (OF) | : 93.25 % | | |

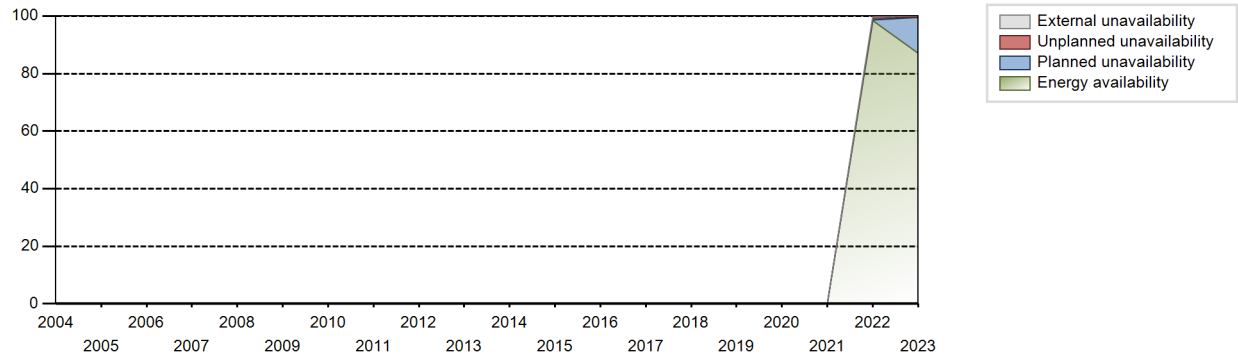
Electricity Production (net) [GWh]



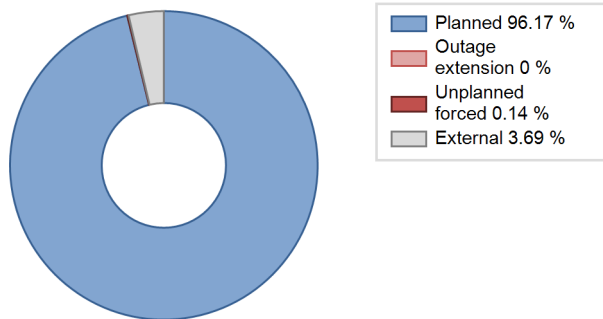
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2022 | 9914.13 | 7723 | 1337 | 98.44 | 99.11 | 98.12 | 100.00 | 0.61 | 0.61 | 0.28 | 0.67 |
| 2023 | 10274.57 | 7723 | 1337 | 87.12 | 87.59 | 87.73 | 88.16 | 0.02 | 0.02 | 12.39 | 0.48 |

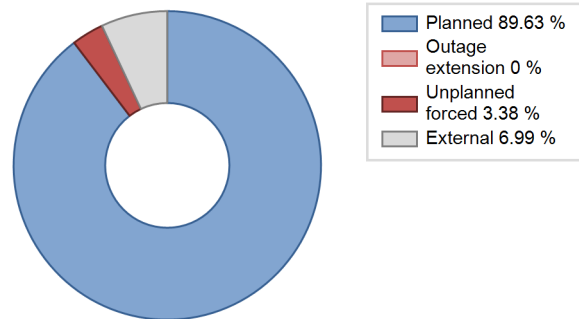
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2022 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 353 | |
| C. Inspection, maintenance or repair combined with refuelling | 1037 | | | 593 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 559 | | |
| Subtotal | 1037 | | | 1152 | 353 | |
| Total | | 1037 | | | 1505 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2022 to 2023 | |
|-----------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 25 |
| 15. Reactor Cooling Systems | | | | 129 |
| 31. Turbine and auxiliaries | | | | 111 |
| Total | | | | 265 |

2023 Operating Experience

AE-03

BARAKAH-3

UNITED ARAB EMIRATES

Status at end of year : **Operational**
 Operator : NAWAH (Nawah Energy Company)
 Owner : ENEC (Emirates Nuclear Energy Corporation)
 Reactor Supplier : KEPCO (Korea Electric Power Corporation)
 Turbine Supplier : KEPCO (Korea Electric Power Corporation)

Reactor Unit Details

Reactor type and model : PWR / APR-1400
 Thermal power : 3983 MWth
 Gross electrical power : 1417 MWe
 Reference unit power (net) : 1337 MWe

Key Dates

Construction Date : 2014-09-24
 Grid Date : 2022-10-08
 Commercial Date : 2023-02-24
 Age at end of year : 1 years

Design Characteristics

Primary Systems

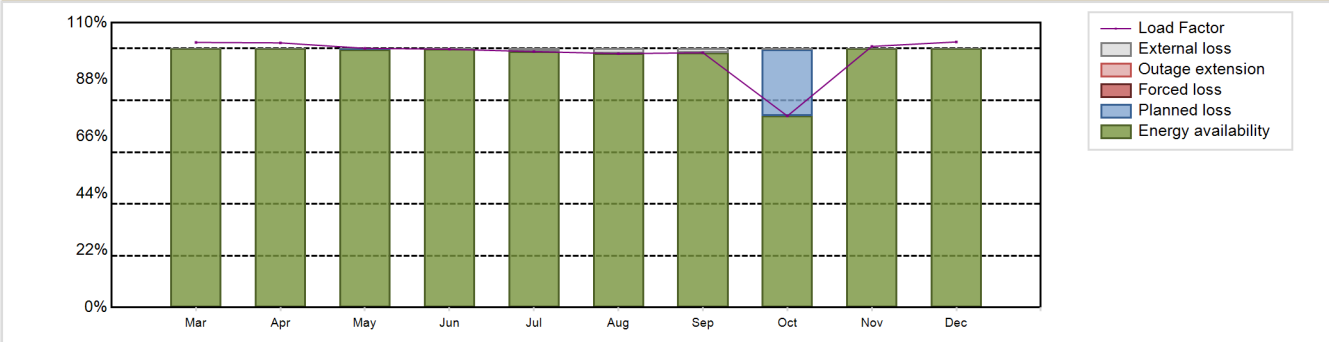
Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : 28914
 Active core diameter [m] : -
 Active core height/length [m] : -
 Number of fissile fuel assemblies/bundles : -
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : -
 Reactor outlet temperature [°C] : -
 Number of SG : 2
 Containment type : Single
 Containment design pressure [MPa] : -
Secondary systems
 Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1500
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : -
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : 2
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 10442.83 GW(e).h
 Energy Availability Factor (EAF) : 96.83 %
 Unit Capability Factor (UCF) : 97.36 %
 Load Factor (LF) : 97.68 %
 Operating Factor (OF) : 97.7 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 2.64 %
 Externally cause unavailability (XUF) : 0.53 %
 Total off-line time : 895 hours

Annual Summary

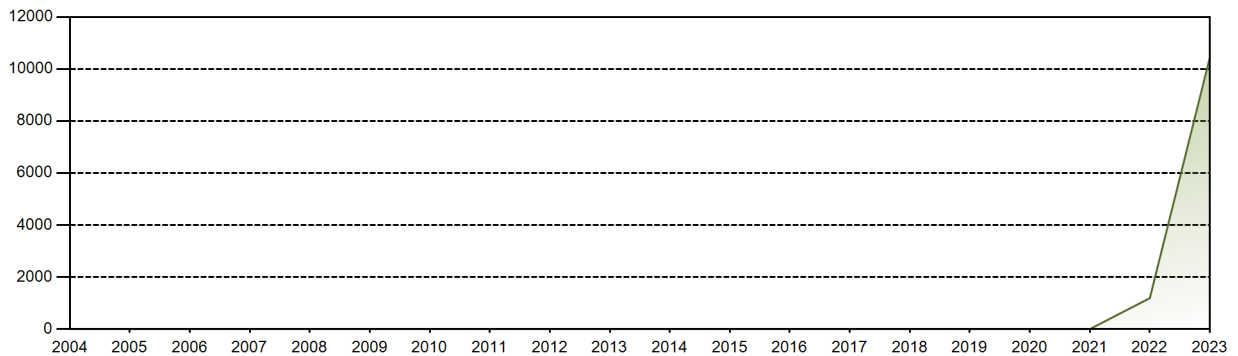


| | Feb | Jan | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-----|-----|---------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|
| GW(e)-h | | | 1018.35 | 983.89 | 995.67 | 960.24 | 983.14 | 975.41 | 947.26 | 735.80 | 970.83 | 1020.34 | 9590.95 |
| EAF [%] | | | 100.00 | 100.00 | 99.61 | 99.75 | 98.83 | 98.06 | 98.40 | 73.97 | 100.00 | 100.00 | 96.83 |
| UCF [%] | | | 100.00 | 100.00 | 99.61 | 100.00 | 100.00 | 100.00 | 100.00 | 74.30 | 100.00 | 100.00 | 97.36 |
| LF [%] | | | 102.38 | 102.21 | 100.09 | 99.75 | 98.83 | 98.06 | 98.40 | 73.97 | 100.85 | 102.57 | 97.68 |
| OF [%] | | | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 77.28 | 100.00 | 100.00 | 97.70 |
| FLR [%] | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | | | 0.00 | 0.00 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 | 25.70 | 0.00 | 0.00 | 2.64 |
| XUF [%] | | | 0.00 | 0.00 | 0.00 | 0.25 | 1.17 | 1.94 | 1.60 | 0.33 | 0.00 | 0.00 | 0.53 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 11632.36 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0 % |
| Cumulative Energy Availability Factor (EAF) | : 96.83 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0 % |
| Cumulative Unit Capability Factor (UCF) | : 97.36 % | Cumulative Planned Unavailability Factor (PUF) | : 2.64 % |
| Cumulative Load Factor (LF) | : 97.68 % | Cumulative Externally cause unavailability (XUF) | : 0.53 % |
| Cumulative Operating Factor (OF) | : 97.7 % | | |

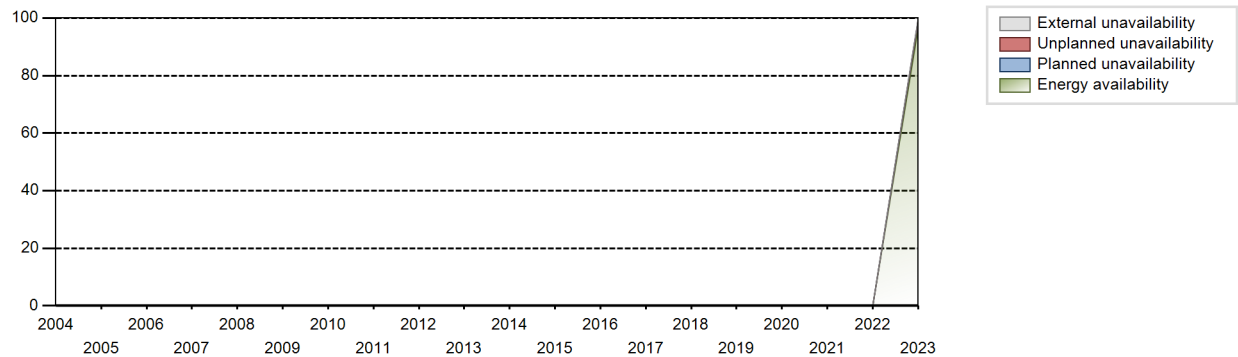
Electricity Production (net) [GWh]



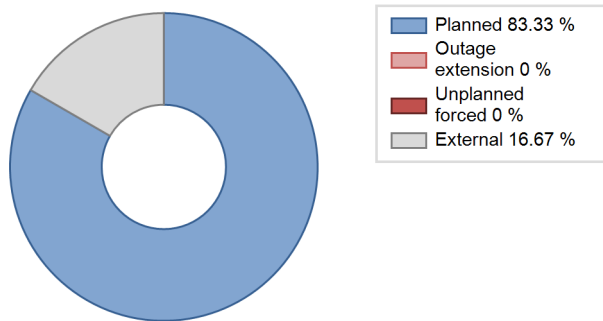
Performance for Years of Commercial Operation

| Year | Energy | Time Online | Reference Unit Power | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|----------|-------------|----------------------|-------|-------|-------|-------|------|------|------|------|
| | [GW-h] | [Hours] | [MW] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2023 | 10442.83 | 7865 | 1337 | 96.83 | 97.36 | 97.68 | 97.70 | 0.00 | 0.00 | 2.64 | 0.53 |

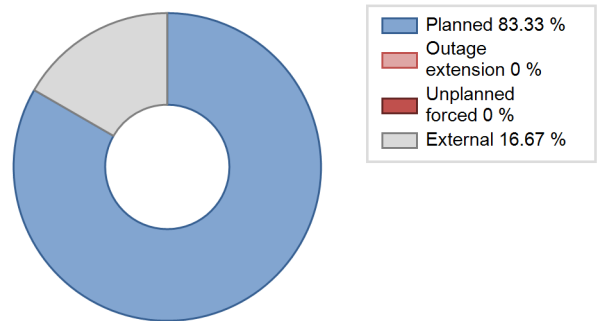
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2023 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 100 | |
| D. Inspection, maintenance or repair without refuelling | 169 | | | 203 | | |
| E. Testing of plant systems or components | 726 | | | 1176 | | |
| Subtotal | 895 | | | 1379 | 100 | |
| Total | | 895 | | | 1479 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2023 to 2023 | |
|-----------------------------|------------|--|-------------------------------------|-----------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 66 |
| Total | | | | 66 |

2023 Operating Experience

GB-19A HARTLEPOOL A-1 UNITED KINGDOM

Status at end of year : **Operational**
 Operator : EDF UK (EDF Energy)
 Owner : EDF UK (EDF Energy)
 Reactor Supplier : NPC (NUCLEAR POWER CO., LTD.)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))

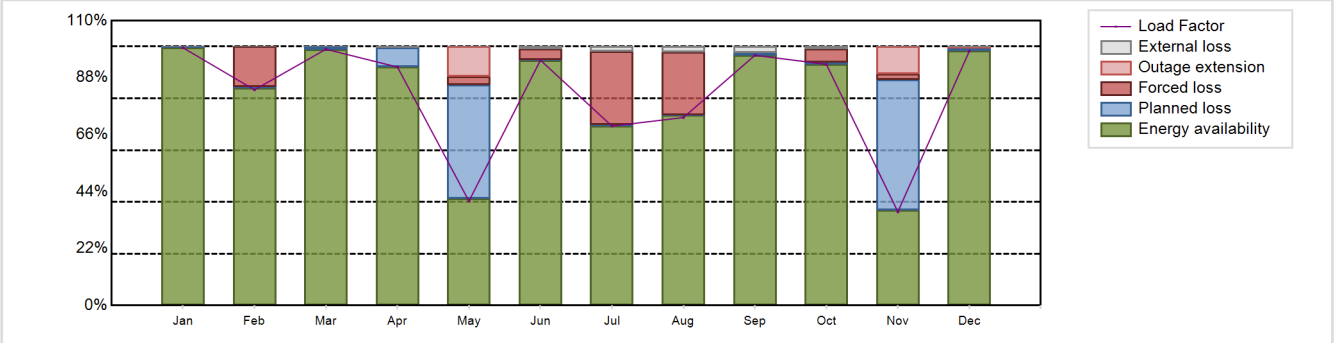


| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : GCR / AGR | Construction Date | : 1968-10-01 |
| Thermal power | : 1500 MWth | Grid Date | : 1983-08-01 |
| Gross electrical power | : 655 MWe | Commercial Date | : 1989-04-01 |
| Reference unit power (net) | : 590 MWe | Age at end of year | : 40 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 4.14 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 650 |
| Fuel material | : UO2 | Number of SG | : 8 |
| Refuelling type | : OFF-line | Containment type | : NA |
| Moderator material | : GRAPHITE | Containment design pressure [MPa] | : NA |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 4 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 7.5 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 9.37 | HP cylinder inlet steam pressure [MPa] | : 15.96 |
| Active core height/length [m] | : 8.3 | Output voltage [kV] | : 23 |
| Number of fissile fuel assemblies/bundles | : 2592 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 16.8 | Number of main condensate pumps | : 2 |
| Number of control rod assemblies | : 44 | Number of FW pumps for full power operation | : 1 |
| Number of external reactor coolant loops | : 8 | Number of on-site safety related diesel generators | : NA |
| Coolant type | : CO2 | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4199.98 GW(e).h | Forced Loss Rate (FLR) | : 7.76 % |
| Energy Availability Factor (EAF) | : 81.55 % | Unplanned Capability Loss Factor (UCL) | : 8.82 % |
| Unit Capability Factor (UCF) | : 82.26 % | Planned Unavailability Factor (PUF) | : 8.91 % |
| Load Factor (LF) | : 81.26 % | Externally cause unavailability (XUF) | : 0.72 % |
| Operating Factor (OF) | : 86.22 % | Total off-line time | : 1207 hours |

Annual Summary

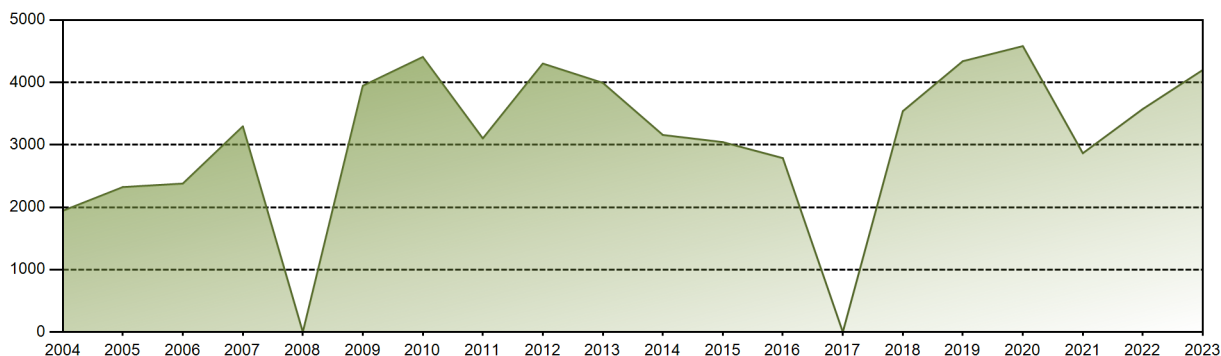


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 436.98 | 330.31 | 433.89 | 391.26 | 176.95 | 402.53 | 304.27 | 318.66 | 410.55 | 409.44 | 153.79 | 431.36 | 4199.98 |
| EAF [%] | 99.55 | 84.04 | 98.98 | 92.25 | 41.32 | 94.76 | 69.35 | 73.43 | 96.65 | 93.15 | 36.90 | 98.27 | 81.55 |
| UCF [%] | 99.55 | 84.04 | 98.98 | 92.53 | 41.32 | 95.67 | 71.16 | 75.66 | 99.10 | 93.94 | 36.90 | 98.34 | 82.26 |
| LF [%] | 99.55 | 83.31 | 98.98 | 92.10 | 40.31 | 94.76 | 69.32 | 72.59 | 96.65 | 93.15 | 36.20 | 98.27 | 81.26 |
| OF [%] | 100.00 | 88.69 | 100.00 | 94.72 | 51.08 | 100.00 | 72.31 | 78.23 | 100.00 | 100.00 | 49.86 | 100.00 | 86.22 |
| FLR [%] | 0.00 | 15.60 | 0.00 | 0.00 | 7.34 | 4.25 | 28.49 | 24.32 | 0.00 | 5.38 | 5.50 | 0.00 | 7.76 |
| UCL [%] | 0.00 | 15.53 | 0.00 | 0.00 | 14.73 | 4.25 | 28.36 | 24.31 | 0.00 | 5.34 | 12.81 | 0.61 | 8.82 |
| PUF [%] | 0.45 | 0.43 | 1.02 | 7.47 | 43.95 | 0.08 | 0.48 | 0.03 | 0.90 | 0.72 | 50.29 | 1.05 | 8.91 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.28 | 0.00 | 0.91 | 1.82 | 2.23 | 2.45 | 0.79 | 0.00 | 0.08 | 0.72 |

Historical Summary

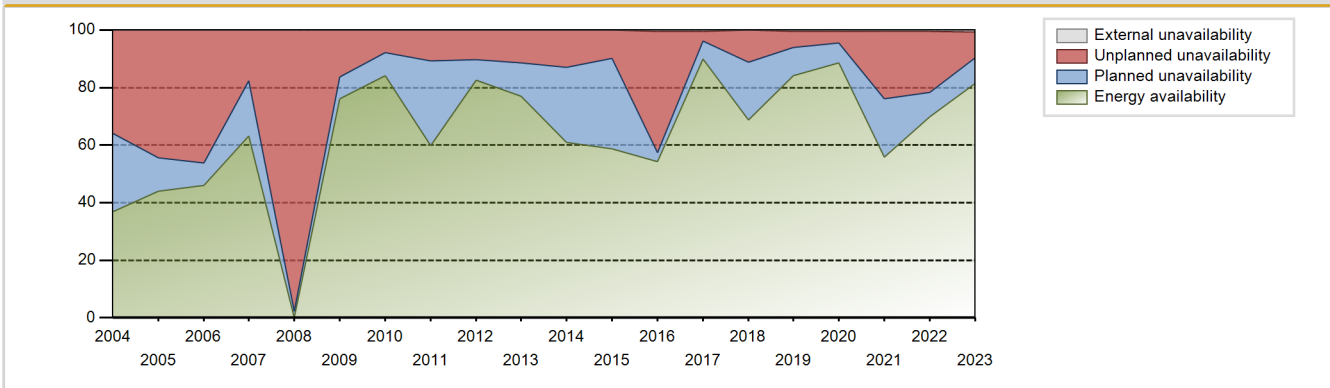
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 130031.36 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.92 % |
| Cumulative Energy Availability Factor (EAF) | : 70.18 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 15.24 % |
| Cumulative Unit Capability Factor (UCF) | : 70.34 % | Cumulative Planned Unavailability Factor (PUF) | : 14.41 % |
| Cumulative Load Factor (LF) | : 68.74 % | Cumulative Externally cause unavailability (XUF) | : 0.17 % |
| Cumulative Operating Factor (OF) | : 73.49 % | | |

Electricity Production (net) [GWh]

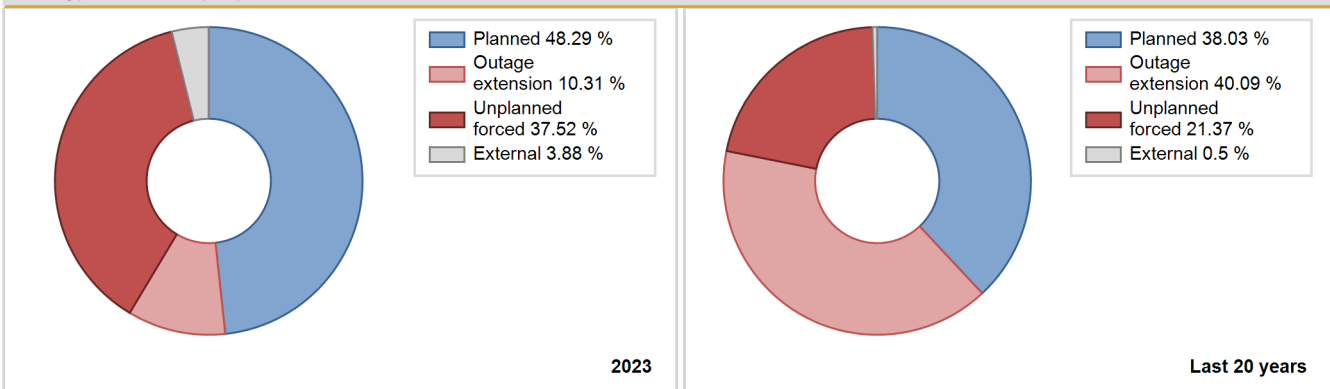


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 1829.47 | 4683 | 539 | 72.77 | 72.77 | 39.07 | 45.19 | 0.00 | 0.00 | 27.23 | 0.00 |
| 1990 | 1698.68 | 3486 | 487 | 40.12 | 40.12 | 39.89 | 39.90 | 18.89 | 9.35 | 50.53 | 0.00 |
| 1991 | 2953.39 | 6791 | 625 | 75.05 | 75.05 | 54.09 | 77.74 | 8.77 | 7.21 | 17.74 | 0.00 |
| 1992 | 2910.40 | 6156 | 510 | 63.46 | 63.64 | 64.09 | 69.14 | 10.21 | 7.24 | 29.12 | 0.18 |
| 1993 | 4449.59 | 7802 | 582 | 87.11 | 87.44 | 87.44 | 89.31 | 4.07 | 3.71 | 8.85 | 0.32 |
| 1994 | 4296.60 | 7716 | 605 | 81.36 | 81.70 | 81.29 | 88.32 | 7.88 | 6.99 | 11.31 | 0.34 |
| 1995 | 3584.24 | 5937 | 605 | 67.72 | 67.72 | 67.44 | 67.59 | 15.59 | 12.51 | 19.78 | 0.00 |
| 1996 | 4518.01 | 7691 | 605 | 85.63 | 85.67 | 85.02 | 87.56 | 1.91 | 1.67 | 12.66 | 0.04 |
| 1997 | 4441.68 | 7644 | 605 | 83.58 | 83.85 | 83.58 | 87.02 | 10.14 | 9.46 | 6.69 | 0.27 |
| 1998 | 3892.34 | 7108 | 605 | 73.52 | 73.52 | 73.24 | 80.92 | 10.20 | 8.35 | 18.13 | 0.00 |
| 1999 | 5000.14 | 8369 | 605 | 94.38 | 94.38 | 94.09 | 95.28 | 1.57 | 1.50 | 4.12 | 0.00 |
| 2000 | 4757.35 | 8153 | 605 | 88.63 | 89.52 | 89.52 | 92.82 | 2.84 | 2.62 | 7.86 | 0.89 |
| 2001 | 4291.19 | 7301 | 605 | 80.93 | 81.00 | 80.75 | 83.12 | 4.86 | 4.14 | 14.87 | 0.07 |
| 2002 | 4627.85 | 7965 | 605 | 87.51 | 87.51 | 87.32 | 90.92 | 4.42 | 4.05 | 8.44 | 0.00 |
| 2003 | 4583.30 | 7856 | 605 | 86.63 | 86.63 | 86.48 | 89.68 | 7.09 | 6.61 | 6.76 | 0.00 |
| 2004 | 1942.67 | 3385 | 605 | 36.88 | 36.88 | 36.56 | 38.54 | 0.50 | 35.99 | 27.13 | 0.00 |
| 2005 | 2322.93 | 4829 | 605 | 43.94 | 43.94 | 43.83 | 55.13 | 48.91 | 44.39 | 11.67 | 0.00 |
| 2006 | 2378.89 | 4291 | 605 | 45.94 | 45.94 | 45.45 | 48.98 | 35.63 | 46.29 | 7.77 | 0.00 |
| 2007 | 3295.79 | 5680 | 595 | 63.08 | 63.08 | 63.23 | 64.84 | 3.17 | 17.69 | 19.23 | 0.00 |
| 2008 | 0.00 | 0 | 595 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 97.78 | 2.22 | 0.00 |
| 2009 | 3945.95 | 6986 | 595 | 76.04 | 76.04 | 75.71 | 79.75 | 4.77 | 16.31 | 7.65 | 0.00 |
| 2010 | 4407.41 | 7547 | 595 | 84.16 | 84.16 | 84.56 | 86.15 | 4.84 | 7.89 | 7.95 | 0.00 |
| 2011 | 3102.64 | 5514 | 595 | 59.86 | 59.86 | 59.53 | 62.95 | 2.28 | 10.66 | 29.48 | 0.00 |
| 2012 | 4301.94 | 7613 | 595 | 82.47 | 82.47 | 82.31 | 86.67 | 4.83 | 10.31 | 7.22 | 0.00 |
| 2013 | 3992.35 | 7557 | 595 | 76.93 | 76.93 | 76.60 | 86.27 | 6.24 | 11.50 | 11.57 | 0.00 |
| 2014 | 3158.04 | 5782 | 595 | 60.92 | 60.92 | 60.59 | 66.00 | 3.01 | 12.87 | 26.21 | 0.00 |
| 2015 | 3043.14 | 6817 | 595 | 58.76 | 58.76 | 58.38 | 77.82 | 1.04 | 9.74 | 31.50 | 0.00 |
| 2016 | 2787.18 | 5559 | | 54.36 | 54.78 | 53.33 | 63.29 | 39.82 | 42.11 | 3.11 | 0.42 |
| 2017 | 0.00 | | | 89.89 | 90.31 | 89.65 | 92.23 | 1.07 | 3.36 | 6.33 | 0.42 |
| 2018 | 3539.00 | 6101 | 590 | 68.66 | 68.72 | 68.47 | 69.65 | 0.01 | 11.07 | 20.21 | 0.06 |
| 2019 | 4340.04 | 7677 | 590 | 84.16 | 84.67 | 83.97 | 87.64 | 4.63 | 5.62 | 9.71 | 0.51 |
| 2020 | 4581.72 | 8063 | 590 | 88.58 | 88.96 | 88.41 | 91.79 | 1.36 | 4.17 | 6.87 | 0.39 |
| 2021 | 2865.20 | 5562 | 590 | 55.89 | 56.44 | 55.44 | 63.49 | 17.44 | 23.24 | 20.33 | 0.55 |
| 2022 | 3574.26 | 6437 | 590 | 69.78 | 70.34 | 69.16 | 73.48 | 0.92 | 21.15 | 8.51 | 0.56 |
| 2023 | 4199.98 | 7553 | 590 | 81.55 | 82.26 | 81.26 | 86.22 | 7.76 | 8.82 | 8.91 | 0.72 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 444 | | | 1071 | |
| B. Refuelling without maintenance | 722 | | | 240 | 16 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 531 | 8 | |
| D. Inspection, maintenance or repair without refuelling | | | | 739 | | |
| E. Testing of plant systems or components | | | | | 13 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 62 | 27 | |
| H. Nuclear regulatory requirements | | | | | 114 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 5 |
| L. Human factor related | | | | | 6 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 41 | |
| Z. Other | | 722 | | 21 | 87 | |
| Subtotal | 722 | 1166 | | 1593 | 1383 | 5 |
| Total | | 1888 | | | 2981 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 379 |
| 12. Reactor I&C Systems | | 17 |
| 13. Reactor Auxiliary Systems | | 28 |
| 15. Reactor Cooling Systems | | 25 |
| 16. Steam generation systems | | 260 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 21. Fuel Handling and Storage Facilities | 722 | 112 |
| 31. Turbine and auxiliaries | | 66 |
| 32. Feedwater and Main Steam System | 76 | 92 |
| 33. Circulating Water System | | 52 |
| 41. Main Generator Systems | | 102 |
| 42. Electrical Power Supply Systems | 368 | 52 |
| Total | 1166 | 1187 |

2023 Operating Experience

GB-19B

HARTLEPOOL A-2

UNITED KINGDOM

Status at end of year : **Operational**
 Operator : EDF UK (EDF Energy)
 Owner : EDF UK (EDF Energy)
 Reactor Supplier : NPC (NUCLEAR POWER CO., LTD.)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))



Reactor Unit Details

Reactor type and model : GCR / AGR
 Thermal power : 1500 MWth
 Gross electrical power : 655 MWe
 Reference unit power (net) : 595 MWe

Key Dates

Construction Date : 1968-10-01
 Grid Date : 1984-10-31
 Commercial Date : 1989-04-01
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : GRAPHITE
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 4
 Part of the core refuelled [%] : 7.5
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 9.37
 Active core height/length [m] : 8.3
 Number of fissile fuel assemblies/bundles : 2592
 Fuel linear heat generation rate [kW/m] : 16.8
 Number of control rod assemblies : 44
 Number of external reactor coolant loops : 8
 Coolant type : CO2

Operating coolant pressure [MPa] : 4.14
 Reactor outlet temperature [°C] : 650
 Number of SG : 8
 Containment type : NA
 Containment design pressure [MPa] : NA

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 15.96
 Output voltage [kV] : 23
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 2
 Number of FW pumps for full power operation : 1
 Number of on-site safety related diesel generators : -

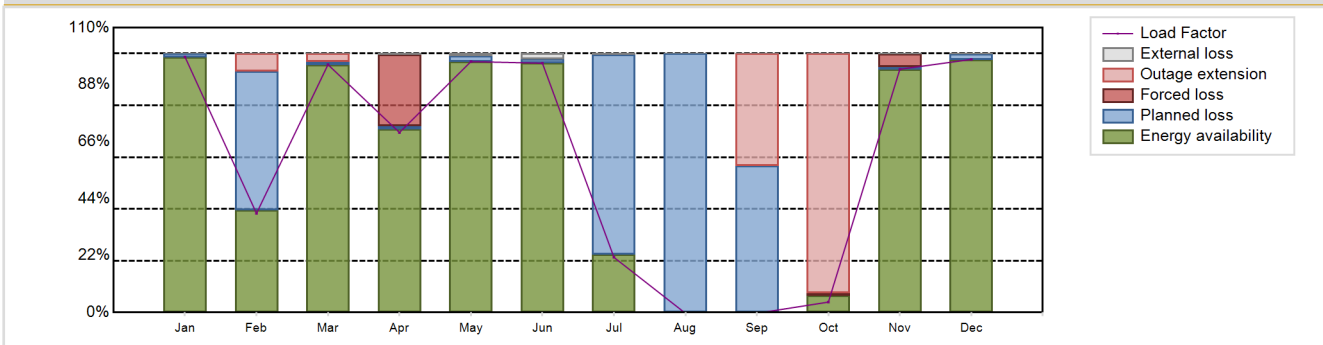
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 3097.65 GW(e).h
 Energy Availability Factor (EAF) : 60 %
 Unit Capability Factor (UCF) : 60.33 %
 Load Factor (LF) : 59.43 %
 Operating Factor (OF) : 63.62 %
 Forced Loss Rate (FLR) : 4.34 %
 Unplanned Capability Loss Factor (UCL) : 14.95 %
 Planned Unavailability Factor (PUF) : 24.72 %
 Externally cause unavailability (XUF) : 0.33 %
 Total off-line time : 3187 hours

Annual Summary

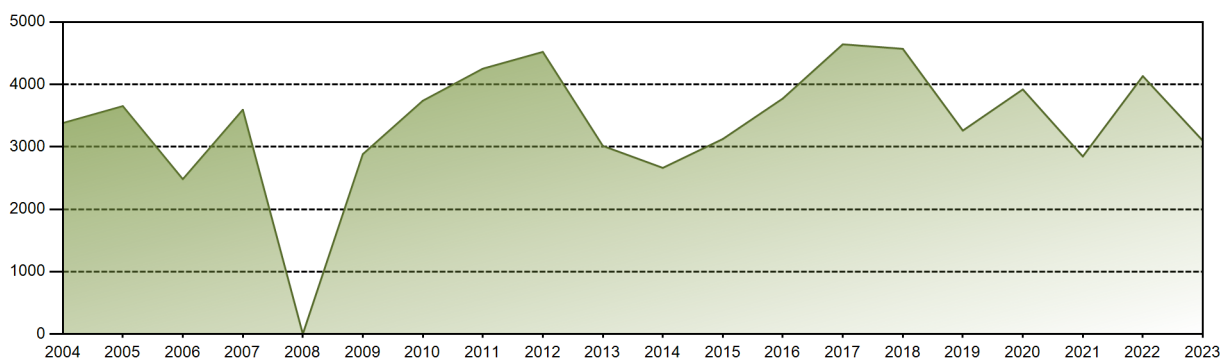


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|-------|--------|-------|-------|--------|--------|---------|
| GW(e)-h | 436.98 | 153.08 | 423.21 | 297.84 | 429.02 | 412.50 | 94.40 | -1.18 | -1.27 | 17.86 | 402.54 | 432.67 | 3097.65 |
| EAF [%] | 98.71 | 39.62 | 95.73 | 70.87 | 96.91 | 96.29 | 22.41 | 0.00 | 0.00 | 6.58 | 93.96 | 97.74 | 60.00 |
| UCF [%] | 98.71 | 39.62 | 95.73 | 71.15 | 97.91 | 98.29 | 22.90 | 0.00 | 0.00 | 6.58 | 94.17 | 97.78 | 60.33 |
| LF [%] | 98.71 | 38.29 | 95.73 | 69.52 | 96.91 | 96.29 | 21.32 | -0.27 | -0.30 | 4.03 | 93.96 | 97.74 | 59.43 |
| OF [%] | 100.00 | 45.24 | 100.00 | 78.33 | 100.00 | 100.00 | 23.92 | 0.00 | 0.00 | 15.03 | 100.00 | 100.00 | 63.62 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 27.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.35 | 4.88 | 0.00 | 4.34 |
| UCL [%] | 0.00 | 6.73 | 3.15 | 27.64 | 0.00 | 0.00 | 0.00 | 0.00 | 43.23 | 93.42 | 4.83 | 0.00 | 14.95 |
| PUF [%] | 1.29 | 53.66 | 1.12 | 1.21 | 2.09 | 1.71 | 77.10 | 100.00 | 56.77 | 0.00 | 1.01 | 2.22 | 24.72 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.27 | 0.99 | 2.00 | 0.49 | 0.00 | 0.00 | 0.00 | 0.20 | 0.04 | 0.33 |

Historical Summary

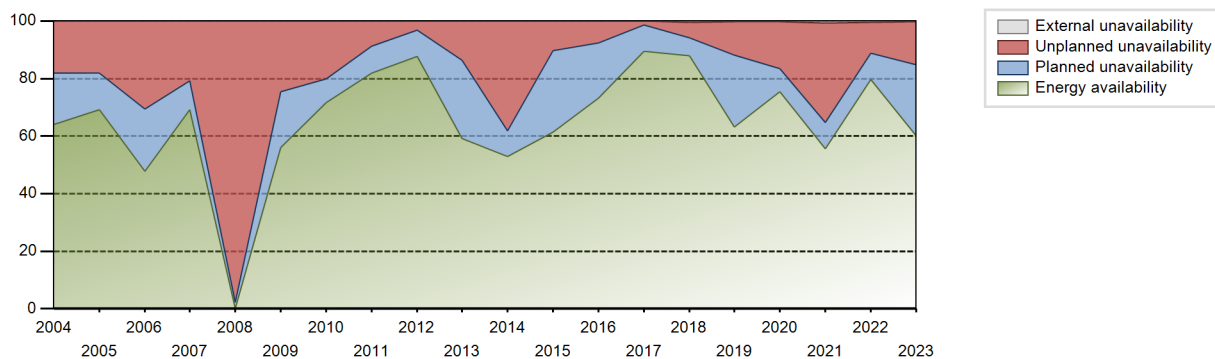
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 124147.35 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 12.3 % |
| Cumulative Energy Availability Factor (EAF) | : 71.07 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 14.16 % |
| Cumulative Unit Capability Factor (UCF) | : 71.26 % | Cumulative Planned Unavailability Factor (PUF) | : 14.58 % |
| Cumulative Load Factor (LF) | : 69.95 % | Cumulative Externally cause unavailability (XUF) | : 0.19 % |
| Cumulative Operating Factor (OF) | : 74.64 % | | |

Electricity Production (net) [GWh]

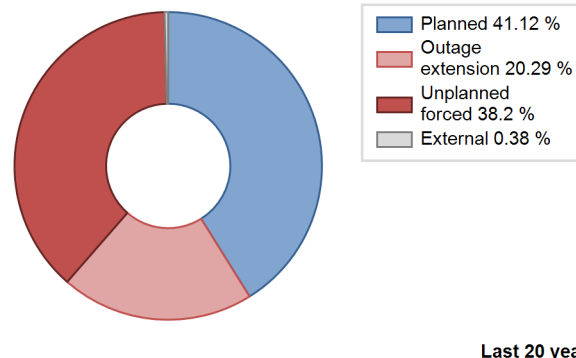
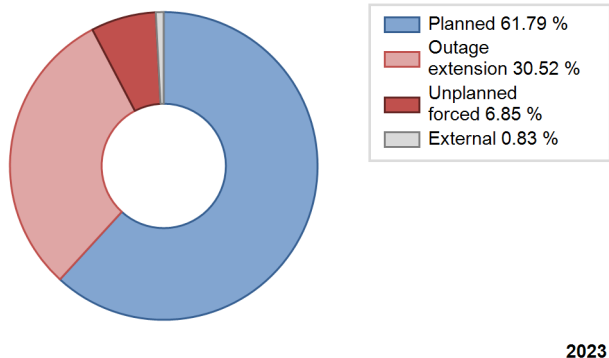


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|-------|--------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 2234.82 | 4689 | 421 | 100.00 | 100.00 | 80.61 | 71.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1990 | 3238.38 | 6796 | 487 | 74.14 | 74.14 | 76.04 | 77.79 | 3.08 | 2.36 | 23.50 | 0.00 |
| 1991 | 1855.91 | 3755 | 625 | 55.12 | 55.12 | 33.99 | 42.98 | 0.80 | 0.44 | 44.44 | 0.00 |
| 1992 | 4316.78 | 7923 | 571 | 87.01 | 87.32 | 84.86 | 88.98 | 3.53 | 3.20 | 9.49 | 0.31 |
| 1993 | 4264.64 | 7682 | 582 | 83.76 | 84.88 | 83.81 | 87.93 | 5.92 | 5.34 | 9.78 | 1.12 |
| 1994 | 3703.92 | 6612 | 605 | 69.91 | 70.24 | 70.08 | 75.69 | 12.80 | 10.31 | 19.45 | 0.33 |
| 1995 | 3750.74 | 6149 | 605 | 70.85 | 70.85 | 70.58 | 70.00 | 19.56 | 17.23 | 11.92 | 0.00 |
| 1996 | 4370.30 | 8131 | 605 | 82.13 | 82.24 | 82.24 | 92.57 | 4.95 | 4.28 | 13.48 | 0.10 |
| 1997 | 4127.88 | 6954 | 605 | 77.18 | 77.95 | 77.67 | 79.17 | 4.70 | 3.84 | 18.21 | 0.76 |
| 1998 | 4555.10 | 7973 | 605 | 85.58 | 85.99 | 85.71 | 90.77 | 7.89 | 7.37 | 6.64 | 0.40 |
| 1999 | 4472.45 | 7808 | 605 | 83.64 | 84.43 | 84.16 | 88.89 | 8.54 | 7.89 | 7.68 | 0.79 |
| 2000 | 4265.86 | 7463 | 605 | 80.27 | 80.27 | 80.27 | 84.96 | 2.23 | 1.83 | 17.90 | 0.00 |
| 2001 | 4635.88 | 8092 | 605 | 87.46 | 87.46 | 87.23 | 92.12 | 1.55 | 1.38 | 11.16 | 0.00 |
| 2002 | 4910.32 | 8383 | 605 | 92.73 | 92.73 | 92.65 | 95.70 | 0.24 | 1.22 | 6.05 | 0.00 |
| 2003 | 3488.43 | 6258 | 605 | 66.45 | 66.45 | 65.82 | 71.44 | 16.79 | 15.26 | 18.29 | 0.00 |
| 2004 | 3380.61 | 6016 | 605 | 64.01 | 64.01 | 63.61 | 68.49 | 4.29 | 18.18 | 17.81 | 0.00 |
| 2005 | 3651.64 | 6428 | 605 | 69.24 | 69.24 | 68.90 | 73.38 | 5.76 | 18.05 | 12.71 | 0.00 |
| 2006 | 2481.11 | 4455 | 605 | 47.76 | 47.76 | 47.41 | 50.86 | 35.15 | 30.49 | 21.76 | 0.00 |
| 2007 | 3593.55 | 6514 | 595 | 69.15 | 69.15 | 68.95 | 74.36 | 22.97 | 20.73 | 10.12 | 0.00 |
| 2008 | 0.00 | 0 | 595 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 97.73 | 2.27 | 0.00 |
| 2009 | 2882.06 | 5360 | 595 | 55.98 | 55.98 | 55.29 | 61.19 | 26.57 | 24.54 | 19.48 | 0.00 |
| 2010 | 3738.08 | 6674 | 595 | 71.70 | 71.70 | 71.72 | 76.19 | 7.77 | 20.13 | 8.17 | 0.00 |
| 2011 | 4251.62 | 7533 | 595 | 81.90 | 81.90 | 81.57 | 85.99 | 2.84 | 8.65 | 9.45 | 0.00 |
| 2012 | 4520.16 | 7880 | 585 | 87.66 | 87.66 | 87.96 | 89.71 | 1.11 | 3.22 | 9.11 | 0.00 |
| 2013 | 3014.48 | 5517 | 585 | 59.23 | 59.23 | 58.82 | 62.98 | 17.79 | 13.57 | 27.20 | 0.00 |
| 2014 | 2662.28 | 5290 | 585 | 52.88 | 52.88 | 51.95 | 60.39 | 39.79 | 38.24 | 8.88 | 0.00 |
| 2015 | 3124.82 | 6811 | 585 | 61.35 | 61.35 | 60.98 | 77.75 | 4.50 | 10.22 | 28.43 | 0.00 |
| 2016 | 3773.67 | 6842 | | 73.22 | 73.25 | 73.44 | 77.89 | 5.02 | 7.54 | 19.22 | 0.03 |
| 2017 | 4641.82 | 7980 | | 89.54 | 89.54 | 90.58 | 91.10 | 0.43 | 1.29 | 9.16 | 0.00 |
| 2018 | 4569.78 | 7950 | 595 | 88.02 | 88.52 | 87.67 | 90.75 | 5.59 | 5.36 | 6.13 | 0.50 |
| 2019 | 3259.78 | 5910 | 595 | 63.11 | 63.38 | 62.54 | 67.47 | 4.53 | 11.49 | 25.14 | 0.27 |
| 2020 | 3919.40 | 7232 | 595 | 75.41 | 75.72 | 74.99 | 82.33 | 7.28 | 16.17 | 8.11 | 0.31 |
| 2021 | 2845.55 | 5404 | 595 | 55.66 | 56.28 | 54.59 | 61.69 | 14.32 | 34.70 | 9.02 | 0.62 |
| 2022 | 4132.36 | 7447 | 595 | 79.62 | 80.18 | 79.28 | 85.01 | 3.70 | 10.57 | 9.25 | 0.56 |
| 2023 | 3097.65 | 5573 | 595 | 60.00 | 60.33 | 59.43 | 63.62 | 4.34 | 14.95 | 24.72 | 0.33 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 156 | | | 1030 | |
| B. Refuelling without maintenance | 353 | | | 220 | 8 | |
| C. Inspection, maintenance or repair combined with refuelling | 1719 | | | 655 | 29 | |
| D. Inspection, maintenance or repair without refuelling | | | | 473 | | |
| E. Testing of plant systems or components | | | | | 4 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 60 | 10 | |
| H. Nuclear regulatory requirements | | | | | 37 | |
| L. Human factor related | | | | | 5 | |
| P. Fire | | | | | 16 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 0 | |
| Z. Other | | 1317 | | 92 | 51 | |
| Subtotal | 2072 | 1473 | | 1500 | 1190 | |
| Total | | 3545 | | | 2690 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 320 |
| 12. Reactor I&C Systems | | 25 |
| 13. Reactor Auxiliary Systems | | 12 |
| 15. Reactor Cooling Systems | | 63 |
| 16. Steam generation systems | | 157 |
| 21. Fuel Handling and Storage Facilities | 285 | 55 |
| 31. Turbine and auxiliaries | | 64 |
| 32. Feedwater and Main Steam System | | 116 |
| 33. Circulating Water System | | 52 |
| 34. Miscellaneous Systems | | 2 |
| 41. Main Generator Systems | 156 | 90 |
| 42. Electrical Power Supply Systems | | 18 |
| Total | 441 | 974 |

Highlights (2023)

Carried out a statutory outage

2023 Operating Experience

GB-20A HEYSHAM A-1 UNITED KINGDOM

Status at end of year : **Operational**
 Operator : EDF UK (EDF Energy)
 Owner : EDF UK (EDF Energy)
 Reactor Supplier : NPC (NUCLEAR POWER CO., LTD.)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : GCR / AGR | Construction Date | : 1970-12-01 |
| Thermal power | : 1500 MWth | Grid Date | : 1983-07-09 |
| Gross electrical power | : 625 MWe | Commercial Date | : 1989-04-01 |
| Reference unit power (net) | : 485 MWe | Age at end of year | : 40 years |

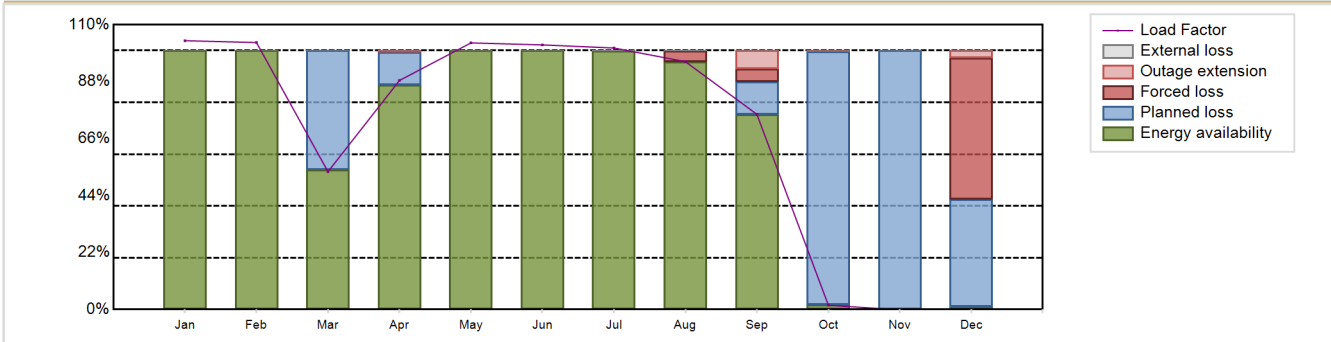
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 4.14 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 650 |
| Refuelling type | : OFF-line | Number of SG | : 8 |
| Moderator material | : GRAPHITE | Containment type | : NA |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : NA |
| Refuelling frequency [month] | : 4 | Secondary systems | |
| Part of the core refuelled [%] | : 7.5 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 33000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 9.37 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 8.3 | HP cylinder inlet steam pressure [MPa] | : 15.96 |
| Number of fissile fuel assemblies/bundles | : 2592 | Output voltage [kV] | : 23 |
| Fuel linear heat generation rate [kW/m] | : 16.8 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 44 | Number of main condensate pumps | : 2 |
| Number of external reactor coolant loops | : 8 | Number of FW pumps for full power operation | : 1 |
| Coolant type | : CO2 | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 2909.14 GW(e).h | Forced Loss Rate (FLR) | : 7.37 % |
| Energy Availability Factor (EAF) | : 67.65 % | Unplanned Capability Loss Factor (UCL) | : 6.29 % |
| Unit Capability Factor (UCF) | : 67.67 % | Planned Unavailability Factor (PUF) | : 26.03 % |
| Load Factor (LF) | : 68.47 % | Externally cause unavailability (XUF) | : 0.02 % |
| Operating Factor (OF) | : 71.59 % | Total off-line time | : 2489 hours |

Annual Summary

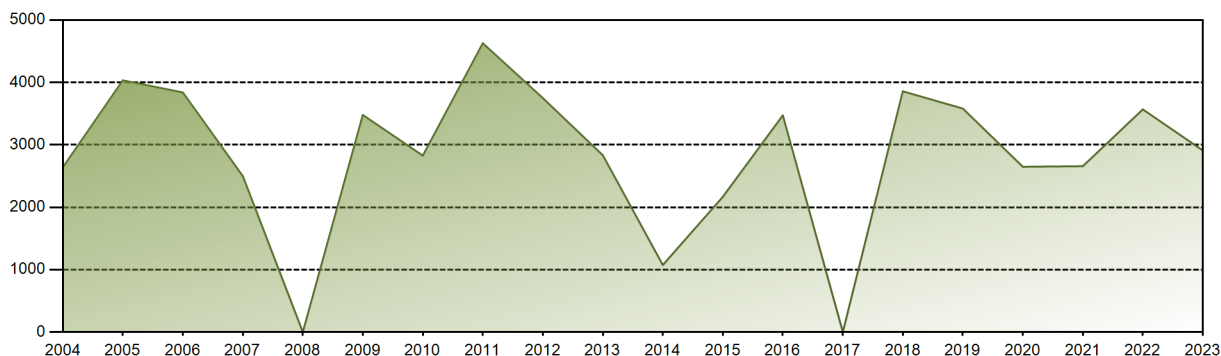


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|-------|---------|
| GW(e)-h | 374.66 | 336.07 | 191.83 | 308.87 | 371.56 | 356.88 | 364.46 | 345.41 | 263.26 | 6.01 | -0.46 | -9.41 | 2909.14 |
| EAF [%] | 100.00 | 100.00 | 53.90 | 86.76 | 100.00 | 100.00 | 99.89 | 95.72 | 75.39 | 1.91 | 0.00 | 1.15 | 67.65 |
| UCF [%] | 100.00 | 100.00 | 53.90 | 86.76 | 100.00 | 100.00 | 100.00 | 95.91 | 75.39 | 1.91 | 0.00 | 1.15 | 67.67 |
| LF [%] | 103.83 | 103.11 | 53.23 | 88.45 | 102.97 | 102.20 | 101.00 | 95.72 | 75.39 | 1.66 | -0.13 | -2.61 | 68.47 |
| OF [%] | 100.00 | 100.00 | 61.37 | 90.97 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 3.22 | 0.00 | 6.45 | 71.59 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.09 | 6.20 | 0.00 | 0.00 | 97.94 | 7.37 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.67 | 0.00 | 0.00 | 0.00 | 4.09 | 12.08 | 0.30 | 0.00 | 57.38 | 6.29 |
| PUF [%] | 0.00 | 0.00 | 46.10 | 12.57 | 0.00 | 0.00 | 0.00 | 0.00 | 12.53 | 97.79 | 100.00 | 41.47 | 26.03 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 119759.36 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 14.11 % |
| Cumulative Energy Availability Factor (EAF) | : 68.3 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 16.54 % |
| Cumulative Unit Capability Factor (UCF) | : 68.57 % | Cumulative Planned Unavailability Factor (PUF) | : 14.88 % |
| Cumulative Load Factor (LF) | : 67.65 % | Cumulative Externally cause unavailability (XUF) | : 0.27 % |
| Cumulative Operating Factor (OF) | : 73.44 % | | |

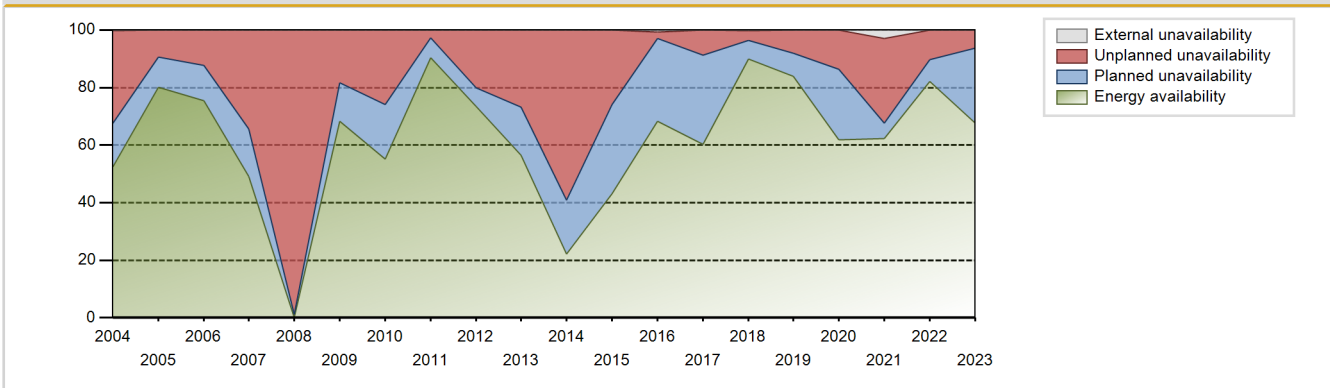
Electricity Production (net) [GWh]



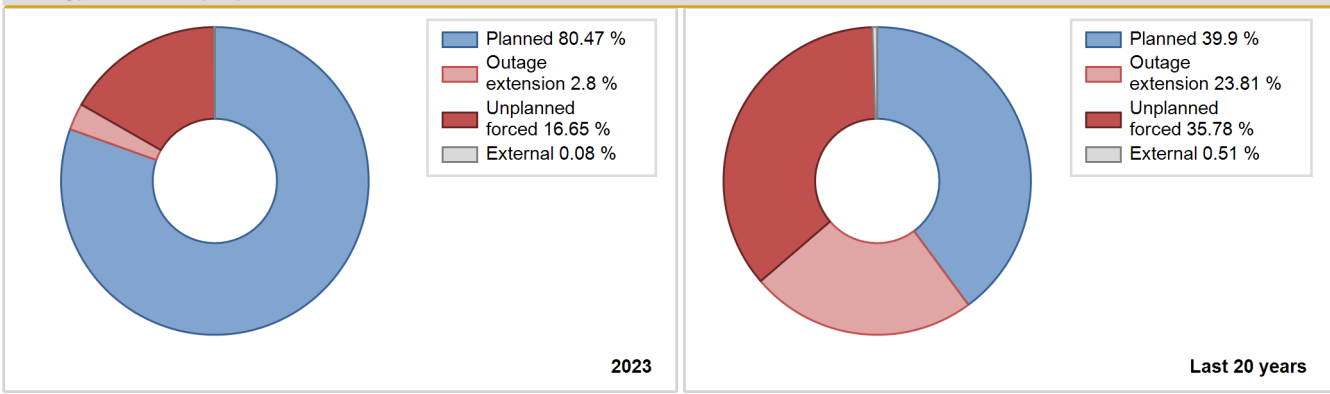
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|-------|--------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 3045.30 | 7113 | 420 | 100.00 | 100.00 | 84.82 | 82.53 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1990 | 1786.74 | 4096 | 487 | 43.38 | 43.38 | 41.95 | 46.89 | 3.74 | 1.68 | 54.94 | 0.00 |
| 1991 | 3826.17 | 7279 | 621 | 86.45 | 86.45 | 70.53 | 83.32 | 0.31 | 0.27 | 13.28 | 0.00 |
| 1992 | 2764.17 | 5981 | 550 | 55.59 | 55.76 | 56.44 | 67.17 | 21.28 | 15.07 | 29.17 | 0.17 |
| 1993 | 3638.22 | 6643 | 555 | 74.28 | 75.00 | 75.04 | 76.04 | 19.28 | 17.92 | 7.09 | 0.71 |
| 1994 | 4563.37 | 8128 | 575 | 90.40 | 90.54 | 90.85 | 93.04 | 2.99 | 2.79 | 6.67 | 0.14 |
| 1995 | 2808.87 | 4794 | 575 | 55.94 | 55.89 | 55.61 | 54.58 | 29.33 | 23.19 | 20.92 | -0.06 |
| 1996 | 4056.80 | 7674 | 575 | 80.19 | 80.32 | 80.32 | 87.36 | 7.13 | 6.16 | 13.52 | 0.13 |
| 1997 | 4298.79 | 7757 | 575 | 84.53 | 85.38 | 85.11 | 88.31 | 7.92 | 7.35 | 7.27 | 0.86 |
| 1998 | 3766.08 | 6950 | 575 | 73.77 | 74.84 | 74.56 | 79.12 | 9.74 | 8.07 | 17.09 | 1.07 |
| 1999 | 4549.83 | 7990 | 575 | 89.73 | 90.35 | 90.08 | 90.96 | 0.61 | 0.55 | 9.09 | 0.62 |
| 2000 | 4587.90 | 8230 | 575 | 90.39 | 90.84 | 90.84 | 93.69 | 3.02 | 2.83 | 6.34 | 0.44 |
| 2001 | 4034.58 | 6959 | 575 | 77.62 | 78.03 | 79.88 | 79.22 | 10.61 | 9.26 | 12.71 | 0.41 |
| 2002 | 4445.53 | 7921 | 575 | 87.93 | 88.39 | 88.26 | 90.42 | 1.67 | 2.60 | 9.01 | 0.46 |
| 2003 | 3746.22 | 6783 | 575 | 74.40 | 74.75 | 74.37 | 77.43 | 20.02 | 18.71 | 6.54 | 0.35 |
| 2004 | 2638.07 | 4951 | 575 | 52.51 | 52.83 | 52.23 | 56.36 | 23.49 | 32.08 | 15.09 | 0.31 |
| 2005 | 4033.07 | 7458 | 575 | 80.14 | 80.14 | 80.07 | 85.14 | 5.25 | 9.34 | 10.52 | 0.00 |
| 2006 | 3839.08 | 7229 | 575 | 75.50 | 75.50 | 75.23 | 82.52 | 13.70 | 12.20 | 12.29 | 0.00 |
| 2007 | 2498.55 | 4892 | 585 | 49.07 | 49.07 | 48.76 | 55.84 | 34.75 | 34.38 | 16.54 | 0.00 |
| 2008 | 0.00 | 0 | 585 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 98.85 | 1.15 | 0.00 |
| 2009 | 3478.25 | 6363 | 585 | 68.38 | 68.38 | 67.87 | 72.64 | 16.25 | 18.31 | 13.31 | 0.00 |
| 2010 | 2826.72 | 5117 | 585 | 55.09 | 55.09 | 55.16 | 58.41 | 14.73 | 25.92 | 18.99 | 0.00 |
| 2011 | 4627.86 | 8225 | 585 | 90.48 | 90.48 | 90.31 | 93.89 | 2.86 | 2.74 | 6.78 | 0.00 |
| 2012 | 3749.04 | 7055 | 585 | 73.38 | 73.38 | 72.96 | 80.32 | 21.36 | 20.03 | 6.59 | 0.00 |
| 2013 | 2833.02 | 5384 | 585 | 56.60 | 56.60 | 55.28 | 61.46 | 8.93 | 26.72 | 16.68 | 0.00 |
| 2014 | 1073.88 | 2841 | 580 | 22.17 | 22.17 | 21.14 | 32.43 | 35.42 | 59.13 | 18.70 | 0.00 |
| 2015 | 2167.04 | 6886 | 580 | 43.07 | 43.07 | 42.65 | 78.61 | 7.13 | 25.99 | 30.94 | 0.00 |
| 2016 | 3472.18 | 7663 | | 68.39 | 69.17 | 68.15 | 87.24 | 1.00 | 2.11 | 28.72 | 0.77 |
| 2017 | 0.00 | | | 60.19 | 60.19 | 59.91 | 72.91 | 0.00 | 8.83 | 30.98 | 0.00 |
| 2018 | 3857.56 | 8018 | 485 | 89.94 | 90.12 | 90.80 | 91.53 | 1.73 | 3.36 | 6.52 | 0.18 |
| 2019 | 3581.24 | 7826 | 485 | 84.01 | 84.09 | 84.29 | 89.34 | 4.73 | 7.97 | 7.94 | 0.08 |
| 2020 | 2648.85 | 5639 | 485 | 61.95 | 61.97 | 62.18 | 64.20 | 9.49 | 13.52 | 24.50 | 0.03 |
| 2021 | 2657.70 | 5625 | 485 | 62.39 | 65.24 | 62.55 | 64.21 | 27.48 | 29.48 | 5.28 | 2.85 |
| 2022 | 3567.83 | 7363 | 485 | 82.08 | 82.08 | 83.98 | 84.05 | 1.48 | 10.18 | 7.74 | 0.00 |
| 2023 | 2909.14 | 6271 | 485 | 67.65 | 67.67 | 68.47 | 71.59 | 7.37 | 6.29 | 26.03 | 0.02 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|--|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 394 | | | 889 | |
| B. Refuelling without maintenance | 352 | | | 180 | 4 | |
| C. Inspection, maintenance or repair combined with refuelling | 1743 | | | 784 | 154 | |
| D. Inspection, maintenance or repair without refuelling | | | | 472 | | |
| E. Testing of plant systems or components | | | | | 73 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 49 | 5 | |
| H. Nuclear regulatory requirements | | | | | 52 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 9 |
| L. Human factor related | | | | | 56 | |
| Z. Other | | | | 51 | 40 | 6 |
| Subtotal | 2095 | 394 | | 1536 | 1273 | 15 |
| Total | | 2489 | | | 2824 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 315 |
| 12. Reactor I&C Systems | | 24 |
| 13. Reactor Auxiliary Systems | | 36 |
| 14. Safety Systems | | 25 |
| 15. Reactor Cooling Systems | | 58 |
| 16. Steam generation systems | | 203 |
| 21. Fuel Handling and Storage Facilities | | 27 |
| 31. Turbine and auxiliaries | 178 | 59 |
| 32. Feedwater and Main Steam System | 216 | 55 |
| 33. Circulating Water System | | 113 |
| 34. Miscellaneous Systems | | 12 |
| 41. Main Generator Systems | | 66 |
| 42. Electrical Power Supply Systems | | 28 |
| Total | 394 | 1021 |

Highlights (2023)

Carried out a statutory outage

2023 Operating Experience

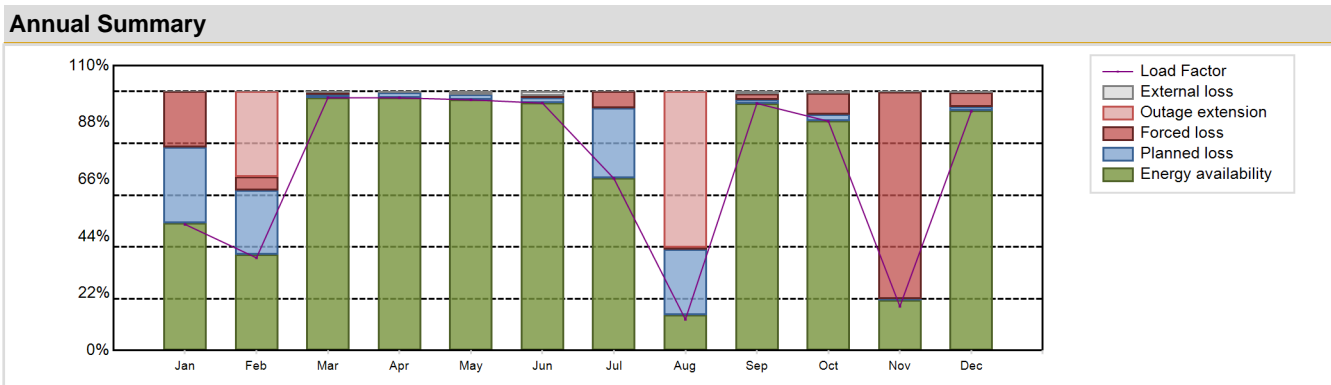
GB-20B HEYSHAM A-2 UNITED KINGDOM

Status at end of year : **Operational**
 Operator : EDF UK (EDF Energy)
 Owner : EDF UK (EDF Energy)
 Reactor Supplier : NPC (NUCLEAR POWER CO., LTD.)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : GCR / AGR | Construction Date | : 1970-12-01 |
| Thermal power | : 1500 MWth | Grid Date | : 1984-10-11 |
| Gross electrical power | : 625 MWe | Commercial Date | : 1989-04-01 |
| Reference unit power (net) | : 575 MWe | Age at end of year | : 39 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 4.14 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 650 |
| Fuel material | : UO2 | Number of SG | : 8 |
| Refuelling type | : OFF-line | Containment type | : NA |
| Moderator material | : GRAPHITE | Containment design pressure [MPa] | : NA |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 4 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 7.5 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 9.37 | HP cylinder inlet steam pressure [MPa] | : 15.96 |
| Active core height/length [m] | : 8.3 | Output voltage [kV] | : 23 |
| Number of fissile fuel assemblies/bundles | : 2592 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 15.6 | Number of main condensate pumps | : 2 |
| Number of control rod assemblies | : 44 | Number of FW pumps for full power operation | : 1 |
| Number of external reactor coolant loops | : 8 | Number of on-site safety related diesel generators | : - |
| Coolant type | : CO2 | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 3553.41 GW(e).h | Forced Loss Rate (FLR) | : 13.2 % |
| Energy Availability Factor (EAF) | : 71.08 % | Unplanned Capability Loss Factor (UCL) | : 18.51 % |
| Unit Capability Factor (UCF) | : 71.54 % | Planned Unavailability Factor (PUF) | : 9.95 % |
| Load Factor (LF) | : 70.55 % | Externally cause unavailability (XUF) | : 0.46 % |
| Operating Factor (OF) | : 77.29 % | Total off-line time | : 1989 hours |

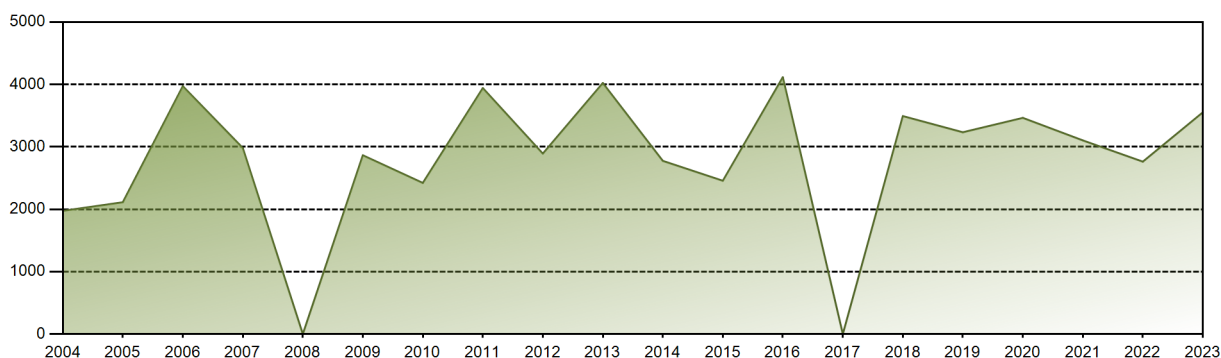


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|-------|--------|---------|
| GW(e)-h | 208.44 | 138.28 | 417.10 | 403.96 | 414.17 | 395.57 | 284.20 | 51.49 | 395.06 | 379.30 | 70.61 | 395.21 | 3553.41 |
| EAF [%] | 49.17 | 36.97 | 97.63 | 97.58 | 96.81 | 95.55 | 66.61 | 13.80 | 95.42 | 88.75 | 19.56 | 92.57 | 71.08 |
| UCF [%] | 49.17 | 36.97 | 97.90 | 98.07 | 97.94 | 97.07 | 66.61 | 13.80 | 96.40 | 89.47 | 19.61 | 92.97 | 71.54 |
| LF [%] | 48.72 | 35.79 | 97.63 | 97.58 | 96.81 | 95.55 | 66.43 | 12.03 | 95.42 | 88.54 | 17.06 | 92.38 | 70.55 |
| OF [%] | 70.97 | 47.62 | 100.00 | 100.00 | 100.00 | 100.00 | 74.19 | 19.62 | 100.00 | 93.96 | 23.33 | 95.43 | 77.29 |
| FLR [%] | 30.45 | 12.44 | 0.80 | 0.00 | 0.00 | 0.78 | 8.60 | 5.56 | 2.15 | 8.41 | 80.30 | 5.66 | 13.20 |
| UCL [%] | 21.53 | 38.22 | 0.79 | 0.00 | 0.00 | 0.76 | 6.27 | 60.88 | 2.12 | 8.21 | 79.95 | 5.57 | 18.51 |
| PUF [%] | 29.30 | 24.81 | 1.31 | 1.93 | 2.06 | 2.17 | 27.13 | 25.32 | 1.48 | 2.32 | 0.43 | 1.46 | 9.95 |
| XUF [%] | 0.00 | 0.00 | 0.27 | 0.50 | 1.13 | 1.52 | 0.00 | 0.00 | 0.98 | 0.72 | 0.06 | 0.39 | 0.46 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 115734.46 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 16.45 % |
| Cumulative Energy Availability Factor (EAF) | : 66.9 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 18.94 % |
| Cumulative Unit Capability Factor (UCF) | : 67.41 % | Cumulative Planned Unavailability Factor (PUF) | : 13.65 % |
| Cumulative Load Factor (LF) | : 66.11 % | Cumulative Externally cause unavailability (XUF) | : 0.51 % |
| Cumulative Operating Factor (OF) | : 73.28 % | | |

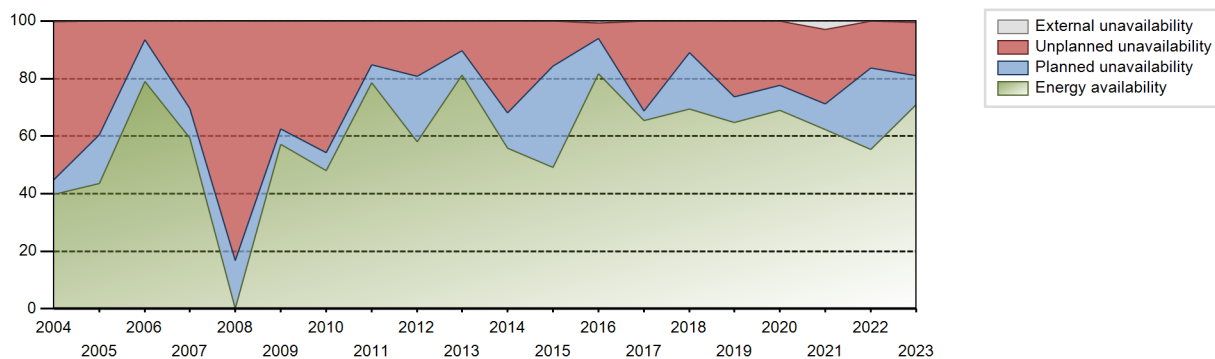
Electricity Production (net) [GWh]



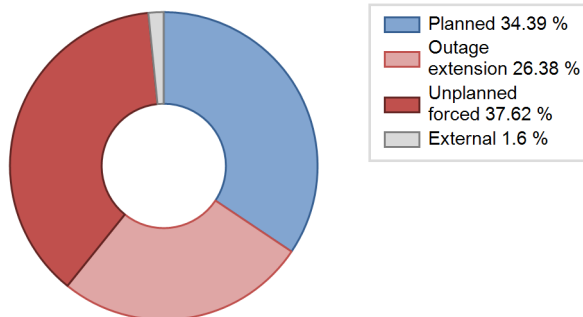
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 2505.64 | 5507 | 470 | 100.00 | 100.00 | 90.38 | 83.43 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1990 | 3044.18 | 6690 | 487 | 71.98 | 71.98 | 71.48 | 76.58 | 9.35 | 7.42 | 20.59 | 0.00 |
| 1991 | 2647.73 | 5132 | 622 | 64.65 | 64.99 | 48.73 | 58.75 | 2.53 | 1.69 | 33.32 | 0.34 |
| 1992 | 3548.13 | 6951 | 550 | 72.79 | 74.58 | 72.45 | 78.07 | 11.81 | 9.99 | 15.43 | 1.79 |
| 1993 | 4336.47 | 7886 | 555 | 88.10 | 88.50 | 89.44 | 90.27 | 2.78 | 2.53 | 8.97 | 0.40 |
| 1994 | 3707.46 | 6652 | 575 | 72.83 | 75.31 | 73.81 | 76.14 | 3.02 | 2.34 | 22.34 | 2.48 |
| 1995 | 3367.50 | 5772 | 575 | 66.95 | 66.95 | 66.67 | 65.71 | 23.46 | 20.52 | 12.54 | 0.00 |
| 1996 | 3561.87 | 6836 | 575 | 70.47 | 70.80 | 70.52 | 77.82 | 5.27 | 3.94 | 25.26 | 0.33 |
| 1997 | 4443.31 | 8026 | 575 | 86.91 | 88.25 | 87.97 | 91.37 | 2.71 | 2.45 | 9.30 | 1.33 |
| 1998 | 4497.56 | 7999 | 575 | 86.67 | 89.32 | 89.05 | 91.06 | 2.11 | 1.93 | 8.75 | 2.65 |
| 1999 | 3712.69 | 6570 | 575 | 71.74 | 73.78 | 73.51 | 74.80 | 13.67 | 11.69 | 14.53 | 2.04 |
| 2000 | 4342.62 | 7946 | 575 | 86.13 | 86.25 | 85.98 | 90.46 | 6.15 | 5.66 | 8.09 | 0.13 |
| 2001 | 4495.02 | 8187 | 575 | 89.27 | 90.80 | 89.00 | 93.20 | 0.92 | 0.84 | 8.35 | 1.54 |
| 2002 | 3407.89 | 6313 | 575 | 68.12 | 68.34 | 67.66 | 72.07 | 12.45 | 13.80 | 17.86 | 0.21 |
| 2003 | 3646.95 | 6595 | 575 | 72.53 | 72.53 | 72.40 | 75.29 | 22.51 | 21.07 | 6.41 | 0.00 |
| 2004 | 1974.61 | 3805 | 575 | 39.74 | 39.90 | 39.09 | 43.32 | 57.95 | 54.98 | 5.12 | 0.16 |
| 2005 | 2112.60 | 3869 | 575 | 43.66 | 43.66 | 41.94 | 44.17 | 41.69 | 39.47 | 16.87 | 0.00 |
| 2006 | 3972.25 | 7735 | 575 | 79.00 | 79.00 | 78.86 | 88.30 | 7.51 | 6.42 | 14.59 | 0.00 |
| 2007 | 2981.62 | 6280 | 575 | 59.35 | 59.35 | 59.19 | 71.69 | 15.78 | 30.34 | 10.31 | 0.00 |
| 2008 | 0.00 | 0 | 575 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 83.27 | 16.72 | 0.00 |
| 2009 | 2865.50 | 6414 | 575 | 57.24 | 57.24 | 56.89 | 73.22 | 20.33 | 37.55 | 5.21 | 0.00 |
| 2010 | 2421.73 | 5862 | 575 | 48.08 | 48.08 | 48.08 | 66.92 | 48.53 | 45.68 | 6.24 | 0.00 |
| 2011 | 3942.22 | 8117 | 575 | 78.49 | 78.49 | 78.27 | 92.66 | 16.25 | 15.22 | 6.29 | 0.00 |
| 2012 | 2891.72 | 5565 | 575 | 58.04 | 58.04 | 57.25 | 63.35 | 23.21 | 19.20 | 22.76 | 0.00 |
| 2013 | 4022.80 | 7464 | 575 | 81.31 | 81.31 | 79.87 | 85.21 | 10.40 | 10.40 | 8.30 | 0.00 |
| 2014 | 2775.28 | 5385 | 575 | 55.75 | 55.75 | 55.10 | 61.47 | 34.05 | 31.86 | 12.39 | 0.00 |
| 2015 | 2456.79 | 5498 | 575 | 49.20 | 49.20 | 48.77 | 62.76 | 3.19 | 15.71 | 35.08 | 0.00 |
| 2016 | 4116.58 | 7646 | 575 | 81.77 | 82.40 | 81.50 | 87.04 | 4.15 | 5.50 | 12.10 | 0.63 |
| 2017 | 0.00 | | 575 | 65.46 | 65.46 | 64.89 | 79.17 | 27.60 | 31.28 | 3.25 | 0.00 |
| 2018 | 3493.12 | 7015 | 575 | 69.50 | 69.50 | 69.35 | 80.08 | 12.90 | 11.02 | 19.48 | 0.00 |
| 2019 | 3233.76 | 6648 | 575 | 64.84 | 64.84 | 64.20 | 75.89 | 25.72 | 26.31 | 8.85 | 0.00 |
| 2020 | 3464.20 | 7036 | 575 | 69.05 | 69.05 | 68.59 | 80.10 | 15.74 | 22.38 | 8.57 | 0.00 |
| 2021 | 3103.23 | 6412 | 575 | 62.30 | 65.17 | 61.61 | 73.20 | 27.52 | 25.90 | 8.93 | 2.87 |
| 2022 | 2762.77 | 5825 | 575 | 55.31 | 55.41 | 54.85 | 66.50 | 15.46 | 16.29 | 28.30 | 0.10 |
| 2023 | 3553.41 | 6771 | 575 | 71.08 | 71.54 | 70.55 | 77.29 | 13.20 | 18.51 | 9.95 | 0.46 |

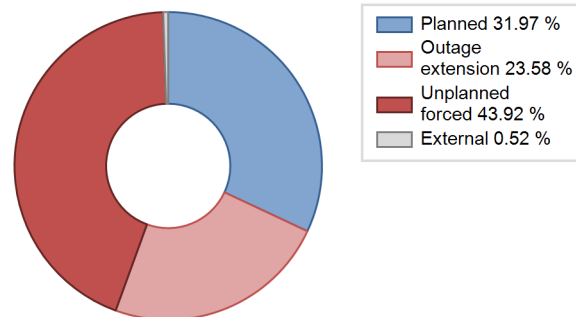
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 1225 | | | 850 | |
| B. Refuelling without maintenance | 763 | | | 222 | 7 | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 678 | 20 | |
| D. Inspection, maintenance or repair without refuelling | | | | 465 | 207 | |
| E. Testing of plant systems or components | | | | 6 | 19 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 17 | 29 | |
| H. Nuclear regulatory requirements | | | | | 97 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 17 |
| L. Human factor related | | | | | 3 | |
| P. Fire | | | | | 3 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 141 | |
| Z. Other | | 179 | | 97 | 73 | 5 |
| Subtotal | 763 | 1404 | | 1485 | 1449 | 22 |
| Total | | 2167 | | | 2956 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|-------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 478 |
| 12. Reactor I&C Systems | | 30 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 34 |
| 15. Reactor Cooling Systems | 409 | 74 |
| 16. Steam generation systems | 185 | 184 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | 179 | 38 |
| 31. Turbine and auxiliaries | 597 | 87 |
| 32. Feedwater and Main Steam System | 34 | 46 |
| 33. Circulating Water System | | 120 |
| 34. Miscellaneous Systems | | 6 |
| 41. Main Generator Systems | | 37 |
| 42. Electrical Power Supply Systems | | 68 |
| Total | 1404 | 1213 |

2023 Operating Experience

GB-22A HEYSHAM B-1 UNITED KINGDOM

Status at end of year : **Operational**
 Operator : EDF UK (EDF Energy)
 Owner : EDF UK (EDF Energy)
 Reactor Supplier : NPC (NUCLEAR POWER CO., LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : GCR / AGR | Construction Date | : 1980-08-01 |
| Thermal power | : 1550 MWth | Grid Date | : 1988-07-12 |
| Gross electrical power | : 680 MWe | Commercial Date | : 1989-04-01 |
| Reference unit power (net) | : 620 MWe | Age at end of year | : 35 years |

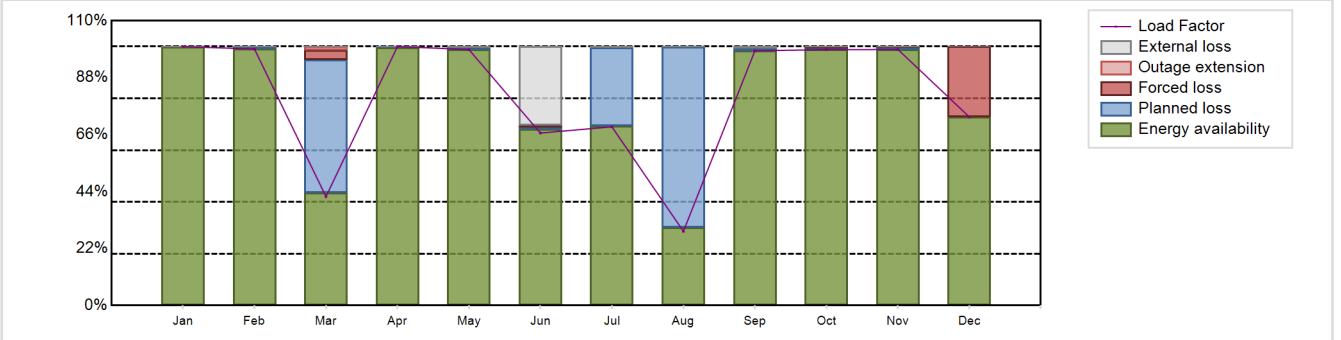
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 4.3 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 635 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : GRAPHITE | Containment type | : NA |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : NA |
| Refuelling frequency [month] | : 2 | Secondary systems | |
| Part of the core refuelled [%] | : 3 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 27000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 9.46 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 8.31 | HP cylinder inlet steam pressure [MPa] | : 15.9 |
| Number of fissile fuel assemblies/bundles | : 332 | Output voltage [kV] | : 23.5 |
| Fuel linear heat generation rate [kW/m] | : 16.8 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 89 | Number of main condensate pumps | : 2 |
| Number of external reactor coolant loops | : NA | Number of FW pumps for full power operation | : - |
| Coolant type | : CO2 | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|----------------|--|--------------|
| Net Energy Production | : 4391 GW(e).h | Forced Loss Rate (FLR) | : 3.16 % |
| Energy Availability Factor (EAF) | : 81.19 % | Unplanned Capability Loss Factor (UCL) | : 2.86 % |
| Unit Capability Factor (UCF) | : 83.86 % | Planned Unavailability Factor (PUF) | : 13.28 % |
| Load Factor (LF) | : 80.85 % | Externally cause unavailability (XUF) | : 2.66 % |
| Operating Factor (OF) | : 86.74 % | Total off-line time | : 1162 hours |

Annual Summary

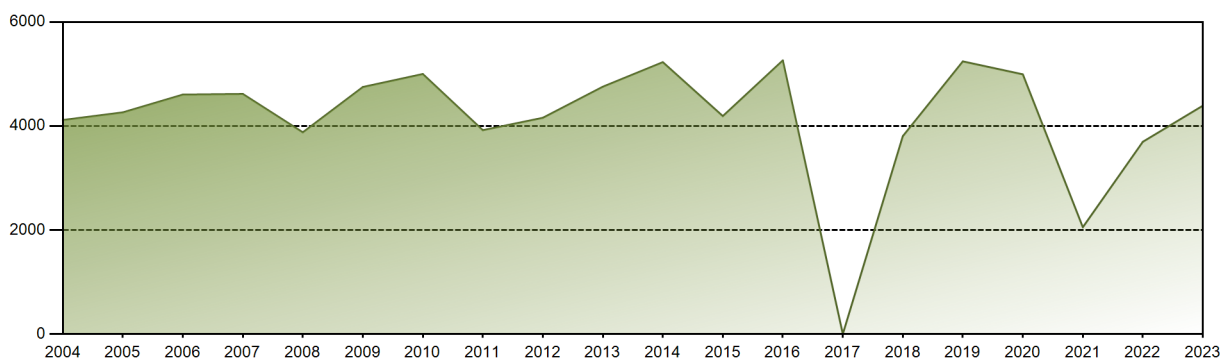


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 461.30 | 412.66 | 193.72 | 446.58 | 455.87 | 297.36 | 318.37 | 132.21 | 439.15 | 456.39 | 441.51 | 335.88 | 4391.00 |
| EAF [%] | 99.81 | 99.04 | 43.50 | 99.73 | 98.83 | 68.10 | 69.35 | 30.02 | 98.38 | 98.81 | 98.91 | 72.81 | 81.19 |
| UCF [%] | 99.81 | 99.18 | 43.50 | 99.73 | 99.09 | 98.57 | 69.65 | 30.29 | 99.08 | 99.04 | 98.93 | 72.81 | 83.86 |
| LF [%] | 100.00 | 99.04 | 42.05 | 100.04 | 98.83 | 66.61 | 69.02 | 28.66 | 98.38 | 98.81 | 98.91 | 72.81 | 80.85 |
| OF [%] | 100.00 | 100.00 | 54.78 | 100.00 | 100.00 | 73.61 | 78.63 | 35.89 | 100.00 | 100.00 | 100.00 | 100.00 | 86.74 |
| FLR [%] | 0.00 | 0.00 | 7.61 | 0.24 | 0.00 | 0.81 | 0.00 | 0.00 | 0.00 | 0.32 | 0.16 | 27.19 | 3.16 |
| UCL [%] | 0.00 | 0.00 | 5.03 | 0.24 | 0.00 | 0.80 | 0.00 | 0.00 | 0.00 | 0.31 | 0.15 | 27.19 | 2.86 |
| PUF [%] | 0.19 | 0.82 | 51.47 | 0.03 | 0.91 | 0.63 | 30.35 | 69.71 | 0.92 | 0.64 | 0.91 | 0.00 | 13.28 |
| XUF [%] | 0.00 | 0.14 | 0.00 | 0.00 | 0.26 | 30.47 | 0.30 | 0.26 | 0.70 | 0.24 | 0.03 | 0.00 | 2.66 |

Historical Summary

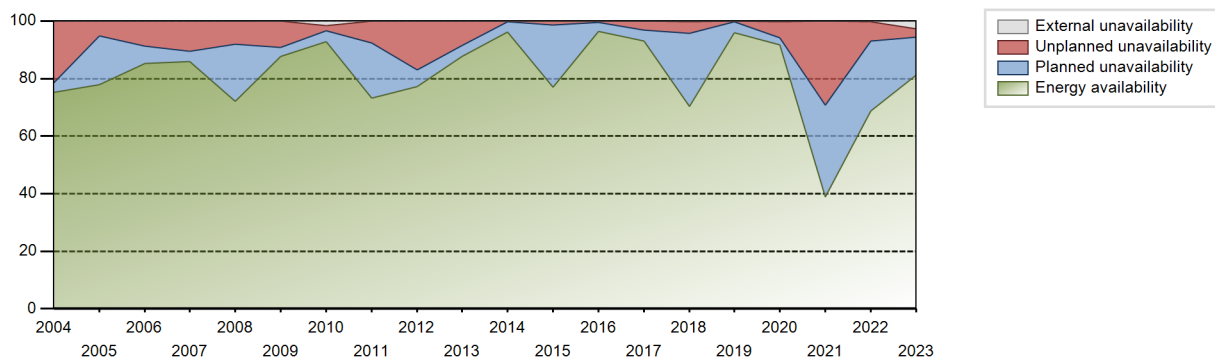
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 145856.35 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.84 % |
| Cumulative Energy Availability Factor (EAF) | : 78.61 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.04 % |
| Cumulative Unit Capability Factor (UCF) | : 79.21 % | Cumulative Planned Unavailability Factor (PUF) | : 14.75 % |
| Cumulative Load Factor (LF) | : 77.93 % | Cumulative Externally cause unavailability (XUF) | : 0.6 % |
| Cumulative Operating Factor (OF) | : 83.06 % | | |

Electricity Production (net) [GWh]

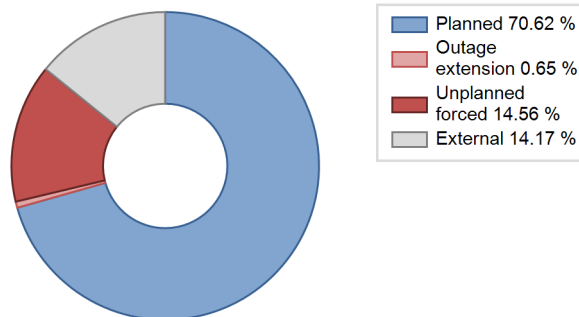


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 2204.46 | 4454 | 615 | 56.92 | 56.92 | 22.19 | 35.13 | 0.00 | 0.00 | 43.08 | 0.00 |
| 1990 | 1487.04 | 3509 | 615 | 27.75 | 27.75 | 27.68 | 40.17 | 1.22 | 0.34 | 71.91 | 0.00 |
| 1991 | 1465.40 | 2786 | 615 | 36.89 | 36.89 | 27.28 | 31.89 | 3.91 | 1.50 | 61.61 | 0.00 |
| 1992 | 4095.95 | 7240 | 615 | 74.85 | 80.22 | 74.80 | 81.31 | 3.95 | 3.30 | 16.48 | 5.37 |
| 1993 | 4498.15 | 7376 | 622 | 82.29 | 83.72 | 82.70 | 84.43 | 2.77 | 2.38 | 13.89 | 1.44 |
| 1994 | 4181.11 | 7255 | 625 | 75.62 | 79.11 | 76.58 | 83.05 | 2.13 | 1.72 | 19.17 | 3.49 |
| 1995 | 5193.85 | 8286 | 625 | 94.47 | 94.88 | 94.61 | 94.33 | 1.61 | 1.55 | 3.57 | 0.41 |
| 1996 | 4707.35 | 7699 | 625 | 84.98 | 85.74 | 85.74 | 87.65 | 3.25 | 2.88 | 11.38 | 0.76 |
| 1997 | 4152.78 | 7105 | 625 | 75.23 | 75.92 | 75.64 | 80.89 | 7.88 | 6.49 | 17.59 | 0.68 |
| 1998 | 5019.39 | 8688 | 625 | 90.49 | 91.70 | 91.43 | 98.91 | 1.20 | 1.12 | 7.18 | 1.21 |
| 1999 | 4235.45 | 7212 | 625 | 76.55 | 77.42 | 77.15 | 82.10 | 9.49 | 8.12 | 14.46 | 0.87 |
| 2000 | 4415.35 | 7502 | 625 | 79.95 | 80.43 | 80.43 | 85.41 | 16.32 | 15.69 | 3.89 | 0.48 |
| 2001 | 5240.97 | 8534 | 625 | 91.45 | 92.02 | 95.46 | 97.15 | 4.27 | 4.10 | 3.88 | 0.57 |
| 2002 | 4413.96 | 7501 | 625 | 80.82 | 80.82 | 80.62 | 85.63 | 4.45 | 4.31 | 14.88 | 0.00 |
| 2003 | 5045.34 | 8444 | 625 | 92.04 | 92.15 | 92.15 | 96.39 | 4.77 | 4.61 | 3.23 | 0.11 |
| 2004 | 4115.67 | 7250 | 625 | 75.33 | 75.36 | 74.97 | 82.54 | 22.13 | 21.42 | 3.22 | 0.03 |
| 2005 | 4262.48 | 7317 | 625 | 77.95 | 77.95 | 77.85 | 83.53 | 6.10 | 5.20 | 16.84 | 0.00 |
| 2006 | 4603.97 | 8057 | 625 | 85.22 | 85.22 | 85.12 | 91.97 | 9.11 | 8.66 | 6.12 | 0.00 |
| 2007 | 4617.34 | 8006 | 615 | 85.83 | 85.83 | 85.71 | 91.39 | 8.94 | 10.48 | 3.69 | 0.00 |
| 2008 | 3879.33 | 7038 | 615 | 72.11 | 72.11 | 71.81 | 80.12 | 5.87 | 8.03 | 19.87 | 0.00 |
| 2009 | 4750.20 | 8497 | 620 | 87.70 | 87.78 | 87.64 | 97.00 | 4.23 | 9.12 | 3.10 | 0.07 |
| 2010 | 5000.04 | 8637 | 620 | 92.80 | 94.43 | 92.06 | 98.60 | 1.27 | 1.81 | 3.76 | 1.63 |
| 2011 | 3920.77 | 6772 | 605 | 73.23 | 73.23 | 73.98 | 77.31 | 1.87 | 7.70 | 19.07 | 0.00 |
| 2012 | 4158.33 | 7238 | 610 | 77.15 | 77.15 | 77.61 | 82.40 | 17.30 | 16.90 | 5.95 | 0.00 |
| 2013 | 4756.06 | 8071 | 610 | 87.70 | 87.70 | 89.00 | 92.13 | 8.74 | 8.48 | 3.82 | 0.00 |
| 2014 | 5228.25 | 8760 | 610 | 96.22 | 96.22 | 97.84 | 100.00 | 0.11 | 0.19 | 3.59 | 0.00 |
| 2015 | 4191.06 | 7038 | 615 | 77.11 | 77.19 | 77.79 | 80.34 | 1.79 | 1.41 | 21.41 | 0.08 |
| 2016 | 5262.55 | 8784 | | 96.35 | 96.35 | 97.42 | 100.00 | 0.04 | 0.48 | 3.16 | 0.00 |
| 2017 | 0.00 | | | 93.14 | 93.17 | 94.04 | 97.15 | 1.40 | 3.03 | 3.80 | 0.03 |
| 2018 | 3805.18 | 6598 | 620 | 70.39 | 70.55 | 70.06 | 75.32 | 4.18 | 4.22 | 25.23 | 0.16 |
| 2019 | 5242.90 | 8760 | 620 | 95.96 | 96.03 | 96.53 | 100.00 | 0.19 | 0.25 | 3.72 | 0.07 |
| 2020 | 4993.67 | 8549 | 620 | 91.65 | 91.89 | 91.69 | 97.32 | 5.71 | 5.57 | 2.55 | 0.23 |
| 2021 | 2054.15 | 3862 | 620 | 38.85 | 38.88 | 37.82 | 44.09 | 26.63 | 29.19 | 31.94 | 0.02 |
| 2022 | 3697.11 | 6340 | 620 | 68.65 | 68.93 | 68.07 | 72.37 | 7.12 | 6.68 | 24.39 | 0.29 |
| 2023 | 4391.00 | 7598 | 620 | 81.19 | 83.86 | 80.85 | 86.74 | 3.16 | 2.86 | 13.28 | 2.66 |

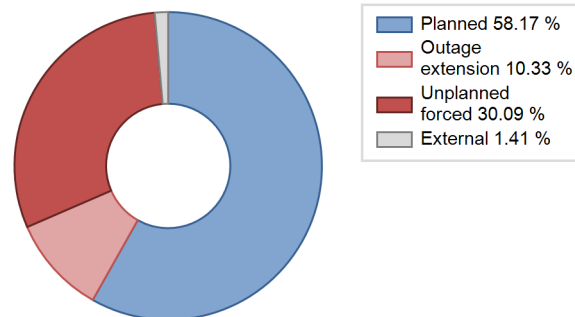
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 283 | |
| B. Refuelling without maintenance | 972 | | | 66 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 622 | 31 | |
| D. Inspection, maintenance or repair without refuelling | | | | 157 | 4 | |
| E. Testing of plant systems or components | | | | 1 | 4 | |
| J. Grid limitation, failure or grid unavailability | | | 190 | | | 32 |
| L. Human factor related | | | | | 22 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 84 | 22 | |
| Z. Other | | | | | 43 | 9 |
| Subtotal | 972 | | 190 | 930 | 409 | 41 |
| Total | | 1162 | | | 1380 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 36 |
| 12. Reactor I&C Systems | | 11 |
| 15. Reactor Cooling Systems | | 4 |
| 16. Steam generation systems | | 21 |
| 21. Fuel Handling and Storage Facilities | | 34 |
| 31. Turbine and auxiliaries | | 110 |
| 32. Feedwater and Main Steam System | | 90 |
| 41. Main Generator Systems | | 17 |
| 42. Electrical Power Supply Systems | | 51 |
| Total | | 374 |

2023 Operating Experience

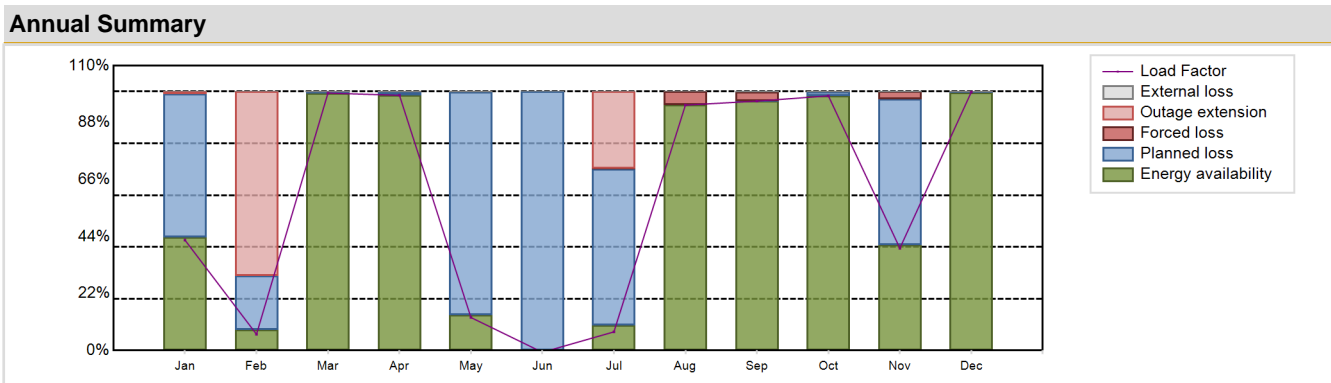
GB-22B HEYSHAM B-2 UNITED KINGDOM

Status at end of year : **Operational**
 Operator : EDF UK (EDF Energy)
 Owner : EDF UK (EDF Energy)
 Reactor Supplier : NPC (NUCLEAR POWER CO., LTD.)
 Turbine Supplier : NEI.P (NEI PARSONS)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : GCR / AGR | Construction Date | : 1980-08-01 |
| Thermal power | : 1550 MWth | Grid Date | : 1988-11-11 |
| Gross electrical power | : 680 MWe | Commercial Date | : 1989-04-01 |
| Reference unit power (net) | : 620 MWe | Age at end of year | : 35 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 4.3 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 635 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : NA |
| Moderator material | : GRAPHITE | Containment design pressure [MPa] | : NA |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 2 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 3 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 27000 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 9.46 | HP cylinder inlet steam pressure [MPa] | : 15.9 |
| Active core height/length [m] | : 8.31 | Output voltage [kV] | : 23.5 |
| Number of fissile fuel assemblies/bundles | : 332 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 16.8 | Number of main condensate pumps | : 2 |
| Number of control rod assemblies | : 89 | Number of FW pumps for full power operation | : 1 |
| Number of external reactor coolant loops | : NA | Number of on-site safety related diesel generators | : 8 |
| Coolant type | : CO2 | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 3168.39 GW(e).h | Forced Loss Rate (FLR) | : 1.6 % |
| Energy Availability Factor (EAF) | : 59.04 % | Unplanned Capability Loss Factor (UCL) | : 9.01 % |
| Unit Capability Factor (UCF) | : 59.08 % | Planned Unavailability Factor (PUF) | : 31.91 % |
| Load Factor (LF) | : 58.34 % | Externally cause unavailability (XUF) | : 0.04 % |
| Operating Factor (OF) | : 62.07 % | Total off-line time | : 3323 hours |

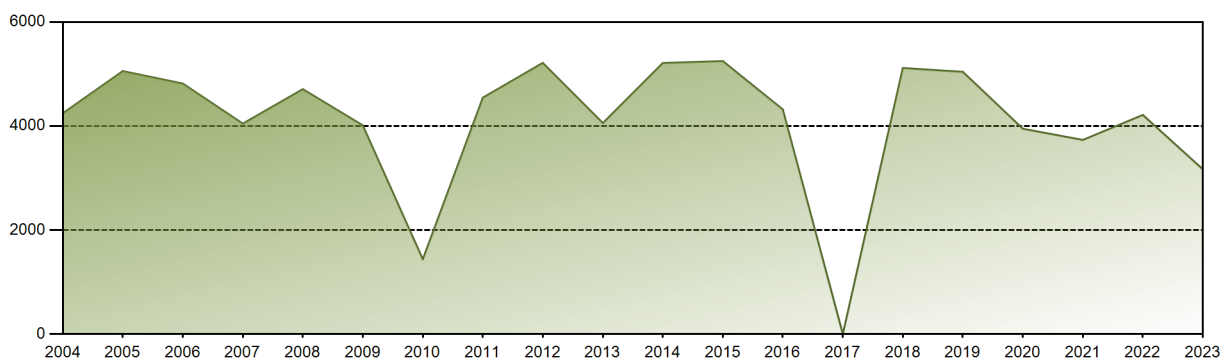


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|-------|--------|--------|-------|--------|-------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 196.70 | 26.17 | 457.98 | 440.03 | 58.86 | -3.02 | 33.25 | 437.24 | 429.95 | 454.29 | 176.30 | 460.63 | 3168.39 |
| EAF [%] | 43.88 | 8.07 | 99.42 | 98.57 | 13.63 | 0.00 | 9.84 | 94.79 | 96.32 | 98.35 | 40.89 | 99.73 | 59.04 |
| UCF [%] | 43.88 | 8.07 | 99.42 | 98.60 | 13.65 | 0.00 | 9.84 | 94.79 | 96.47 | 98.59 | 40.90 | 99.73 | 59.08 |
| LF [%] | 42.64 | 6.28 | 99.42 | 98.57 | 12.76 | -0.68 | 7.21 | 94.79 | 96.32 | 98.35 | 39.49 | 99.86 | 58.34 |
| OF [%] | 48.39 | 13.39 | 100.00 | 100.00 | 14.11 | 0.00 | 15.59 | 100.00 | 100.00 | 100.00 | 48.61 | 100.00 | 62.07 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.32 | 5.21 | 3.37 | 0.00 | 6.48 | 0.00 | 1.60 |
| UCL [%] | 0.86 | 71.12 | 0.00 | 0.00 | 0.00 | 0.00 | 29.82 | 5.21 | 3.37 | 0.00 | 2.83 | 0.00 | 9.01 |
| PUF [%] | 55.26 | 20.81 | 0.58 | 1.40 | 86.35 | 100.00 | 60.34 | 0.00 | 0.16 | 1.41 | 56.26 | 0.27 | 31.91 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.16 | 0.24 | 0.01 | 0.00 | 0.04 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 142307.7 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.22 % |
| Cumulative Energy Availability Factor (EAF) | : 77.49 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.53 % |
| Cumulative Unit Capability Factor (UCF) | : 78.31 % | Cumulative Planned Unavailability Factor (PUF) | : 14.16 % |
| Cumulative Load Factor (LF) | : 76.82 % | Cumulative Externally cause unavailability (XUF) | : 0.82 % |
| Cumulative Operating Factor (OF) | : 81.96 % | | |

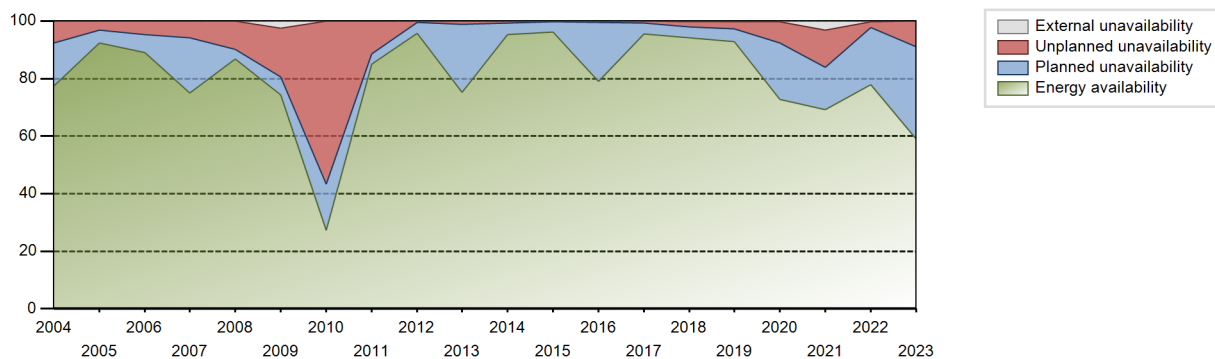
Electricity Production (net) [GWh]



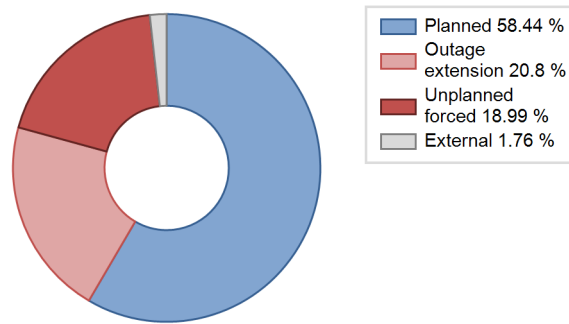
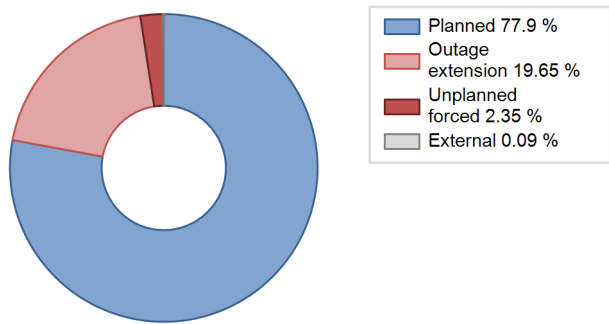
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 3825.57 | 6989 | 615 | 74.41 | 74.41 | 63.81 | 73.90 | 0.00 | 0.00 | 25.59 | 0.00 |
| 1990 | 783.97 | 1901 | 615 | 14.92 | 14.92 | 14.59 | 21.76 | 0.00 | 0.00 | 85.08 | 0.00 |
| 1991 | 2423.97 | 4453 | 615 | 53.43 | 53.66 | 45.12 | 50.97 | 3.43 | 1.91 | 44.43 | 0.23 |
| 1992 | 3486.52 | 6198 | 615 | 64.72 | 66.40 | 63.67 | 69.61 | 1.13 | 0.76 | 32.84 | 1.68 |
| 1993 | 4384.85 | 7125 | 622 | 79.59 | 91.61 | 80.62 | 81.56 | 1.63 | 1.52 | 6.88 | 12.02 |
| 1994 | 4435.32 | 7723 | 625 | 80.75 | 83.96 | 81.23 | 88.40 | 7.89 | 7.19 | 8.85 | 3.21 |
| 1995 | 4498.83 | 7249 | 625 | 82.30 | 82.22 | 81.95 | 82.53 | 7.24 | 6.41 | 11.37 | -0.08 |
| 1996 | 4265.35 | 7103 | 625 | 78.39 | 78.58 | 77.69 | 80.86 | 13.73 | 12.50 | 8.92 | 0.19 |
| 1997 | 4780.70 | 8021 | 625 | 85.46 | 87.35 | 87.08 | 91.31 | 1.26 | 1.12 | 11.53 | 1.89 |
| 1998 | 4209.73 | 7574 | 625 | 76.15 | 76.95 | 76.68 | 86.22 | 6.77 | 5.59 | 17.46 | 0.80 |
| 1999 | 2987.21 | 4987 | 625 | 54.59 | 54.69 | 54.41 | 56.77 | 44.43 | 43.72 | 1.59 | 0.09 |
| 2000 | 5001.88 | 8660 | 625 | 90.49 | 91.11 | 91.11 | 98.59 | 3.12 | 2.94 | 5.95 | 0.62 |
| 2001 | 4234.22 | 7103 | 625 | 90.80 | 91.44 | 77.13 | 80.86 | 4.46 | 4.27 | 4.29 | 0.63 |
| 2002 | 5010.34 | 8521 | 625 | 91.53 | 91.53 | 91.51 | 97.27 | 3.78 | 3.87 | 4.60 | 0.00 |
| 2003 | 4582.83 | 7712 | 625 | 83.75 | 83.91 | 83.70 | 88.04 | 14.27 | 14.06 | 2.04 | 0.15 |
| 2004 | 4244.16 | 7383 | 625 | 77.48 | 77.48 | 77.31 | 84.05 | 7.02 | 7.63 | 14.89 | 0.00 |
| 2005 | 5056.80 | 8564 | 625 | 92.32 | 92.32 | 92.36 | 97.76 | 3.29 | 3.21 | 4.47 | 0.00 |
| 2006 | 4816.70 | 8293 | 625 | 89.08 | 89.08 | 89.05 | 94.67 | 4.91 | 4.79 | 6.14 | 0.00 |
| 2007 | 4046.74 | 7104 | 615 | 74.92 | 74.92 | 75.11 | 81.10 | 3.81 | 5.74 | 19.34 | 0.00 |
| 2008 | 4709.31 | 8252 | 620 | 86.70 | 86.71 | 86.65 | 93.94 | 9.64 | 9.82 | 3.47 | 0.01 |
| 2009 | 4012.10 | 7268 | 620 | 74.22 | 76.77 | 73.87 | 82.97 | 15.69 | 16.80 | 6.43 | 2.55 |
| 2010 | 1437.40 | 2719 | 620 | 27.24 | 27.24 | 26.47 | 31.04 | 12.02 | 56.55 | 16.21 | 0.00 |
| 2011 | 4545.68 | 7968 | 605 | 84.99 | 84.99 | 85.77 | 90.96 | 11.75 | 11.39 | 3.62 | 0.00 |
| 2012 | 5214.03 | 8784 | 610 | 95.80 | 95.86 | 97.31 | 100.00 | 0.15 | 0.42 | 3.72 | 0.06 |
| 2013 | 4057.17 | 6945 | 610 | 75.17 | 75.17 | 75.93 | 79.28 | 1.42 | 1.20 | 23.63 | 0.00 |
| 2014 | 5211.77 | 8713 | 610 | 95.26 | 95.26 | 97.53 | 99.46 | 0.80 | 0.77 | 3.97 | 0.00 |
| 2015 | 5249.04 | 8760 | 615 | 96.20 | 96.27 | 97.43 | 100.00 | 0.07 | 0.07 | 3.65 | 0.07 |
| 2016 | 4319.05 | 7214 | | 79.08 | 79.09 | 79.95 | 82.13 | 0.58 | 0.46 | 20.45 | 0.01 |
| 2017 | 0.00 | | | 95.49 | 95.56 | 96.19 | 100.00 | 0.24 | 0.56 | 3.88 | 0.07 |
| 2018 | 5116.17 | 8624 | 620 | 94.20 | 94.50 | 94.20 | 98.45 | 1.79 | 1.80 | 3.70 | 0.30 |
| 2019 | 5042.29 | 8635 | 620 | 92.82 | 93.07 | 92.84 | 98.57 | 2.28 | 2.57 | 4.37 | 0.25 |
| 2020 | 3948.62 | 6782 | 620 | 72.85 | 73.05 | 72.50 | 77.21 | 3.60 | 7.35 | 19.61 | 0.20 |
| 2021 | 3733.11 | 7143 | 620 | 69.21 | 72.26 | 68.73 | 81.54 | 8.52 | 13.01 | 14.73 | 3.05 |
| 2022 | 4213.26 | 7249 | 620 | 77.88 | 78.14 | 77.58 | 82.75 | 2.42 | 1.94 | 19.92 | 0.26 |
| 2023 | 3168.39 | 5437 | 620 | 59.04 | 59.08 | 58.34 | 62.07 | 1.60 | 9.01 | 31.91 | 0.04 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 532 | | | 476 | |
| B. Refuelling without maintenance | 894 | | | 89 | 4 | |
| C. Inspection, maintenance or repair combined with refuelling | 1808 | | | 642 | 14 | |
| D. Inspection, maintenance or repair without refuelling | | | | 211 | | |
| E. Testing of plant systems or components | | | | | 6 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 34 |
| L. Human factor related | | | | | 5 | |
| P. Fire | | | | | 1 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 14 | 37 | |
| Z. Other | | 271 | | | 23 | 31 |
| Subtotal | 2702 | 803 | | 956 | 566 | 65 |
| Total | | 3505 | | | 1587 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 18 |
| 12. Reactor I&C Systems | | 10 |
| 15. Reactor Cooling Systems | | 0 |
| 16. Steam generation systems | | 14 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 21. Fuel Handling and Storage Facilities | | 56 |
| 31. Turbine and auxiliaries | 532 | 202 |
| 32. Feedwater and Main Steam System | | 29 |
| 33. Circulating Water System | | 127 |
| 41. Main Generator Systems | | 77 |
| 42. Electrical Power Supply Systems | | 9 |
| Total | | 544 |

Highlights (2023)

Carried out a statutory outage

2023 Operating Experience

GB-24

SIZEWELL B

UNITED KINGDOM

Status at end of year : **Operational**
 Operator : EDF UK (EDF Energy)
 Owner : EDF UK (EDF Energy)
 Reactor Supplier : PPC (PWR POWER PROJECTS, Ltd.)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))

Reactor Unit Details

Reactor type and model : PWR / SNUPPS
 Thermal power : 3425 MWth
 Gross electrical power : 1250 MWe
 Reference unit power (net) : 1198 MWe

Key Dates

Construction Date : 1988-07-18
 Grid Date : 1995-02-14
 Commercial Date : 1995-09-22
 Age at end of year : 28 years

Design Characteristics

Primary Systems
 Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 43
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.01
 Reactor outlet temperature [°C] : 323.4
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 0.35

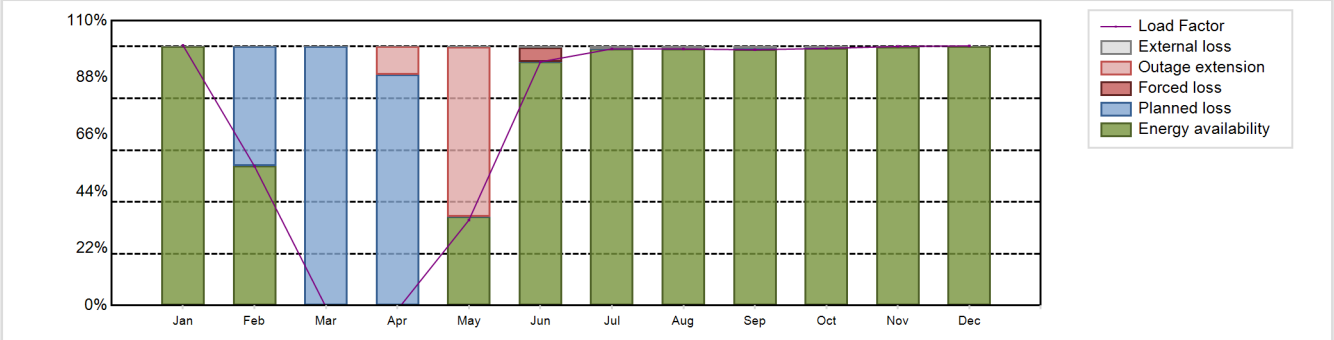
Secondary systems
 Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 3000
 Number of LP cylinders per turbine : 3
 HP cylinder inlet steam pressure [MPa] : 6.71
 Output voltage [kV] : 23.5
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : 4
 Number of FW pumps for full power operation : 4
 Number of on-site safety related diesel generators : 6

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7676.68 GW(e).h
 Energy Availability Factor (EAF) : 73.39 %
 Unit Capability Factor (UCF) : 73.67 %
 Load Factor (LF) : 73.15 %
 Operating Factor (OF) : 74.95 %
 Forced Loss Rate (FLR) : 0.6 %
 Unplanned Capability Loss Factor (UCL) : 6.9 %
 Planned Unavailability Factor (PUF) : 19.43 %
 Externally cause unavailability (XUF) : 0.28 %
 Total off-line time : 2194 hours

Annual Summary

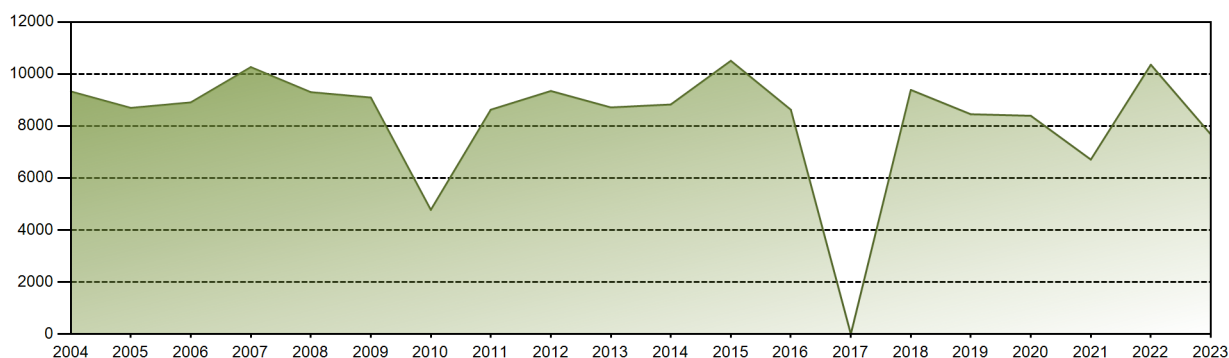


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 895.53 | 433.02 | -5.21 | -13.90 | 294.25 | 811.66 | 883.39 | 882.96 | 851.90 | 886.25 | 863.09 | 893.73 | 7676.68 |
| EAF [%] | 100.00 | 53.97 | 0.00 | 0.00 | 34.35 | 94.10 | 99.11 | 99.06 | 98.76 | 99.30 | 99.97 | 100.00 | 73.39 |
| UCF [%] | 100.00 | 53.97 | 0.00 | 0.00 | 34.41 | 94.55 | 99.99 | 99.91 | 99.50 | 99.65 | 100.00 | 100.00 | 73.67 |
| LF [%] | 100.47 | 53.79 | -0.58 | -1.61 | 33.01 | 94.10 | 99.11 | 99.06 | 98.76 | 99.30 | 100.06 | 100.27 | 73.15 |
| OF [%] | 100.00 | 58.48 | 0.00 | 0.00 | 39.25 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 74.95 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 10.72 | 65.58 | 5.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.90 |
| PUF [%] | 0.00 | 46.03 | 100.00 | 89.28 | 0.01 | 0.02 | 0.01 | 0.09 | 0.50 | 0.35 | 0.00 | 0.00 | 19.43 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.46 | 0.88 | 0.85 | 0.74 | 0.35 | 0.03 | 0.00 | 0.28 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 224330.73 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.19 % |
| Cumulative Energy Availability Factor (EAF) | : 83.78 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.95 % |
| Cumulative Unit Capability Factor (UCF) | : 84.57 % | Cumulative Planned Unavailability Factor (PUF) | : 8.48 % |
| Cumulative Load Factor (LF) | : 83.14 % | Cumulative Externally cause unavailability (XUF) | : 0.79 % |
| Cumulative Operating Factor (OF) | : 85.91 % | | |

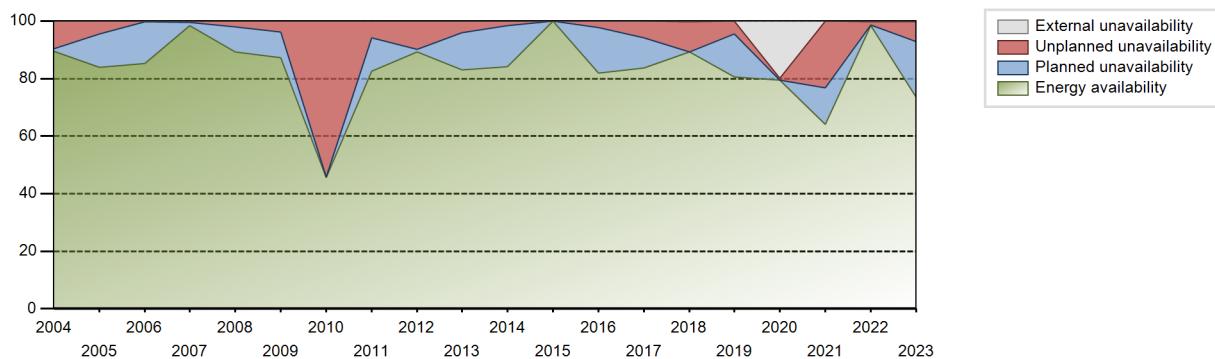
Electricity Production (net) [GWh]



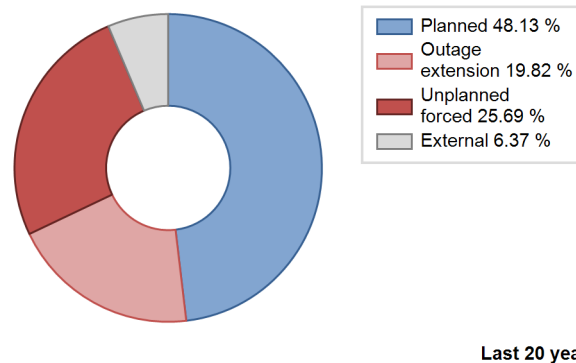
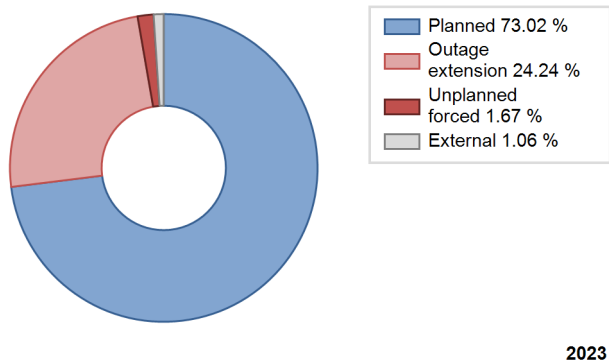
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF | |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | |
| 1995 | 0.00 | 0 | 1188 | 99.79 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 |
| 1996 | 8488.47 | 7367 | 1188 | 81.38 | 81.34 | 81.34 | 83.87 | 5.51 | 4.74 | 13.91 | -0.04 | |
| 1997 | 8469.81 | 6992 | 1188 | 81.51 | 81.44 | 81.16 | 79.60 | 5.68 | 4.91 | 13.65 | -0.07 | |
| 1998 | 10123.09 | 8705 | 1188 | 97.38 | 97.28 | 97.01 | 99.10 | 2.71 | 2.71 | 0.01 | -0.10 | |
| 1999 | 7959.01 | 7134 | 1188 | 76.53 | 76.54 | 76.27 | 81.22 | 11.22 | 9.68 | 13.78 | 0.01 | |
| 2000 | 8527.18 | 7612 | 1188 | 81.62 | 81.71 | 81.71 | 86.66 | 9.10 | 8.18 | 10.10 | 0.09 | |
| 2001 | 9197.96 | 7784 | 1188 | 77.17 | 77.44 | 88.14 | 88.62 | 12.71 | 11.28 | 11.28 | 0.27 | |
| 2002 | 9195.04 | 7862 | 1188 | 88.48 | 88.90 | 88.36 | 89.75 | 2.36 | 2.15 | 8.95 | 0.42 | |
| 2003 | 8854.19 | 7613 | 1188 | 88.74 | 89.26 | 85.08 | 86.91 | 2.36 | 2.16 | 8.58 | 0.52 | |
| 2004 | 9329.11 | 8685 | 1188 | 89.42 | 89.42 | 89.40 | 98.87 | 9.72 | 9.63 | 0.94 | 0.00 | |
| 2005 | 8696.25 | 7476 | 1188 | 83.93 | 83.93 | 83.56 | 85.34 | 0.00 | 4.53 | 11.54 | 0.00 | |
| 2006 | 8908.26 | 7570 | 1196 | 85.25 | 85.25 | 85.17 | 86.42 | 0.33 | 0.28 | 14.47 | 0.00 | |
| 2007 | 10264.31 | 8760 | 1188 | 98.46 | 98.46 | 98.47 | 100.00 | 0.38 | 0.38 | 1.16 | 0.00 | |
| 2008 | 9301.23 | 8097 | 1188 | 89.23 | 89.23 | 89.13 | 92.18 | 2.05 | 2.06 | 8.71 | 0.00 | |
| 2009 | 9094.88 | 7863 | 1188 | 87.35 | 87.35 | 87.39 | 89.76 | 0.92 | 3.80 | 8.85 | 0.00 | |
| 2010 | 4774.80 | 4032 | 1188 | 45.63 | 45.63 | 45.88 | 46.03 | 54.31 | 54.24 | 0.13 | 0.00 | |
| 2011 | 8627.40 | 7463 | 1191 | 82.54 | 82.54 | 82.69 | 85.19 | 3.43 | 5.77 | 11.69 | 0.00 | |
| 2012 | 9346.24 | 8348 | 1191 | 89.20 | 89.20 | 89.34 | 95.04 | 9.95 | 9.86 | 0.95 | 0.00 | |
| 2013 | 8714.72 | 7612 | 1198 | 83.03 | 83.03 | 83.04 | 86.89 | 0.23 | 3.97 | 13.00 | 0.00 | |
| 2014 | 8828.14 | 7589 | 1198 | 84.08 | 84.08 | 84.12 | 86.63 | 0.69 | 1.58 | 14.34 | 0.00 | |
| 2015 | 10507.34 | 8760 | 1198 | 99.91 | 99.98 | 100.12 | 100.00 | 0.02 | 0.02 | 0.00 | 0.06 | |
| 2016 | 8626.70 | 7280 | 1198 | 81.89 | 82.00 | 81.98 | 82.88 | 0.14 | 2.13 | 15.87 | 0.11 | |
| 2017 | 0.00 | | 1198 | 83.72 | 83.82 | 83.90 | 83.94 | 0.01 | 5.84 | 10.35 | 0.10 | |
| 2018 | 9388.12 | 8039 | 1198 | 89.22 | 89.37 | 89.46 | 91.77 | 2.20 | 10.63 | 0.00 | 0.15 | |
| 2019 | 8452.10 | 7175 | 1198 | 80.54 | 80.64 | 80.54 | 81.91 | 0.18 | 4.32 | 15.04 | 0.10 | |
| 2020 | 8393.47 | 8743 | 1198 | 79.54 | 99.43 | 79.76 | 99.53 | 0.57 | 0.57 | 0.00 | 19.89 | |
| 2021 | 6709.39 | 5689 | 1198 | 64.18 | 64.23 | 63.93 | 64.94 | 0.00 | 23.07 | 12.69 | 0.06 | |
| 2022 | 10357.17 | 8676 | 1198 | 98.50 | 98.70 | 98.69 | 99.04 | 1.27 | 1.27 | 0.02 | 0.21 | |
| 2023 | 7676.68 | 6566 | 1198 | 73.39 | 73.67 | 73.15 | 74.95 | 0.60 | 6.90 | 19.43 | 0.28 | |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1995 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 605 | | | 457 | |
| C. Inspection, maintenance or repair combined with refuelling | 1665 | | | 705 | 50 | |
| D. Inspection, maintenance or repair without refuelling | | | | 1 | | |
| E. Testing of plant systems or components | | | | | 3 | |
| L. Human factor related | | | | | 3 | |
| Z. Other | | | | | 3 | |
| Subtotal | 1665 | 605 | | 706 | 516 | |
| Total | | 2270 | | | 1222 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1995 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 69 |
| 12. Reactor I&C Systems | | 19 |
| 13. Reactor Auxiliary Systems | | 14 |
| 14. Safety Systems | 605 | 51 |
| 15. Reactor Cooling Systems | | 171 |
| 16. Steam generation systems | | 48 |
| 31. Turbine and auxiliaries | | 2 |
| 32. Feedwater and Main Steam System | | 13 |
| 34. Miscellaneous Systems | | 0 |
| 41. Main Generator Systems | | 53 |
| 42. Electrical Power Supply Systems | | 12 |
| Total | 605 | 452 |

Highlights (2023)

Carried out a statutory outage

2023 Operating Experience

GB-23A TORNESS-1 UNITED KINGDOM

Status at end of year : **Operational**
 Operator : EDF UK (EDF Energy)
 Owner : EDF UK (EDF Energy)
 Reactor Supplier : NNC (NATIONAL NUCLEAR CORPORATION)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : GCR / AGR | Construction Date | : 1980-08-01 |
| Thermal power | : 1623 MWth | Grid Date | : 1988-05-25 |
| Gross electrical power | : 682 MWe | Commercial Date | : 1988-05-25 |
| Reference unit power (net) | : 595 MWe | Age at end of year | : 35 years |

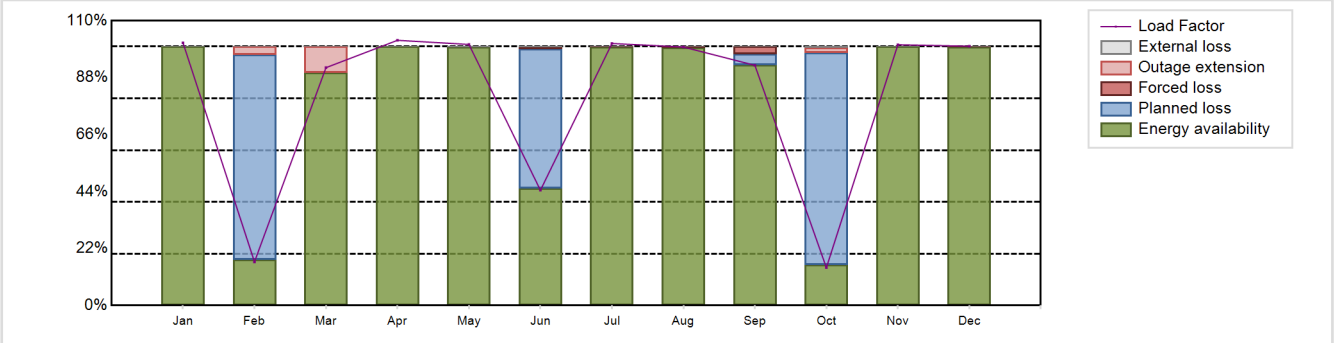
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|----------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 4.3 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 635 |
| Refuelling type | : ON-line | Number of SG | : 4 |
| Moderator material | : GRAPHITE | Containment type | : NA |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : NA |
| Refuelling frequency [month] | : 2 | Secondary systems | |
| Part of the core refuelled [%] | : 3 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 27000 | Turbine speed [rpm] | : 3000 |
| Active core diameter [m] | : 9.46 | Number of LP cylinders per turbine | : 3 |
| Active core height/length [m] | : 8.31 | HP cylinder inlet steam pressure [MPa] | : 15.9 |
| Number of fissile fuel assemblies/bundles | : 332 | Output voltage [kV] | : 23.5 |
| Fuel linear heat generation rate [kW/m] | : 16.8 | Primary means of condenser cooling | : Sea (once-through) |
| Number of control rod assemblies | : 89 | Number of main condensate pumps | : 2 |
| Number of external reactor coolant loops | : NA | Number of FW pumps for full power operation | : 1 |
| Coolant type | : CO2 | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4225.69 GW(e).h | Forced Loss Rate (FLR) | : 0.42 % |
| Energy Availability Factor (EAF) | : 80.53 % | Unplanned Capability Loss Factor (UCL) | : 1.61 % |
| Unit Capability Factor (UCF) | : 80.57 % | Planned Unavailability Factor (PUF) | : 17.82 % |
| Load Factor (LF) | : 81.07 % | Externally cause unavailability (XUF) | : 0.03 % |
| Operating Factor (OF) | : 82.1 % | Total off-line time | : 1568 hours |

Annual Summary

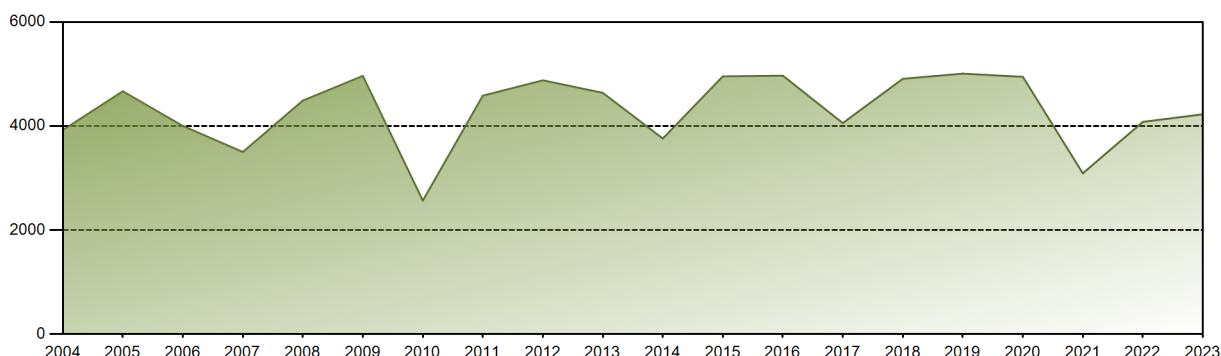


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|-------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 449.20 | 67.37 | 406.13 | 438.79 | 446.34 | 190.79 | 448.04 | 441.94 | 397.47 | 64.85 | 431.44 | 443.34 | 4225.69 |
| EAF [%] | 100.00 | 17.66 | 89.87 | 100.00 | 99.98 | 45.34 | 99.94 | 99.70 | 92.84 | 15.80 | 100.00 | 99.82 | 80.53 |
| UCF [%] | 100.00 | 17.66 | 89.87 | 100.00 | 99.99 | 45.39 | 99.94 | 99.70 | 92.84 | 16.11 | 100.00 | 99.82 | 80.57 |
| LF [%] | 101.47 | 16.85 | 91.87 | 102.43 | 100.83 | 44.54 | 101.21 | 99.83 | 92.78 | 14.63 | 100.71 | 100.15 | 81.07 |
| OF [%] | 100.00 | 17.71 | 93.41 | 100.00 | 100.00 | 50.28 | 100.00 | 100.00 | 96.53 | 21.74 | 100.00 | 100.00 | 82.10 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.76 | 0.06 | 0.30 | 2.89 | 0.00 | 0.00 | 0.18 | 0.42 |
| UCL [%] | 0.00 | 3.09 | 10.13 | 0.00 | 0.00 | 0.81 | 0.06 | 0.30 | 2.76 | 2.10 | 0.00 | 0.18 | 1.61 |
| PUF [%] | 0.00 | 79.25 | 0.00 | 0.00 | 0.01 | 53.80 | 0.00 | 0.00 | 4.40 | 81.79 | 0.00 | 0.00 | 17.82 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 | 0.00 | 0.03 |

Historical Summary

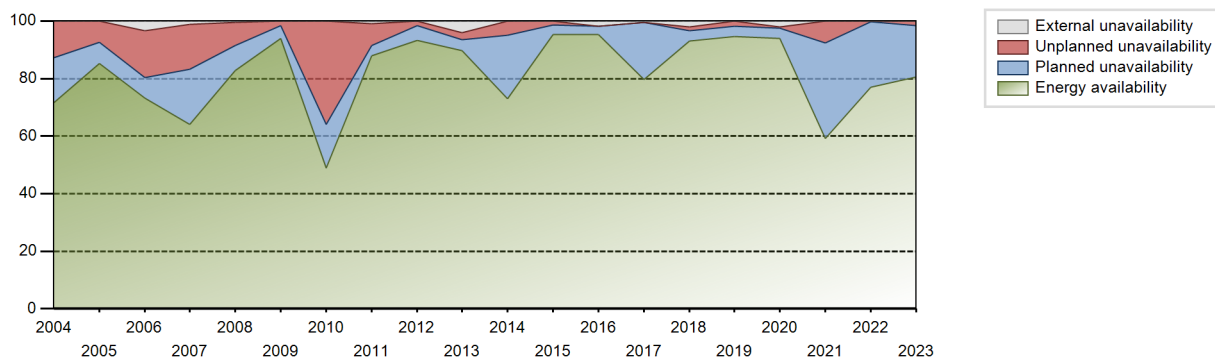
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 140330.54 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.16 % |
| Cumulative Energy Availability Factor (EAF) | : 77.49 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.24 % |
| Cumulative Unit Capability Factor (UCF) | : 78.98 % | Cumulative Planned Unavailability Factor (PUF) | : 14.78 % |
| Cumulative Load Factor (LF) | : 75.08 % | Cumulative Externally cause unavailability (XUF) | : 1.49 % |
| Cumulative Operating Factor (OF) | : 82.67 % | | |

Electricity Production (net) [GWh]

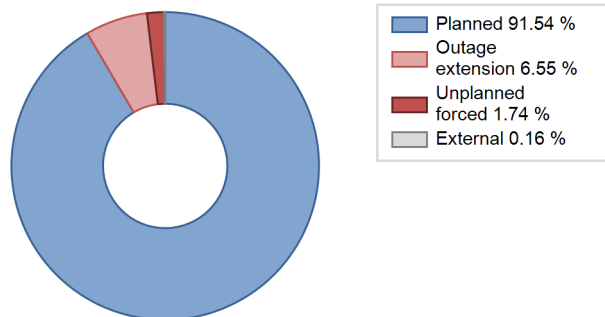


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 2287.10 | 4330 | 638 | 69.41 | 92.32 | 68.07 | 82.99 | 7.68 | 7.68 | 0.00 | 22.91 |
| 1989 | 2162.10 | 4582 | 625 | 39.47 | 53.23 | 39.60 | 52.45 | 4.16 | 2.31 | 44.46 | 13.76 |
| 1990 | 1938.35 | 3943 | 625 | 35.66 | 35.66 | 35.50 | 45.14 | 10.53 | 4.20 | 60.14 | 0.00 |
| 1991 | 2513.60 | 5011 | 625 | 45.97 | 45.97 | 46.04 | 57.36 | 6.72 | 3.31 | 50.72 | 0.00 |
| 1992 | 4532.90 | 7792 | 632 | 81.66 | 81.66 | 80.55 | 87.51 | 4.22 | 3.60 | 14.74 | 0.00 |
| 1993 | 3603.10 | 6358 | 632 | 67.68 | 67.89 | 62.91 | 70.15 | 10.75 | 8.18 | 23.93 | 0.21 |
| 1994 | 4329.90 | 7716 | 632 | 79.51 | 86.73 | 78.42 | 88.32 | 0.00 | 0.00 | 13.27 | 7.22 |
| 1995 | 4058.60 | 6867 | 632 | 75.19 | 75.19 | 71.54 | 76.50 | 0.48 | 0.36 | 24.44 | 0.00 |
| 1996 | 1178.10 | 2043 | 632 | 96.64 | 96.64 | 21.22 | 23.26 | 0.38 | 0.37 | 2.99 | 0.00 |
| 1997 | 4909.44 | 8050 | 625 | 89.70 | 89.70 | 89.43 | 91.64 | 0.09 | 0.08 | 10.22 | 0.00 |
| 1998 | 4297.87 | 7153 | 625 | 78.56 | 78.56 | 78.29 | 81.43 | 2.61 | 2.11 | 19.33 | 0.00 |
| 1999 | 5157.76 | 8737 | 625 | 94.22 | 94.22 | 93.95 | 99.46 | 0.22 | 0.21 | 5.57 | 0.00 |
| 2000 | 4376.80 | 8769 | 625 | 79.72 | 79.72 | 79.72 | 99.83 | 16.50 | 15.76 | 4.52 | 0.00 |
| 2001 | 3968.48 | 7613 | 625 | 70.24 | 70.24 | 72.29 | 86.67 | 18.14 | 15.57 | 14.19 | 0.00 |
| 2002 | 3761.93 | 6719 | 625 | 68.71 | 69.64 | 68.71 | 76.70 | 24.65 | 24.01 | 6.35 | 0.93 |
| 2003 | 4681.94 | 8347 | 625 | 85.61 | 85.76 | 85.51 | 95.29 | 7.20 | 8.00 | 6.24 | 0.15 |
| 2004 | 3921.80 | 6993 | 625 | 71.68 | 71.68 | 71.44 | 79.61 | 12.51 | 12.74 | 15.58 | 0.00 |
| 2005 | 4667.73 | 8372 | 625 | 85.34 | 85.34 | 85.26 | 95.57 | 6.95 | 7.34 | 7.32 | 0.00 |
| 2006 | 4000.87 | 7939 | 625 | 73.31 | 76.74 | 73.08 | 90.63 | 14.29 | 16.15 | 7.11 | 3.43 |
| 2007 | 3500.94 | 6234 | 625 | 64.16 | 65.32 | 63.94 | 71.16 | 14.34 | 15.57 | 19.11 | 1.16 |
| 2008 | 4488.12 | 8110 | 615 | 82.89 | 83.47 | 82.75 | 92.33 | 8.62 | 7.88 | 8.65 | 0.59 |
| 2009 | 4963.55 | 8760 | 600 | 93.86 | 93.86 | 93.86 | 100.00 | 1.42 | 1.55 | 4.59 | 0.00 |
| 2010 | 2565.36 | 5302 | 600 | 48.82 | 48.82 | 48.81 | 60.53 | 34.51 | 35.95 | 15.23 | 0.00 |
| 2011 | 4582.85 | 8393 | 600 | 87.99 | 88.91 | 87.19 | 95.81 | 5.98 | 7.56 | 3.53 | 0.92 |
| 2012 | 4878.05 | 8784 | 595 | 93.33 | 93.35 | 93.33 | 100.00 | 1.12 | 1.57 | 5.08 | 0.01 |
| 2013 | 4637.66 | 8451 | 590 | 89.80 | 93.80 | 89.73 | 96.47 | 1.96 | 2.40 | 3.79 | 4.01 |
| 2014 | 3758.73 | 6823 | 590 | 73.02 | 73.05 | 72.73 | 77.89 | 4.81 | 4.82 | 22.14 | 0.03 |
| 2015 | 4954.38 | 8760 | 590 | 95.37 | 95.45 | 95.86 | 100.00 | 1.44 | 1.39 | 3.15 | 0.08 |
| 2016 | 4968.15 | 8678 | 590 | 95.29 | 97.07 | 95.86 | 98.79 | 0.00 | 0.00 | 2.92 | 1.78 |
| 2017 | 4056.96 | 7235 | | 79.60 | 80.02 | 78.50 | 82.59 | 0.01 | 0.16 | 19.82 | 0.42 |
| 2018 | 4908.39 | 8610 | 595 | 93.14 | 95.08 | 94.17 | 98.29 | 1.45 | 1.43 | 3.49 | 1.94 |
| 2019 | 5006.74 | 8760 | 595 | 94.66 | 94.75 | 96.06 | 100.00 | 1.12 | 1.67 | 3.58 | 0.09 |
| 2020 | 4946.16 | 8784 | 595 | 94.00 | 95.95 | 94.64 | 100.00 | 0.48 | 0.54 | 3.51 | 1.96 |
| 2021 | 3090.34 | 5372 | 595 | 59.23 | 59.27 | 59.29 | 61.32 | 0.38 | 7.53 | 33.20 | 0.04 |
| 2022 | 4079.44 | 6890 | 595 | 77.04 | 77.04 | 78.27 | 78.65 | 0.36 | 0.28 | 22.68 | 0.00 |
| 2023 | 4225.69 | 7192 | 595 | 80.53 | 80.57 | 81.07 | 82.10 | 0.42 | 1.61 | 17.82 | 0.03 |

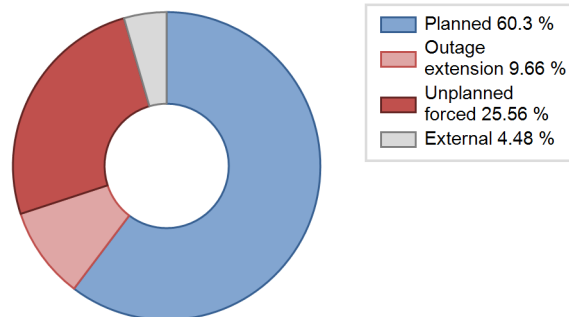
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 214 | |
| B. Refuelling without maintenance | 1497 | | | 143 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 563 | 20 | |
| D. Inspection, maintenance or repair without refuelling | | | | 141 | | |
| E. Testing of plant systems or components | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 27 | |
| M. Governmental requirements or court decisions | | | | | | 9 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 16 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | 1 | | | 11 | |
| Z. Other | | 141 | | 71 | 38 | 41 |
| Subtotal | 1497 | 142 | | 918 | 311 | 68 |
| Total | | 1639 | | | 1297 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 1 | 11 |
| 12. Reactor I&C Systems | | 18 |
| 14. Safety Systems | | 4 |
| 15. Reactor Cooling Systems | | 49 |
| 16. Steam generation systems | | 6 |
| 21. Fuel Handling and Storage Facilities | 141 | 28 |
| 31. Turbine and auxiliaries | | 15 |
| 32. Feedwater and Main Steam System | | 8 |
| 33. Circulating Water System | | 25 |
| 41. Main Generator Systems | | 52 |
| 42. Electrical Power Supply Systems | | 55 |
| Total | 142 | 271 |

2023 Operating Experience

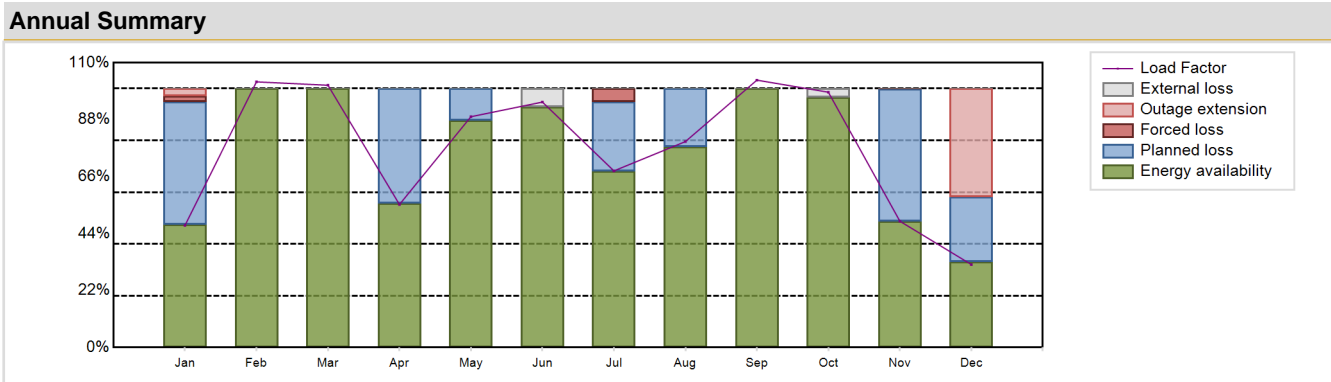
GB-23B TORNESS-2 UNITED KINGDOM

Status at end of year : **Operational**
 Operator : EDF UK (EDF Energy)
 Owner : EDF UK (EDF Energy)
 Reactor Supplier : NNC (NATIONAL NUCLEAR CORPORATION)
 Turbine Supplier : GEC (GENERAL ELECTRIC COMPANY (UK))

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------|--------------------|--------------|
| Reactor type and model | : GCR / AGR | Construction Date | : 1980-08-01 |
| Thermal power | : 1623 MWth | Grid Date | : 1989-02-03 |
| Gross electrical power | : 682 MWe | Commercial Date | : 1989-02-03 |
| Reference unit power (net) | : 605 MWe | Age at end of year | : 34 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 4.3 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 635 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : ON-line | Containment type | : NA |
| Moderator material | : GRAPHITE | Containment design pressure [MPa] | : NA |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 2 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 3 | Turbine speed [rpm] | : 3000 |
| Average discharge burnup [MWd/t] | : 27000 | Number of LP cylinders per turbine | : 3 |
| Active core diameter [m] | : 9.46 | HP cylinder inlet steam pressure [MPa] | : 15.9 |
| Active core height/length [m] | : 8.31 | Output voltage [kV] | : 23.5 |
| Number of fissile fuel assemblies/bundles | : 332 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 16.8 | Number of main condensate pumps | : 2 |
| Number of control rod assemblies | : 89 | Number of FW pumps for full power operation | : 1 |
| Number of external reactor coolant loops | : NA | Number of on-site safety related diesel generators | : - |
| Coolant type | : CO2 | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4055.74 GW(e).h | Forced Loss Rate (FLR) | : 0.83 % |
| Energy Availability Factor (EAF) | : 75.46 % | Unplanned Capability Loss Factor (UCL) | : 4.43 % |
| Unit Capability Factor (UCF) | : 76.35 % | Planned Unavailability Factor (PUF) | : 19.23 % |
| Load Factor (LF) | : 76.53 % | Externally cause unavailability (XUF) | : 0.88 % |
| Operating Factor (OF) | : 78.07 % | Total off-line time | : 1921 hours |

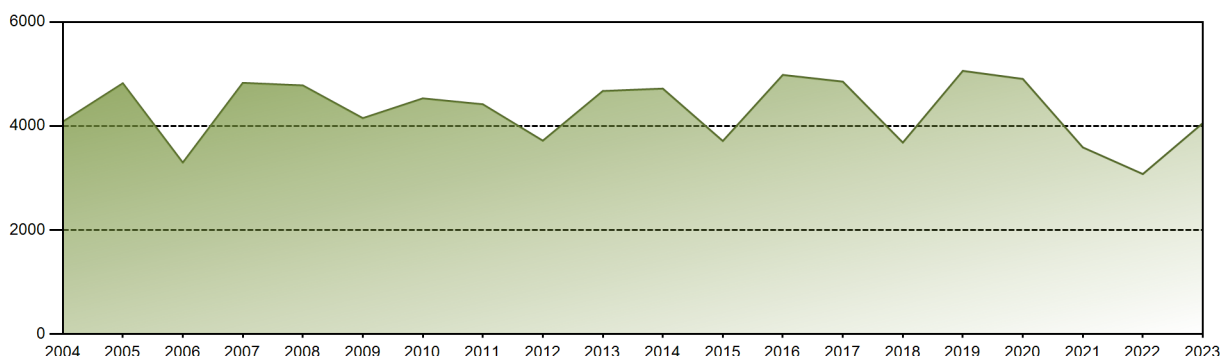


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 212.33 | 417.14 | 455.34 | 240.60 | 401.27 | 412.93 | 307.07 | 357.99 | 449.82 | 444.44 | 212.53 | 144.26 | 4055.74 |
| EAF [%] | 47.45 | 100.00 | 100.00 | 55.74 | 87.73 | 92.83 | 68.06 | 77.42 | 100.00 | 96.53 | 48.85 | 33.18 | 75.46 |
| UCF [%] | 47.45 | 100.00 | 100.00 | 55.74 | 87.73 | 100.00 | 68.06 | 77.42 | 100.00 | 100.00 | 48.85 | 33.18 | 76.35 |
| LF [%] | 47.17 | 102.60 | 101.30 | 55.23 | 89.15 | 94.80 | 68.22 | 79.53 | 103.26 | 98.61 | 48.79 | 32.05 | 76.53 |
| OF [%] | 55.51 | 100.00 | 100.00 | 56.39 | 90.32 | 94.31 | 74.06 | 81.45 | 100.00 | 100.00 | 49.86 | 36.69 | 78.07 |
| FLR [%] | 4.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.10 | 0.00 | 0.00 | 0.00 | 0.26 | 0.00 | 0.83 |
| UCL [%] | 5.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.20 | 0.00 | 0.00 | 0.00 | 0.13 | 41.77 | 4.43 |
| PUF [%] | 47.55 | 0.00 | 0.00 | 44.26 | 12.27 | 0.00 | 26.74 | 22.58 | 0.00 | 0.00 | 51.03 | 25.05 | 19.23 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.17 | 0.00 | 0.00 | 0.00 | 3.47 | 0.00 | 0.00 | 0.88 |

Historical Summary

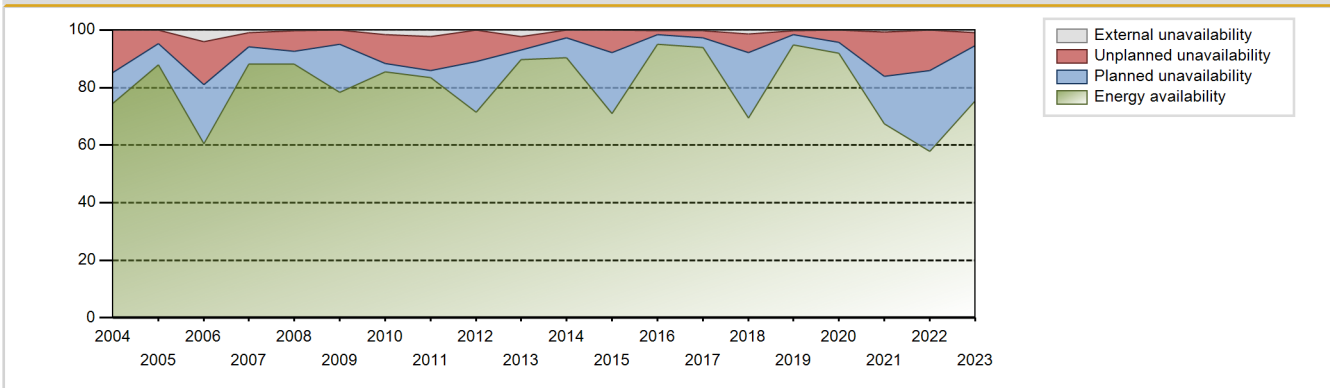
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 136902.89 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.09 % |
| Cumulative Energy Availability Factor (EAF) | : 76.47 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.05 % |
| Cumulative Unit Capability Factor (UCF) | : 77.46 % | Cumulative Planned Unavailability Factor (PUF) | : 14.48 % |
| Cumulative Load Factor (LF) | : 74.2 % | Cumulative Externally cause unavailability (XUF) | : 0.99 % |
| Cumulative Operating Factor (OF) | : 82.47 % | | |

Electricity Production (net) [GWh]

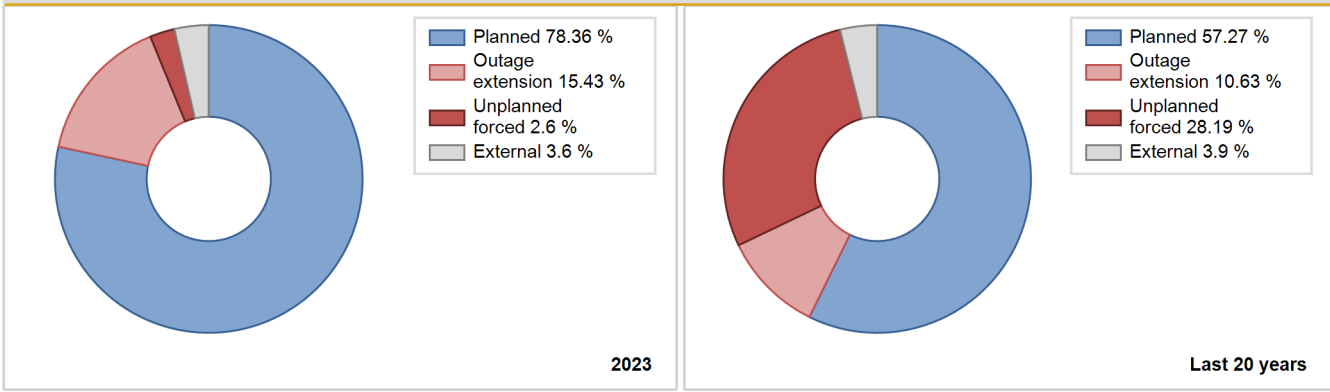


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 3633.80 | 7068 | 625 | 74.21 | 87.39 | 73.28 | 89.08 | 4.32 | 3.94 | 8.67 | 13.18 |
| 1990 | 1948.30 | 4211 | 625 | 36.08 | 36.08 | 35.68 | 48.20 | 6.46 | 2.49 | 61.43 | 0.00 |
| 1991 | 2651.30 | 5068 | 625 | 48.37 | 48.37 | 48.56 | 58.01 | 4.70 | 2.38 | 49.25 | 0.00 |
| 1992 | 3732.70 | 6560 | 625 | 67.02 | 67.02 | 67.07 | 73.67 | 5.42 | 3.84 | 29.14 | 0.00 |
| 1993 | 4038.00 | 7168 | 632 | 74.35 | 74.35 | 73.14 | 82.05 | 3.86 | 2.99 | 22.66 | 0.00 |
| 1994 | 3478.09 | 6264 | 632 | 65.46 | 71.21 | 62.82 | 71.51 | 1.36 | 0.98 | 27.81 | 5.74 |
| 1995 | 4651.90 | 7909 | 632 | 85.88 | 85.88 | 81.31 | 87.37 | 1.10 | 0.95 | 13.17 | 0.00 |
| 1996 | 1571.30 | 2409 | 632 | 96.20 | 96.20 | 28.30 | 27.42 | 0.00 | 0.00 | 3.80 | 0.00 |
| 1997 | 4217.98 | 7181 | 625 | 77.72 | 77.72 | 76.83 | 81.75 | 1.33 | 1.04 | 21.24 | 0.00 |
| 1998 | 5094.36 | 8713 | 625 | 93.68 | 93.68 | 92.79 | 99.19 | 0.63 | 0.60 | 5.72 | 0.00 |
| 1999 | 4983.97 | 8588 | 625 | 91.06 | 91.06 | 90.78 | 97.77 | 4.07 | 3.86 | 5.08 | 0.00 |
| 2000 | 3936.12 | 7686 | 625 | 71.70 | 71.70 | 71.70 | 87.50 | 17.72 | 15.45 | 12.86 | 0.00 |
| 2001 | 4293.57 | 8476 | 625 | 76.57 | 77.15 | 78.21 | 96.49 | 19.60 | 18.81 | 4.03 | 0.58 |
| 2002 | 1945.61 | 3751 | 625 | 35.73 | 36.99 | 35.54 | 42.82 | 61.93 | 60.74 | 2.27 | 1.26 |
| 2003 | 3782.85 | 6874 | 625 | 69.44 | 69.44 | 69.09 | 78.47 | 14.58 | 14.03 | 16.53 | 0.00 |
| 2004 | 4082.96 | 7682 | 625 | 74.61 | 74.61 | 74.37 | 87.45 | 10.63 | 14.69 | 10.69 | 0.00 |
| 2005 | 4821.85 | 8570 | 625 | 87.85 | 87.85 | 88.07 | 97.83 | 4.80 | 4.64 | 7.51 | 0.00 |
| 2006 | 3297.00 | 6456 | 625 | 60.46 | 64.44 | 60.22 | 73.70 | 12.00 | 14.99 | 20.57 | 3.98 |
| 2007 | 4829.04 | 8480 | 625 | 88.26 | 89.19 | 88.20 | 96.80 | 5.15 | 4.87 | 5.94 | 0.93 |
| 2008 | 4780.78 | 8494 | 615 | 88.23 | 88.40 | 88.14 | 96.70 | 7.06 | 7.23 | 4.37 | 0.17 |
| 2009 | 4151.18 | 7303 | 605 | 78.30 | 78.30 | 78.01 | 83.37 | 3.43 | 5.01 | 16.70 | 0.00 |
| 2010 | 4531.25 | 8345 | 605 | 85.50 | 87.13 | 85.50 | 95.26 | 9.83 | 9.97 | 2.91 | 1.63 |
| 2011 | 4417.91 | 8235 | 605 | 83.48 | 85.67 | 83.36 | 94.01 | 12.08 | 11.95 | 2.39 | 2.18 |
| 2012 | 3717.79 | 6632 | 595 | 71.43 | 71.43 | 71.13 | 75.50 | 3.31 | 10.85 | 17.72 | 0.00 |
| 2013 | 4672.85 | 8287 | 595 | 89.68 | 91.85 | 89.65 | 94.60 | 4.83 | 4.74 | 3.41 | 2.16 |
| 2014 | 4718.74 | 8274 | 595 | 90.41 | 90.50 | 90.53 | 94.45 | 2.71 | 2.52 | 6.98 | 0.09 |
| 2015 | 3711.61 | 6684 | 595 | 70.90 | 70.91 | 71.21 | 76.30 | 4.29 | 7.83 | 21.25 | 0.02 |
| 2016 | 4982.13 | 8746 | 595 | 95.11 | 95.32 | 95.32 | 99.57 | 0.96 | 1.44 | 3.23 | 0.21 |
| 2017 | 4853.06 | 8710 | | 94.02 | 94.35 | 93.11 | 99.43 | 0.80 | 2.36 | 3.29 | 0.33 |
| 2018 | 3680.98 | 6602 | 605 | 69.34 | 70.78 | 69.46 | 75.37 | 8.41 | 6.49 | 22.73 | 1.44 |
| 2019 | 5059.93 | 8760 | 605 | 94.81 | 95.01 | 95.47 | 100.00 | 0.91 | 1.48 | 3.52 | 0.20 |
| 2020 | 4904.72 | 8615 | 605 | 92.01 | 92.04 | 92.29 | 98.08 | 4.03 | 4.26 | 3.70 | 0.03 |
| 2021 | 3589.01 | 7005 | 605 | 67.51 | 68.23 | 67.72 | 79.97 | 12.88 | 15.32 | 16.45 | 0.72 |
| 2022 | 3076.41 | 6048 | 605 | 57.80 | 57.80 | 58.05 | 69.04 | 19.56 | 14.05 | 28.15 | 0.00 |
| 2023 | 4055.74 | 6839 | 605 | 75.46 | 76.35 | 76.53 | 78.07 | 0.83 | 4.43 | 19.23 | 0.88 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 366 | | | 285 | |
| B. Refuelling without maintenance | 1596 | | | 96 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 585 | 36 | |
| D. Inspection, maintenance or repair without refuelling | | | | 156 | | |
| E. Testing of plant systems or components | | | | | 5 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 13 | 14 | |
| J. Grid limitation, failure or grid unavailability | | | 41 | | | 1 |
| L. Human factor related | | | | | 3 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 24 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 5 | 86 | |
| Z. Other | | | | | 24 | 17 |
| Subtotal | 1596 | 366 | 41 | 855 | 453 | 42 |
| Total | | 2003 | | | 1350 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 21 |
| 12. Reactor I&C Systems | | 15 |
| 13. Reactor Auxiliary Systems | | 5 |
| 15. Reactor Cooling Systems | 366 | 163 |
| 16. Steam generation systems | | 34 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 12 |
| 21. Fuel Handling and Storage Facilities | | 104 |
| 31. Turbine and auxiliaries | | 16 |
| 32. Feedwater and Main Steam System | | 13 |
| 33. Circulating Water System | | 24 |
| 34. Miscellaneous Systems | | 2 |
| 41. Main Generator Systems | | 5 |
| 42. Electrical Power Supply Systems | | 16 |
| Total | 366 | 430 |

2023 Operating Experience

US-313

ANO-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : ENTERGY (Entergy Nuclear Operations, Inc.)
 Owner : ENTARK (ENTERGY ARKANSAS, INC.)
 Reactor Supplier : B&W (BABCOCK & WILCOX CO.)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / B&W LLP (DRYAMB)
 Thermal power : 2568 MWth
 Gross electrical power : 903 MWe
 Reference unit power (net) : 836 MWe

Key Dates

Construction Date : 1968-10-01
 Grid Date : 1974-08-17
 Commercial Date : 1974-12-19
 Age at end of year : 49 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 35000
 Active core diameter [m] : 3.27
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 18
 Number of control rod assemblies : 60
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.3
 Reactor outlet temperature [°C] : 318
 Number of SG : 2
 Containment type : -
 Containment design pressure [MPa] : 0.415

Secondary systems

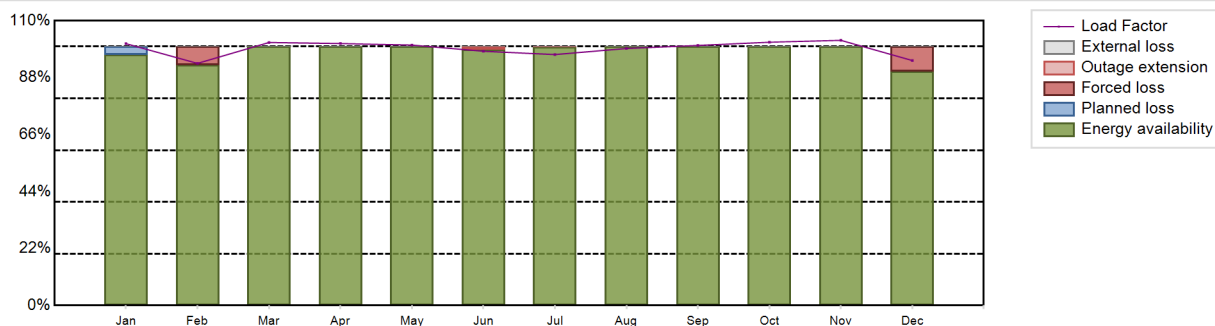
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.3
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7274.18 GW(e).h
 Energy Availability Factor (EAF) : 98.27 %
 Unit Capability Factor (UCF) : 98.27 %
 Load Factor (LF) : 99.33 %
 Operating Factor (OF) : 98.85 %

Forced Loss Rate (FLR) : 1.37 %
 Unplanned Capability Loss Factor (UCL) : 1.46 %
 Planned Unavailability Factor (PUF) : 0.26 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 101 hours

Annual Summary

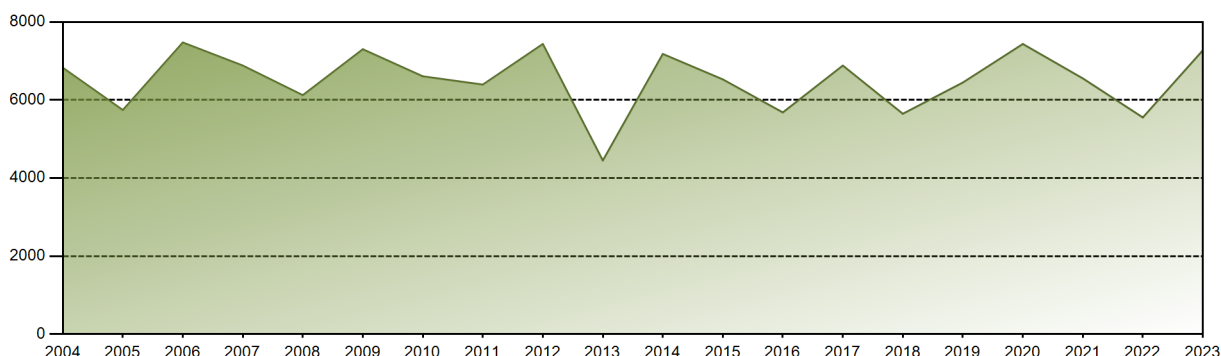


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 629.00 | 525.38 | 630.99 | 609.00 | 625.63 | 591.03 | 602.80 | 617.40 | 604.60 | 632.51 | 617.35 | 588.48 | 7274.18 |
| EAF [%] | 96.90 | 92.86 | 100.00 | 100.00 | 100.00 | 98.93 | 99.94 | 100.00 | 100.00 | 100.00 | 100.00 | 90.32 | 98.27 |
| UCF [%] | 96.90 | 92.86 | 100.00 | 100.00 | 100.00 | 98.93 | 99.94 | 100.00 | 100.00 | 100.00 | 100.00 | 90.32 | 98.27 |
| LF [%] | 101.13 | 93.52 | 101.58 | 101.18 | 100.59 | 98.19 | 96.92 | 99.26 | 100.45 | 101.69 | 102.42 | 94.61 | 99.33 |
| OF [%] | 100.00 | 92.41 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.28 | 98.85 |
| FLR [%] | 0.00 | 7.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.68 | 1.37 |
| UCL [%] | 0.00 | 7.14 | 0.00 | 0.00 | 0.00 | 1.07 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 9.68 | 1.46 |
| PUF [%] | 3.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 283064.7 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.5 % |
| Cumulative Energy Availability Factor (EAF) | : 81.88 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.79 % |
| Cumulative Unit Capability Factor (UCF) | : 82.22 % | Cumulative Planned Unavailability Factor (PUF) | : 12.99 % |
| Cumulative Load Factor (LF) | : 78.79 % | Cumulative Externally cause unavailability (XUF) | : 0.35 % |
| Cumulative Operating Factor (OF) | : 82.34 % | | |

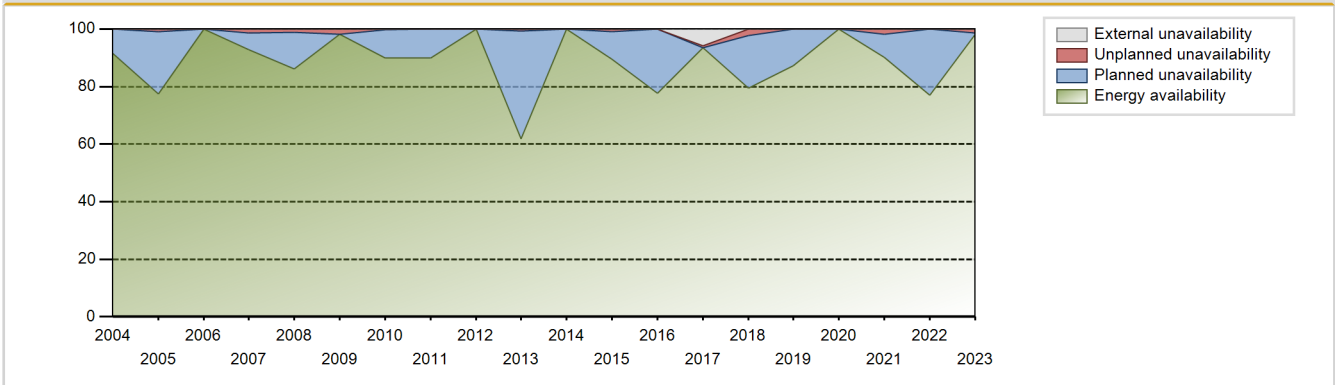
Electricity Production (net) [GWh]



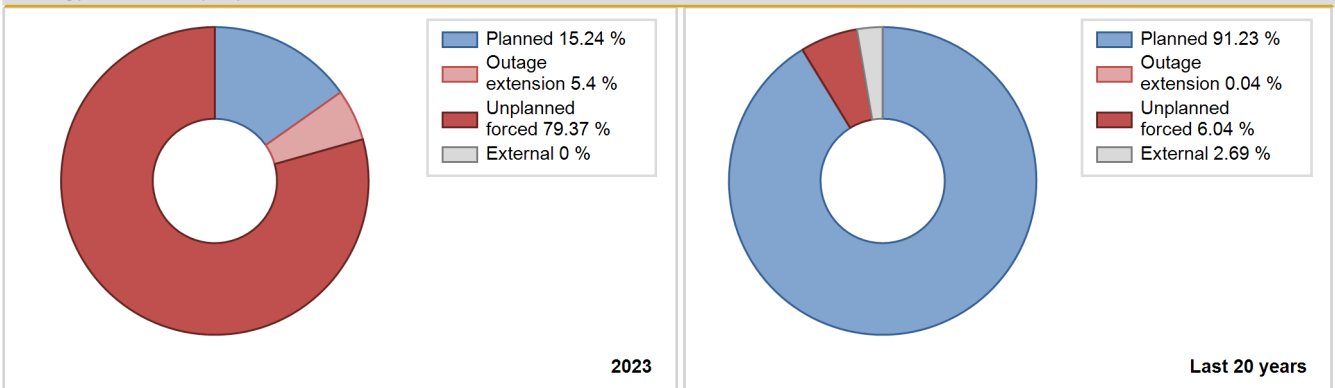
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1974 | | | | Data not provided | | | | | | | |
| 1975 | 4898.40 | 6661 | 797 | 67.71 | 67.71 | 70.16 | 76.04 | 10.27 | 7.75 | 24.54 | 0.00 |
| 1976 | 3888.00 | 4966 | 836 | 53.00 | 53.00 | 52.95 | 56.53 | 25.47 | 18.11 | 28.89 | 0.00 |
| 1977 | 5103.10 | 6688 | 836 | 69.67 | 69.67 | 69.68 | 76.35 | 6.76 | 5.05 | 25.28 | 0.00 |
| 1978 | 5249.80 | 6676 | 836 | 71.72 | 71.72 | 71.69 | 76.21 | 12.66 | 10.40 | 17.88 | 0.00 |
| 1979 | 3323.40 | 4253 | 836 | 45.38 | 45.38 | 45.38 | 48.55 | 38.62 | 28.55 | 26.07 | 0.00 |
| 1980 | 3781.20 | 5570 | 836 | 63.70 | 74.77 | 51.49 | 63.41 | 21.95 | 21.03 | 4.20 | 11.06 |
| 1981 | 4900.80 | 6336 | 836 | 72.55 | 72.55 | 66.92 | 72.33 | 8.69 | 6.90 | 20.55 | 0.00 |
| 1982 | 3721.40 | 5671 | 836 | 64.79 | 64.79 | 50.82 | 64.74 | 12.50 | 9.26 | 25.96 | 0.00 |
| 1983 | 3220.60 | 4191 | 836 | 48.26 | 48.26 | 43.98 | 47.84 | 33.32 | 24.12 | 27.63 | 0.00 |
| 1984 | 4604.13 | 6150 | 836 | 70.06 | 70.06 | 62.70 | 70.01 | 1.20 | 0.85 | 29.09 | 0.00 |
| 1985 | 5190.35 | 6852 | 836 | 78.25 | 78.25 | 70.87 | 78.22 | 16.02 | 14.92 | 6.82 | 0.00 |
| 1986 | 3589.93 | 5446 | 836 | 62.20 | 62.20 | 49.02 | 62.17 | 8.05 | 5.45 | 32.35 | 0.00 |
| 1987 | 4763.34 | 7720 | 836 | 88.17 | 88.17 | 65.04 | 88.13 | 4.45 | 4.11 | 7.73 | 0.00 |
| 1988 | 3963.24 | 5996 | 836 | 68.28 | 68.28 | 53.97 | 68.26 | 3.24 | 2.28 | 29.44 | 0.00 |
| 1989 | 3377.00 | 5871 | 836 | 67.07 | 67.07 | 46.11 | 67.02 | 27.55 | 25.50 | 7.43 | 0.00 |
| 1990 | 4145.80 | 6437 | 836 | 75.88 | 75.88 | 56.61 | 73.48 | 1.60 | 1.23 | 22.89 | 0.00 |
| 1991 | 6540.51 | 7991 | 836 | 91.27 | 91.27 | 89.31 | 91.22 | 3.54 | 3.34 | 5.39 | 0.00 |
| 1992 | 5833.14 | 7088 | 836 | 80.69 | 80.69 | 79.43 | 80.69 | 0.07 | 0.06 | 19.25 | 0.00 |
| 1993 | 6126.55 | 7520 | 836 | 85.86 | 85.86 | 83.66 | 85.84 | 2.74 | 2.42 | 11.72 | 0.00 |
| 1994 | 7198.56 | 8643 | 836 | 98.69 | 98.69 | 98.30 | 98.66 | 1.31 | 1.31 | 0.00 | 0.00 |
| 1995 | 5978.22 | 7493 | 836 | 85.59 | 85.59 | 81.63 | 85.54 | 1.83 | 1.60 | 12.81 | 0.00 |
| 1996 | 6287.02 | 7613 | 836 | 86.70 | 86.70 | 85.61 | 86.67 | 4.59 | 4.17 | 9.13 | 0.00 |
| 1997 | 7251.10 | 8723 | 836 | 99.59 | 99.59 | 99.01 | 99.58 | 0.41 | 0.41 | 0.00 | 0.00 |
| 1998 | 6216.85 | 7364 | 836 | 84.11 | 84.11 | 84.89 | 84.06 | 4.45 | 3.92 | 11.98 | 0.00 |
| 1999 | 6714.72 | 7907 | 836 | 90.30 | 90.30 | 91.69 | 90.26 | 1.49 | 1.36 | 8.34 | 0.00 |
| 2000 | 6410.14 | 7748 | 836 | 88.22 | 88.22 | 87.29 | 88.21 | 8.37 | 8.06 | 3.71 | 0.00 |
| 2001 | 6875.47 | 8100 | 836 | 91.81 | 91.81 | 93.88 | 92.47 | 1.39 | 1.29 | 6.90 | 0.00 |
| 2002 | 6568.63 | 7820 | 836 | 89.15 | 89.15 | 89.69 | 89.27 | 0.00 | 0.00 | 10.85 | 0.00 |
| 2003 | 6794.30 | 8050 | 836 | 91.82 | 91.82 | 92.78 | 91.89 | 8.18 | 8.18 | 0.00 | 0.00 |
| 2004 | 6827.58 | 8045 | 836 | 91.57 | 91.57 | 92.98 | 91.59 | 0.00 | 0.00 | 8.43 | 0.00 |
| 2005 | 5743.24 | 6778 | 840 | 77.38 | 77.38 | 78.05 | 77.37 | 1.29 | 1.01 | 21.61 | 0.00 |
| 2006 | 7474.87 | 8760 | 836 | 100.00 | 100.00 | 102.06 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 6882.81 | 8122 | 843 | 92.80 | 92.80 | 93.20 | 92.72 | 1.54 | 1.45 | 5.75 | 0.00 |
| 2008 | 6124.05 | 7558 | 843 | 86.06 | 86.06 | 82.70 | 86.04 | 1.29 | 1.12 | 12.82 | 0.00 |
| 2009 | 7302.10 | 8595 | 842 | 98.12 | 98.12 | 99.00 | 98.12 | 1.88 | 1.88 | 0.00 | 0.00 |
| 2010 | 6607.09 | 7883 | 842 | 90.00 | 90.00 | 89.58 | 89.99 | 0.31 | 0.28 | 9.71 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2011 | 6395.49 | 7872 | 842 | 89.87 | 89.87 | 86.71 | 89.86 | 0.00 | 0.00 | 10.13 | 0.00 |
| 2012 | 7436.06 | 8784 | 842 | 100.00 | 100.00 | 100.54 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 4448.74 | 5415 | 836 | 61.79 | 61.79 | 60.74 | 61.81 | 1.22 | 0.76 | 37.45 | 0.00 |
| 2014 | 7180.53 | 8760 | 836 | 100.00 | 100.00 | 98.05 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 6528.76 | 7832 | 836 | 89.40 | 89.40 | 89.15 | 89.41 | 0.96 | 0.87 | 9.73 | 0.00 |
| 2016 | 5681.14 | 6821 | 836 | 77.65 | 77.65 | 77.36 | 77.65 | 0.00 | 0.00 | 22.35 | 0.00 |
| 2017 | 6883.54 | 8193 | 836 | 93.53 | 99.44 | 93.99 | 93.53 | 0.56 | 0.56 | 0.00 | 5.91 |
| 2018 | 5647.03 | 6966 | 836 | 79.53 | 79.53 | 77.11 | 79.52 | 2.67 | 2.18 | 18.29 | 0.00 |
| 2019 | 6447.65 | 7644 | 836 | 87.26 | 87.26 | 88.04 | 87.26 | 0.00 | 0.00 | 12.74 | 0.00 |
| 2020 | 7436.38 | 8783 | 836 | 100.00 | 100.00 | 101.27 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 6553.94 | 7897 | 836 | 90.15 | 90.15 | 89.49 | 90.15 | 1.91 | 1.76 | 8.09 | 0.00 |
| 2022 | 5552.65 | 6753 | 836 | 77.10 | 77.10 | 75.82 | 77.09 | 0.00 | 0.00 | 22.90 | 0.00 |
| 2023 | 7274.18 | 8659 | 836 | 98.27 | 98.27 | 99.33 | 98.85 | 1.37 | 1.46 | 0.26 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1974 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 48 | | | 439 | |
| B. Refuelling without maintenance | | | | 55 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 793 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 97 | | |
| E. Testing of plant systems or components | | | | 2 | 2 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 39 | | |
| H. Nuclear regulatory requirements | | | | | 34 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 4 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 14 |
| P. Fire | | | | | 3 | |
| Z. Other | | | | 42 | 4 | |
| Subtotal | | 48 | | 1028 | 486 | 15 |
| Total | | 48 | | | 1529 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1974 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 48 | 61 |
| 12. Reactor I&C Systems | | 26 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 25 |
| 15. Reactor Cooling Systems | | 35 |
| 16. Steam generation systems | | 38 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 15 |
| 31. Turbine and auxiliaries | | 97 |
| 32. Feedwater and Main Steam System | | 49 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | | 3 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 61 |
| 42. Electrical Power Supply Systems | | 27 |
| Total | 48 | 455 |

2023 Operating Experience

US-368

ANO-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : ENTERGY (Entergy Nuclear Operations, Inc.)
 Owner : ENTARK (ENTERGY ARKANSAS, INC.)
 Reactor Supplier : CE (COMBUSTION ENGINEERING CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / CE 2LP (DRYAMB)
 Thermal power : 3026 MWth
 Gross electrical power : 1065 MWe
 Reference unit power (net) : 988 MWe

Key Dates

Construction Date : 1968-12-06
 Grid Date : 1978-12-26
 Commercial Date : 1980-03-26
 Age at end of year : 45 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 35000
 Active core diameter [m] : 3.12
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 18
 Number of control rod assemblies : 73
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 323
 Number of SG : 2
 Containment type : -
 Containment design pressure [MPa] : 0.38

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.08
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

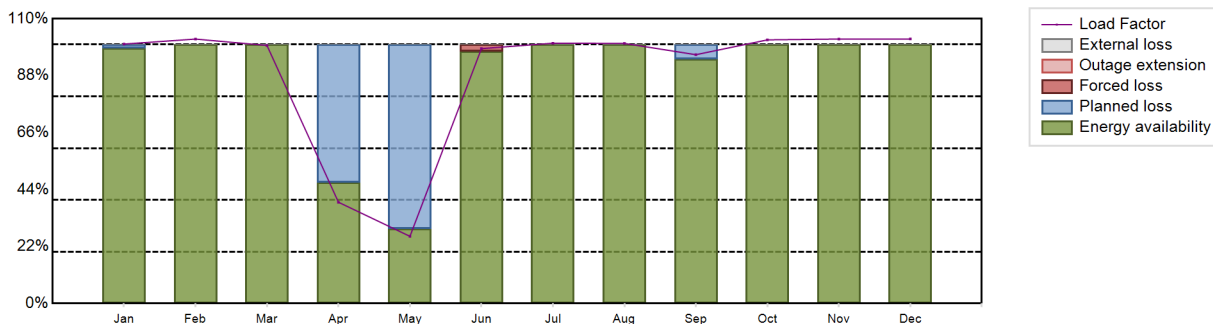
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7703.81 GW(e).h
 Energy Availability Factor (EAF) : 88.79 %
 Unit Capability Factor (UCF) : 88.79 %
 Load Factor (LF) : 89.01 %
 Operating Factor (OF) : 89.58 %

Forced Loss Rate (FLR) : 0.23 %
 Unplanned Capability Loss Factor (UCL) : 0.21 %
 Planned Unavailability Factor (PUF) : 11 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 913 hours

Annual Summary

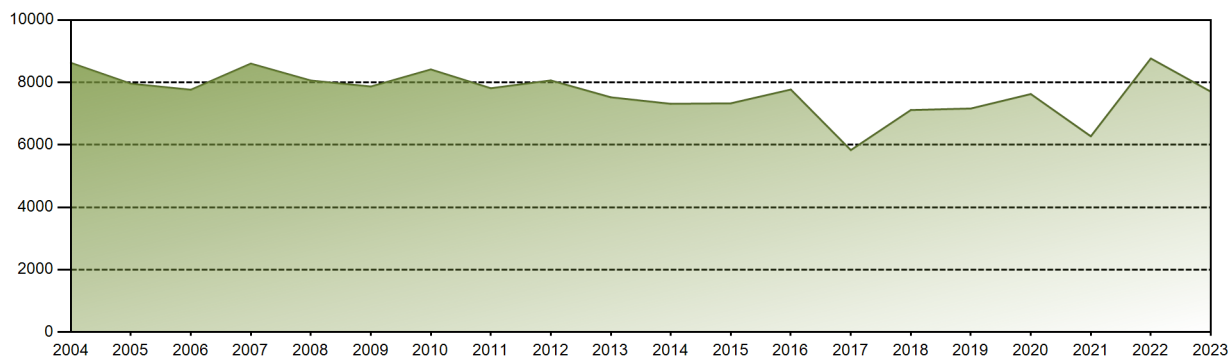


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 736.58 | 678.10 | 731.70 | 278.29 | 190.75 | 700.25 | 739.00 | 738.47 | 683.63 | 748.47 | 727.62 | 750.95 | 7703.81 |
| EAF [%] | 98.55 | 100.00 | 100.00 | 46.66 | 28.85 | 97.50 | 100.00 | 100.00 | 94.50 | 100.00 | 100.00 | 100.00 | 88.79 |
| UCF [%] | 98.55 | 100.00 | 100.00 | 46.66 | 28.85 | 97.50 | 100.00 | 100.00 | 94.50 | 100.00 | 100.00 | 100.00 | 88.79 |
| LF [%] | 100.20 | 102.13 | 99.68 | 39.12 | 25.95 | 98.44 | 100.53 | 100.46 | 96.10 | 101.82 | 102.14 | 102.16 | 89.01 |
| OF [%] | 100.00 | 100.00 | 100.00 | 46.67 | 28.90 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 89.58 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 |
| PUF [%] | 1.45 | 0.00 | 0.00 | 53.34 | 71.15 | 0.00 | 0.00 | 0.00 | 5.50 | 0.00 | 0.00 | 0.00 | 11.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 297731.96 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.09 % |
| Cumulative Energy Availability Factor (EAF) | : 84.6 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.81 % |
| Cumulative Unit Capability Factor (UCF) | : 84.72 % | Cumulative Planned Unavailability Factor (PUF) | : 10.47 % |
| Cumulative Load Factor (LF) | : 84.36 % | Cumulative Externally cause unavailability (XUF) | : 0.12 % |
| Cumulative Operating Factor (OF) | : 84.32 % | | |

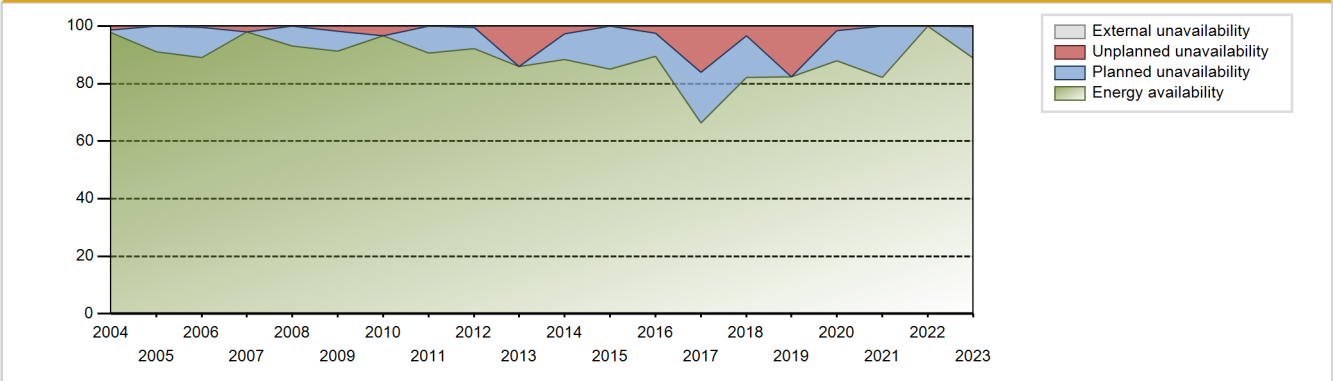
Electricity Production (net) [GWh]



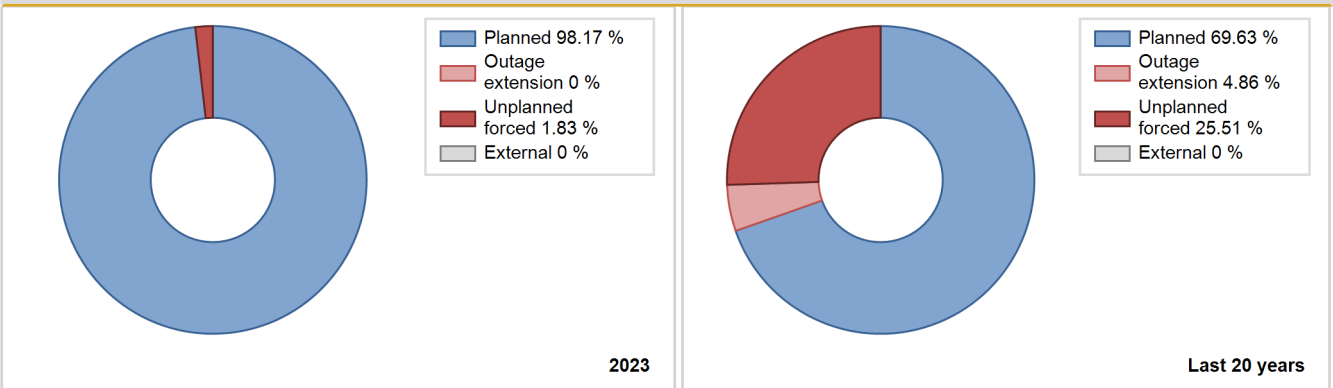
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | 3646.60 | 4913 | 884 | 73.39 | 80.25 | 60.50 | 72.74 | 19.75 | 19.75 | 0.00 | 6.85 |
| 1981 | 4323.60 | 5622 | 858 | 65.23 | 65.23 | 57.52 | 64.18 | 10.27 | 7.47 | 27.31 | 0.00 |
| 1982 | 3807.50 | 5023 | 858 | 57.88 | 57.88 | 50.66 | 57.34 | 22.77 | 17.07 | 25.05 | 0.00 |
| 1983 | 4427.90 | 5380 | 858 | 61.45 | 61.45 | 58.91 | 61.42 | 19.19 | 14.60 | 23.95 | 0.00 |
| 1984 | 6203.57 | 7439 | 858 | 84.74 | 84.74 | 82.31 | 84.69 | 7.34 | 6.71 | 8.55 | 0.00 |
| 1985 | 4701.15 | 6040 | 858 | 68.99 | 69.16 | 62.55 | 68.95 | 13.85 | 11.12 | 19.73 | 0.17 |
| 1986 | 5314.34 | 6274 | 858 | 71.65 | 71.65 | 70.71 | 71.62 | 4.57 | 3.43 | 24.92 | 0.00 |
| 1987 | 6605.17 | 7678 | 858 | 87.69 | 87.69 | 87.88 | 87.65 | 12.31 | 12.31 | 0.00 | 0.00 |
| 1988 | 4952.90 | 5867 | 858 | 66.82 | 66.82 | 65.72 | 66.79 | 8.13 | 5.91 | 27.27 | 0.00 |
| 1989 | 5472.22 | 6514 | 858 | 74.42 | 74.42 | 72.81 | 74.36 | 11.75 | 9.91 | 15.67 | 0.00 |
| 1990 | 7129.57 | 8211 | 858 | 93.76 | 93.76 | 94.86 | 93.73 | 3.76 | 3.66 | 2.58 | 0.00 |
| 1991 | 6123.35 | 7187 | 858 | 82.05 | 82.05 | 81.47 | 82.04 | 2.60 | 2.19 | 15.75 | 0.00 |
| 1992 | 5504.76 | 6390 | 858 | 72.76 | 72.76 | 73.04 | 72.75 | 16.96 | 14.86 | 12.39 | 0.00 |
| 1993 | 7344.72 | 8346 | 858 | 95.27 | 95.27 | 97.72 | 95.27 | 0.44 | 0.42 | 4.30 | 0.00 |
| 1994 | 6724.88 | 7707 | 858 | 88.00 | 88.00 | 89.47 | 87.98 | 0.00 | 0.00 | 12.00 | 0.00 |
| 1995 | 5694.52 | 6644 | 858 | 75.92 | 75.92 | 75.76 | 75.84 | 6.02 | 4.86 | 19.21 | 0.00 |
| 1996 | 7063.90 | 8049 | 858 | 91.64 | 91.64 | 93.73 | 91.63 | 8.36 | 8.36 | 0.00 | 0.00 |
| 1997 | 6957.03 | 8013 | 858 | 91.50 | 91.50 | 92.56 | 91.47 | 0.00 | 0.00 | 8.50 | 0.00 |
| 1998 | 6877.28 | 7995 | 858 | 91.28 | 91.28 | 91.50 | 91.27 | 2.01 | 1.87 | 6.84 | 0.00 |
| 1999 | 6226.87 | 7219 | 858 | 82.43 | 82.43 | 82.85 | 82.41 | 0.00 | 0.00 | 17.57 | 0.00 |
| 2000 | 5265.35 | 6077 | 858 | 69.20 | 69.20 | 69.86 | 69.18 | 3.82 | 2.75 | 28.05 | 0.00 |
| 2001 | 7917.02 | 8498 | 858 | 96.84 | 96.84 | 105.33 | 97.01 | 3.16 | 3.16 | 0.00 | 0.00 |
| 2002 | 8002.15 | 8203 | 858 | 93.10 | 93.10 | 106.47 | 93.64 | 0.42 | 0.39 | 6.51 | 0.00 |
| 2003 | 7925.72 | 8156 | 858 | 92.55 | 92.55 | 105.45 | 93.11 | 1.44 | 1.35 | 6.10 | 0.00 |
| 2004 | 8627.56 | 8580 | 1000 | 97.71 | 97.71 | 98.22 | 97.68 | 1.41 | 1.40 | 0.89 | 0.00 |
| 2005 | 7959.45 | 7966 | 1000 | 90.95 | 90.95 | 90.85 | 90.93 | 0.00 | 0.00 | 9.05 | 0.00 |
| 2006 | 7765.40 | 7793 | 998 | 88.99 | 88.99 | 88.82 | 88.96 | 0.43 | 0.38 | 10.63 | 0.00 |
| 2007 | 8603.30 | 8584 | 995 | 98.02 | 98.02 | 98.70 | 97.99 | 1.98 | 1.98 | 0.00 | 0.00 |
| 2008 | 8060.45 | 8166 | 995 | 92.98 | 92.98 | 92.22 | 92.96 | 0.01 | 0.01 | 7.01 | 0.00 |
| 2009 | 7867.87 | 7986 | 997 | 91.21 | 91.21 | 90.09 | 91.16 | 1.85 | 1.72 | 7.06 | 0.00 |
| 2010 | 8415.59 | 8472 | 993 | 96.72 | 96.72 | 96.75 | 96.71 | 3.28 | 3.28 | 0.00 | 0.00 |
| 2011 | 7812.57 | 7944 | 993 | 90.70 | 90.70 | 89.81 | 90.68 | 0.00 | 0.00 | 9.30 | 0.00 |
| 2012 | 8063.57 | 8090 | 993 | 92.13 | 92.13 | 92.45 | 92.10 | 0.48 | 0.45 | 7.43 | 0.00 |
| 2013 | 7522.80 | 7537 | 992 | 86.02 | 86.02 | 86.56 | 86.03 | 13.98 | 13.98 | 0.00 | 0.00 |
| 2014 | 7313.90 | 7382 | 993 | 88.39 | 88.39 | 84.08 | 84.27 | 2.94 | 2.68 | 8.93 | 0.00 |
| 2015 | 7329.68 | 7441 | 993 | 84.94 | 84.94 | 84.26 | 84.94 | 0.00 | 0.00 | 15.06 | 0.00 |
| 2016 | 7771.44 | 7854 | 993 | 89.41 | 89.41 | 89.10 | 89.41 | 2.82 | 2.59 | 8.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|-------|-------|-------|------|
| 2017 | 5831.07 | 6325 | 993 | 66.37 | 66.37 | 67.03 | 72.20 | 7.51 | 16.19 | 17.45 | 0.00 |
| 2018 | 7114.93 | 7196 | 988 | 82.14 | 82.14 | 82.21 | 82.15 | 3.98 | 3.41 | 14.45 | 0.00 |
| 2019 | 7163.64 | 7216 | 988 | 82.39 | 82.39 | 82.77 | 82.37 | 17.61 | 17.61 | 0.00 | 0.00 |
| 2020 | 7626.67 | 7715 | 988 | 87.84 | 87.84 | 87.88 | 87.83 | 1.84 | 1.64 | 10.52 | 0.00 |
| 2021 | 6272.92 | 7199 | 988 | 82.18 | 82.18 | 72.48 | 82.18 | 0.00 | 0.00 | 17.82 | 0.00 |
| 2022 | 8767.06 | 8760 | 988 | 100.00 | 100.00 | 101.30 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 7703.81 | 7847 | 988 | 88.79 | 88.79 | 89.01 | 89.58 | 0.23 | 0.21 | 11.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 72 | | | 439 | |
| B. Refuelling without maintenance | | | | 57 | | |
| C. Inspection, maintenance or repair combined with refuelling | 913 | | | 794 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 93 | | |
| E. Testing of plant systems or components | | | | 10 | 16 | |
| H. Nuclear regulatory requirements | | | | 16 | 22 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 19 |
| L. Human factor related | | | | | 9 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| P. Fire | | | | | 18 | |
| Z. Other | | | | | 4 | |
| Subtotal | 913 | 72 | | 970 | 508 | 19 |
| Total | | 985 | | | 1497 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1980 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 4 |
| 12. Reactor I&C Systems | | 49 |
| 13. Reactor Auxiliary Systems | | 14 |
| 14. Safety Systems | | 67 |
| 15. Reactor Cooling Systems | | 137 |
| 16. Steam generation systems | | 54 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 34 |
| 32. Feedwater and Main Steam System | 72 | 42 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 25 |
| 41. Main Generator Systems | | 7 |
| 42. Electrical Power Supply Systems | | 46 |
| Total | 72 | 482 |

2023 Operating Experience

US-334

BEAVER VALLEY-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : FENOC (FIRST ENERGY NUCLEAR OPERATING CO.)
 Owner : PPL_SUSQ (PPL Susquehanna, LLC)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 3LP (DRYSUB)
 Thermal power : 2900 MWth
 Gross electrical power : 959 MWe
 Reference unit power (net) : 908 MWe

Key Dates

Construction Date : 1970-06-26
 Grid Date : 1976-06-14
 Commercial Date : 1976-10-01
 Age at end of year : 47 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 43727
 Active core diameter [m] : 3.05
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.06
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.82
 Reactor outlet temperature [°C] : 322
 Number of SG : 3
 Containment type : -
 Containment design pressure [MPa] : 0.38

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.3
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

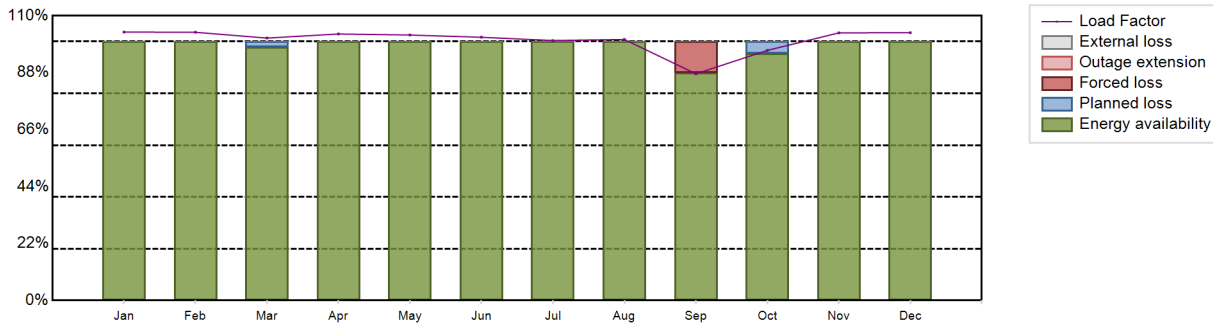
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8006.88 GW(e).h
 Energy Availability Factor (EAF) : 98.44 %
 Unit Capability Factor (UCF) : 98.44 %
 Load Factor (LF) : 100.66 %
 Operating Factor (OF) : 100 %

Forced Loss Rate (FLR) : 1 %
 Unplanned Capability Loss Factor (UCL) : 1 %
 Planned Unavailability Factor (PUF) : 0.56 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

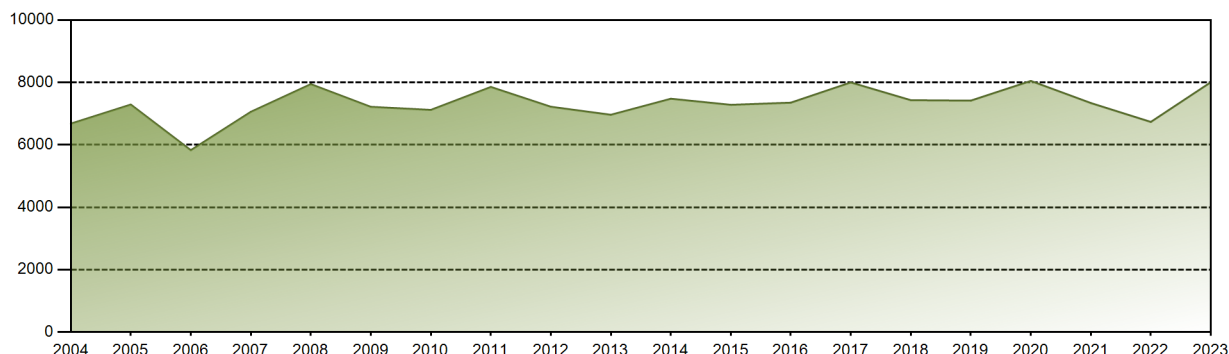


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 700.56 | 632.07 | 683.83 | 672.96 | 692.65 | 664.71 | 678.32 | 681.09 | 572.40 | 652.66 | 676.74 | 698.89 | 8006.88 |
| EAF [%] | 100.00 | 100.00 | 98.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.87 | 95.35 | 100.00 | 100.00 | 98.44 |
| UCF [%] | 100.00 | 100.00 | 98.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.87 | 95.35 | 100.00 | 100.00 | 98.44 |
| LF [%] | 103.70 | 103.59 | 101.36 | 102.94 | 102.53 | 101.67 | 100.41 | 100.82 | 87.56 | 96.61 | 103.37 | 103.45 | 100.66 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.13 | 0.00 | 0.00 | 0.00 | 1.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.13 | 0.00 | 0.00 | 0.00 | 1.00 |
| PUF [%] | 0.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.65 | 0.00 | 0.00 | 0.56 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 270944.12 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 9.18 % |
| Cumulative Energy Availability Factor (EAF) | : 79.4 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.02 % |
| Cumulative Unit Capability Factor (UCF) | : 79.4 % | Cumulative Planned Unavailability Factor (PUF) | : 12.57 % |
| Cumulative Load Factor (LF) | : 77.25 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 79.12 % | | |

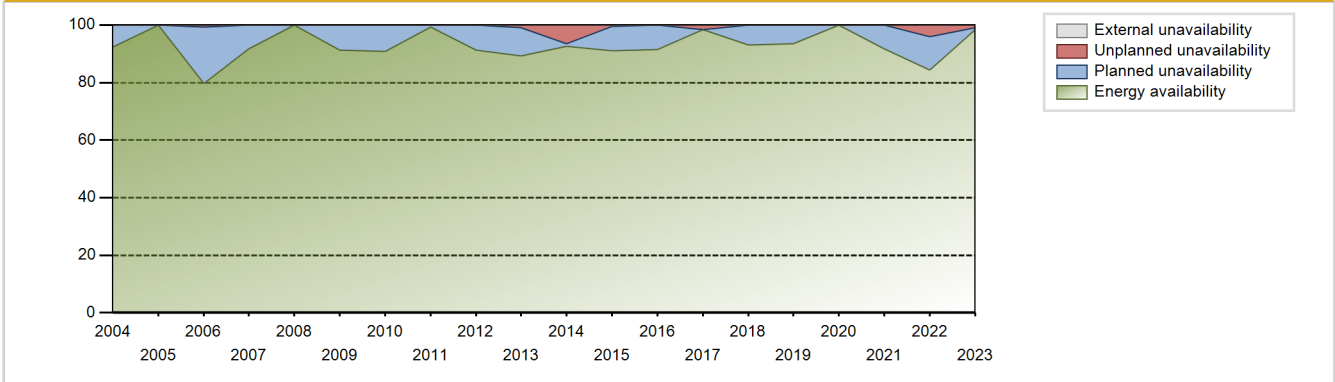
Electricity Production (net) [GWh]



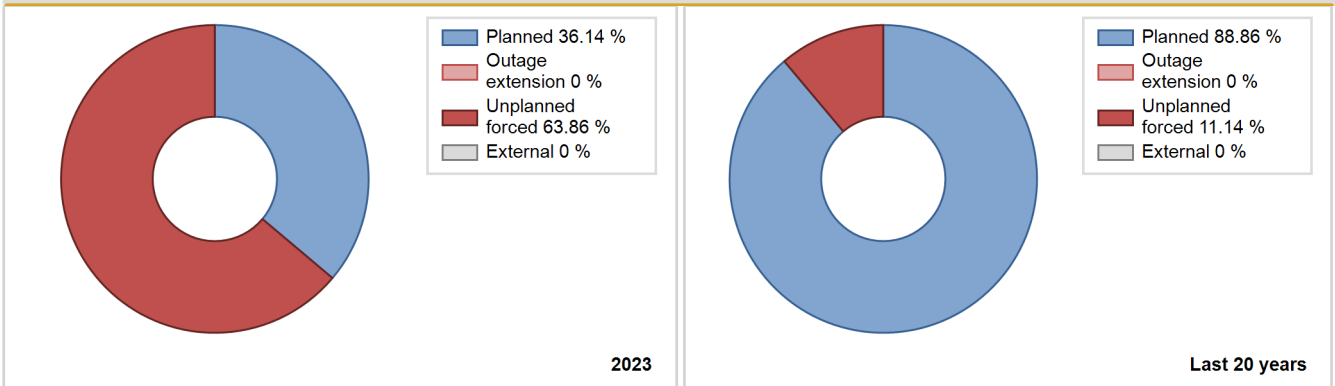
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1976 | 504.50 | 821 | 834 | 100.00 | 100.00 | 16.12 | 37.18 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1977 | 2870.30 | 4312 | 843 | 39.24 | 39.24 | 38.87 | 49.22 | 49.37 | 38.27 | 22.49 | 0.00 |
| 1978 | 2481.40 | 3569 | 800 | 35.43 | 35.43 | 35.41 | 40.74 | 56.65 | 46.30 | 18.27 | 0.00 |
| 1979 | 1778.40 | 3498 | 815 | 24.85 | 24.85 | 24.91 | 39.93 | 72.84 | 66.64 | 8.51 | 0.00 |
| 1980 | 300.70 | 600 | 811 | 6.92 | 6.92 | 4.22 | 6.83 | 38.56 | 4.34 | 88.74 | 0.00 |
| 1981 | 4674.70 | 6444 | 810 | 73.88 | 73.88 | 65.88 | 73.56 | 26.11 | 26.11 | 0.01 | 0.00 |
| 1982 | 2717.40 | 3644 | 810 | 41.73 | 41.73 | 38.30 | 41.60 | 5.02 | 2.21 | 56.06 | 0.00 |
| 1983 | 4682.20 | 5976 | 810 | 68.55 | 68.55 | 65.99 | 68.22 | 3.54 | 2.51 | 28.94 | 0.00 |
| 1984 | 4756.84 | 6301 | 810 | 71.77 | 71.77 | 66.86 | 71.73 | 3.00 | 2.22 | 26.01 | 0.00 |
| 1985 | 5901.46 | 8046 | 810 | 91.92 | 91.92 | 83.17 | 91.85 | 7.12 | 7.05 | 1.03 | 0.00 |
| 1986 | 4784.15 | 6195 | 810 | 70.74 | 70.74 | 67.42 | 70.72 | 4.47 | 3.31 | 25.95 | 0.00 |
| 1987 | 5620.94 | 7320 | 810 | 84.03 | 84.03 | 79.22 | 83.56 | 2.95 | 2.55 | 13.42 | 0.00 |
| 1988 | 4993.62 | 6989 | 810 | 79.59 | 79.59 | 70.18 | 79.57 | 4.41 | 3.67 | 16.73 | 0.00 |
| 1989 | 3794.29 | 5822 | 810 | 66.49 | 66.49 | 53.47 | 66.46 | 9.22 | 6.75 | 26.76 | 0.00 |
| 1990 | 6167.05 | 8074 | 810 | 92.20 | 92.20 | 86.91 | 92.17 | 4.10 | 3.94 | 3.86 | 0.00 |
| 1991 | 3710.88 | 4883 | 810 | 55.76 | 55.76 | 52.30 | 55.74 | 22.93 | 16.59 | 27.65 | 0.00 |
| 1992 | 6298.39 | 8218 | 810 | 93.58 | 93.58 | 88.52 | 93.56 | 6.42 | 6.42 | 0.00 | 0.00 |
| 1993 | 4359.75 | 5891 | 810 | 67.26 | 67.26 | 61.44 | 67.25 | 13.44 | 10.45 | 22.29 | 0.00 |
| 1994 | 5504.38 | 6991 | 810 | 79.87 | 79.87 | 77.57 | 79.81 | 20.13 | 20.13 | 0.00 | 0.00 |
| 1995 | 5449.22 | 6813 | 810 | 77.83 | 77.83 | 76.80 | 77.77 | 5.69 | 4.69 | 17.48 | 0.00 |
| 1996 | 5698.05 | 7132 | 810 | 81.25 | 81.25 | 80.08 | 81.19 | 5.94 | 5.13 | 13.62 | 0.00 |
| 1997 | 4025.78 | 4972 | 810 | 56.77 | 56.77 | 56.74 | 56.76 | 32.90 | 27.83 | 15.40 | 0.00 |
| 1998 | 2829.29 | 3557 | 810 | 40.43 | 40.43 | 39.87 | 40.61 | 59.09 | 58.39 | 1.18 | 0.00 |
| 1999 | 6106.21 | 7746 | 810 | 88.47 | 88.47 | 86.06 | 88.42 | 7.39 | 7.06 | 4.47 | 0.00 |
| 2000 | 5883.02 | 7430 | 810 | 84.60 | 84.60 | 82.68 | 84.59 | 1.64 | 1.41 | 14.00 | 0.00 |
| 2001 | 5991.02 | 7407 | 821 | 84.64 | 84.64 | 84.14 | 84.55 | 2.80 | 2.44 | 12.92 | 0.00 |
| 2002 | 6989.86 | 8490 | 821 | 96.96 | 96.96 | 97.19 | 96.92 | 0.62 | 0.61 | 2.43 | 0.00 |
| 2003 | 5985.36 | 7359 | 821 | 84.13 | 84.13 | 83.22 | 84.01 | 1.14 | 0.97 | 14.90 | 0.00 |
| 2004 | 6678.55 | 8119 | 821 | 92.44 | 92.44 | 92.61 | 92.43 | 0.00 | 0.00 | 7.56 | 0.00 |
| 2005 | 7290.28 | 8760 | 821 | 100.00 | 100.00 | 101.37 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2006 | 5828.55 | 6973 | 851 | 79.63 | 79.63 | 78.18 | 79.59 | 0.96 | 0.78 | 19.59 | 0.00 |
| 2007 | 7057.66 | 8017 | 892 | 91.62 | 91.62 | 90.32 | 91.52 | 0.00 | 0.00 | 8.38 | 0.00 |
| 2008 | 7945.03 | 8784 | 892 | 100.00 | 100.00 | 101.40 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 7217.48 | 7999 | 892 | 91.32 | 91.32 | 92.37 | 91.31 | 0.00 | 0.00 | 8.68 | 0.00 |
| 2010 | 7119.41 | 7963 | 892 | 90.91 | 90.91 | 91.11 | 90.90 | 0.00 | 0.00 | 9.09 | 0.00 |
| 2011 | 7854.57 | 8702 | 892 | 99.34 | 99.34 | 100.52 | 99.34 | 0.00 | 0.00 | 0.66 | 0.00 |
| 2012 | 7220.58 | 8010 | 892 | 91.20 | 91.20 | 92.15 | 91.19 | 0.00 | 0.00 | 8.80 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2013 | 6963.06 | 7825 | 921 | 89.35 | 89.35 | 88.86 | 89.32 | 0.91 | 0.82 | 9.83 | 0.00 |
| 2014 | 7477.39 | 8116 | 921 | 92.65 | 92.65 | 92.68 | 92.65 | 6.56 | 6.51 | 0.84 | 0.00 |
| 2015 | 7282.19 | 7971 | 921 | 91.00 | 91.00 | 90.26 | 90.99 | 0.47 | 0.43 | 8.57 | 0.00 |
| 2016 | 7351.14 | 8031 | 921 | 91.43 | 91.43 | 90.87 | 91.43 | 0.00 | 0.00 | 8.57 | 0.00 |
| 2017 | 7999.17 | 8624 | 921 | 98.44 | 98.44 | 99.15 | 98.45 | 1.56 | 1.56 | 0.00 | 0.00 |
| 2018 | 7430.72 | 8156 | 908 | 93.11 | 93.11 | 93.42 | 93.11 | 0.00 | 0.00 | 6.89 | 0.00 |
| 2019 | 7416.90 | 8193 | 908 | 93.53 | 93.53 | 93.25 | 93.53 | 0.00 | 0.00 | 6.47 | 0.00 |
| 2020 | 8047.73 | 8783 | 908 | 100.00 | 100.00 | 100.90 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 7339.79 | 8028 | 908 | 91.65 | 91.65 | 92.28 | 91.64 | 0.00 | 0.00 | 8.35 | 0.00 |
| 2022 | 6734.41 | 7394 | 908 | 84.41 | 84.41 | 84.67 | 84.41 | 4.66 | 4.12 | 11.47 | 0.00 |
| 2023 | 8006.89 | 8760 | 908 | 98.44 | 98.44 | 100.66 | 100.00 | 1.00 | 1.00 | 0.56 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1976 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 488 | |
| B. Refuelling without maintenance | | | | 50 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 929 | 4 | |
| D. Inspection, maintenance or repair without refuelling | | | | 80 | | |
| E. Testing of plant systems or components | | | | 7 | 14 | |
| H. Nuclear regulatory requirements | | | | | 89 | |
| L. Human factor related | | | | | 10 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| Z. Other | | | | 15 | 131 | |
| Subtotal | | | | 1081 | 736 | 2 |
| Total | | 0 | | | 1819 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1976 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 42 |
| 12. Reactor I&C Systems | | 6 |
| 13. Reactor Auxiliary Systems | | 23 |
| 14. Safety Systems | | 29 |
| 15. Reactor Cooling Systems | | 262 |
| 16. Steam generation systems | | 2 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 4 |
| 31. Turbine and auxiliaries | | 17 |
| 32. Feedwater and Main Steam System | | 104 |
| 34. Miscellaneous Systems | | 41 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 15 |
| 42. Electrical Power Supply Systems | | 120 |
| Total | | 666 |

2023 Operating Experience

US-412

BEAVER VALLEY-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : FENOC (FIRST ENERGY NUCLEAR OPERATING CO.)
 Owner : OHIO ED (OHIO EDISON CO.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 3LP (DRYSUB)
 Thermal power : 2900 MWth
 Gross electrical power : 958 MWe
 Reference unit power (net) : 905 MWe

Key Dates

Construction Date : 1974-05-03
 Grid Date : 1987-08-17
 Commercial Date : 1987-11-17
 Age at end of year : 36 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 36351
 Active core diameter [m] : 3.05
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.06
 Number of control rod assemblies : 48
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 322
 Number of SG : 3
 Containment type : -
 Containment design pressure [MPa] : 0.38

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.3
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

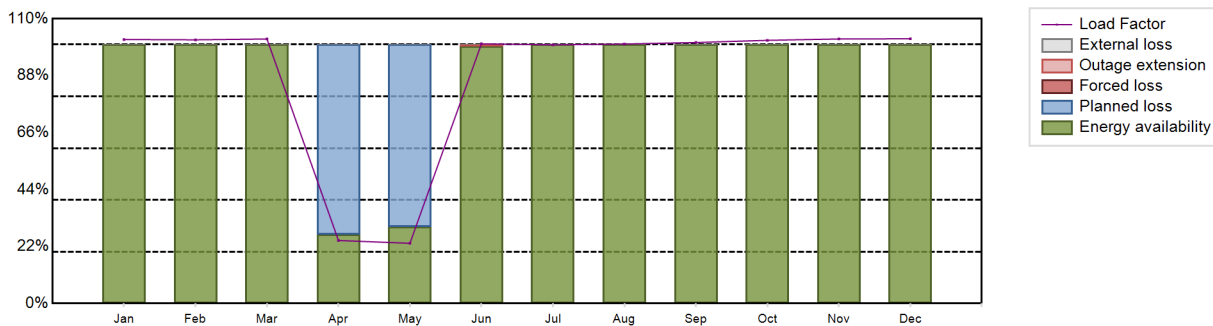
: none

Annual Production Results (2023)

Net Energy Production : 7005.57 GW(e).h
 Energy Availability Factor (EAF) : 87.94 %
 Unit Capability Factor (UCF) : 87.94 %
 Load Factor (LF) : 88.37 %
 Operating Factor (OF) : 87.99 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0.05 %
 Planned Unavailability Factor (PUF) : 12.01 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1052 hours

Annual Summary

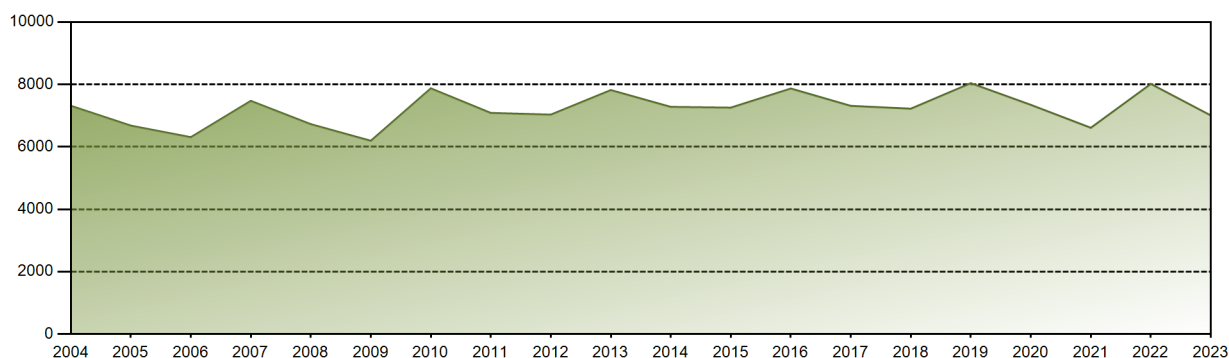


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 686.49 | 619.38 | 686.95 | 158.72 | 156.64 | 653.54 | 672.63 | 674.86 | 656.79 | 684.42 | 666.60 | 688.55 | 7005.57 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 26.67 | 29.57 | 99.33 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.94 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 26.67 | 29.57 | 99.33 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.94 |
| LF [%] | 101.96 | 101.84 | 102.16 | 24.36 | 23.26 | 100.30 | 99.90 | 100.23 | 100.80 | 101.65 | 102.16 | 102.26 | 88.37 |
| OF [%] | 100.00 | 100.00 | 100.00 | 26.67 | 29.57 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.99 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 73.33 | 70.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

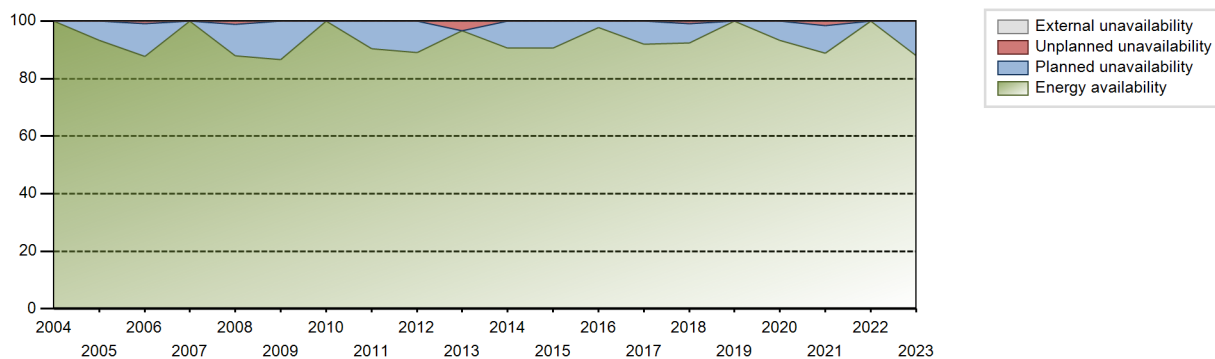
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 236911.68 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.05 % |
| Cumulative Energy Availability Factor (EAF) | : 89.07 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.76 % |
| Cumulative Unit Capability Factor (UCF) | : 89.07 % | Cumulative Planned Unavailability Factor (PUF) | : 7.16 % |
| Cumulative Load Factor (LF) | : 87.18 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 88.57 % | | |

Electricity Production (net) [GWh]

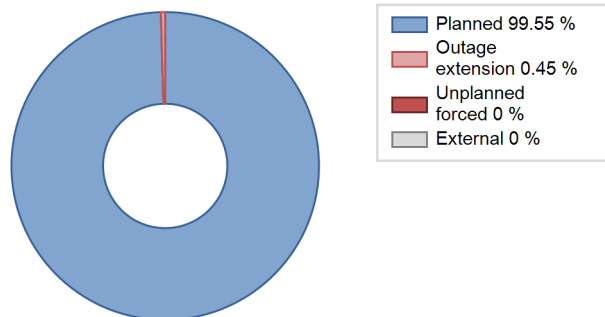


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 738.10 | 950 | 822 | 100.00 | 100.00 | 93.42 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1988 | 6477.06 | 8224 | 833 | 93.78 | 93.78 | 88.52 | 93.62 | 2.42 | 2.33 | 3.89 | 0.00 |
| 1989 | 4557.14 | 6245 | 833 | 71.68 | 71.68 | 62.45 | 71.29 | 11.01 | 8.87 | 19.45 | 0.00 |
| 1990 | 4291.55 | 6734 | 827 | 77.09 | 77.09 | 59.20 | 76.87 | 1.66 | 1.30 | 21.60 | 0.00 |
| 1991 | 6762.16 | 8720 | 820 | 99.54 | 99.54 | 94.14 | 99.54 | 0.46 | 0.46 | 0.00 | 0.00 |
| 1992 | 5647.13 | 7342 | 820 | 94.83 | 94.83 | 78.40 | 83.58 | 0.18 | 0.17 | 5.00 | 0.00 |
| 1993 | 5212.68 | 6770 | 820 | 77.29 | 77.29 | 72.57 | 77.28 | 1.57 | 1.23 | 21.47 | 0.00 |
| 1994 | 7024.73 | 8481 | 820 | 96.83 | 96.83 | 97.79 | 96.82 | 3.17 | 3.17 | 0.00 | 0.00 |
| 1995 | 6047.02 | 7616 | 820 | 86.97 | 86.97 | 84.18 | 86.94 | 0.50 | 0.43 | 12.59 | 0.00 |
| 1996 | 4788.59 | 6169 | 820 | 70.30 | 70.30 | 66.48 | 70.23 | 18.40 | 15.85 | 13.85 | 0.00 |
| 1997 | 6158.70 | 7583 | 820 | 86.62 | 86.62 | 85.74 | 86.56 | 13.38 | 13.38 | 0.00 | 0.00 |
| 1998 | 1808.72 | 2179 | 820 | 25.12 | 25.12 | 25.18 | 24.87 | 74.87 | 74.86 | 0.02 | 0.00 |
| 1999 | 5752.52 | 7155 | 820 | 81.70 | 81.70 | 80.08 | 81.68 | 8.23 | 7.33 | 10.97 | 0.00 |
| 2000 | 6227.85 | 7804 | 820 | 88.86 | 88.86 | 86.46 | 88.84 | 2.45 | 2.23 | 8.91 | 0.00 |
| 2001 | 7191.65 | 8702 | 831 | 99.35 | 99.35 | 99.78 | 99.34 | 0.65 | 0.65 | 0.00 | 0.00 |
| 2002 | 6604.31 | 8133 | 831 | 92.95 | 92.95 | 90.72 | 92.84 | 0.22 | 0.20 | 6.85 | 0.00 |
| 2003 | 6636.99 | 8037 | 831 | 91.76 | 91.76 | 91.17 | 91.75 | 0.34 | 0.32 | 7.92 | 0.00 |
| 2004 | 7314.83 | 8784 | 831 | 100.00 | 100.00 | 100.21 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 6680.03 | 8169 | 831 | 93.26 | 93.26 | 91.76 | 93.25 | 0.00 | 0.00 | 6.74 | 0.00 |
| 2006 | 6309.51 | 7673 | 851 | 87.61 | 87.61 | 84.64 | 87.59 | 1.10 | 0.98 | 11.42 | 0.00 |
| 2007 | 7473.20 | 8760 | 846 | 100.00 | 100.00 | 100.84 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 6726.20 | 7744 | 890 | 87.93 | 87.93 | 87.84 | 88.16 | 1.34 | 1.20 | 10.88 | 0.00 |
| 2009 | 6193.96 | 7651 | 846 | 86.69 | 86.69 | 83.58 | 87.34 | 0.00 | 0.00 | 13.31 | 0.00 |
| 2010 | 7874.15 | 8760 | 885 | 100.00 | 100.00 | 101.57 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 7085.78 | 7920 | 885 | 90.42 | 90.42 | 91.40 | 90.41 | 0.00 | 0.00 | 9.58 | 0.00 |
| 2012 | 7032.52 | 7828 | 885 | 89.13 | 89.13 | 90.46 | 89.12 | 0.00 | 0.00 | 10.87 | 0.00 |
| 2013 | 7818.59 | 8458 | 885 | 96.55 | 96.55 | 100.84 | 96.54 | 3.45 | 3.45 | 0.00 | 0.00 |
| 2014 | 7279.91 | 7929 | 904 | 90.71 | 90.71 | 91.93 | 90.51 | 0.00 | 0.00 | 9.29 | 0.00 |
| 2015 | 7255.59 | 7931 | 904 | 90.53 | 90.53 | 91.62 | 90.54 | 0.00 | 0.00 | 9.47 | 0.00 |
| 2016 | 7868.44 | 8579 | 904 | 97.67 | 97.67 | 99.09 | 97.67 | 0.00 | 0.00 | 2.33 | 0.00 |
| 2017 | 7312.33 | 8058 | 905 | 91.99 | 91.99 | 92.24 | 91.99 | 0.00 | 0.00 | 8.01 | 0.00 |
| 2018 | 7222.74 | 8085 | 905 | 92.29 | 92.29 | 91.11 | 92.29 | 1.08 | 1.01 | 6.70 | 0.00 |
| 2019 | 8039.57 | 8760 | 905 | 100.00 | 100.00 | 101.41 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 7345.66 | 8190 | 905 | 93.25 | 93.25 | 92.40 | 93.24 | 0.00 | 0.00 | 6.75 | 0.00 |
| 2021 | 6610.08 | 7784 | 905 | 88.85 | 88.85 | 83.38 | 88.86 | 1.81 | 1.64 | 9.51 | 0.00 |
| 2022 | 8015.62 | 8760 | 905 | 100.00 | 100.00 | 101.11 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 7005.57 | 7708 | 905 | 87.94 | 87.94 | 88.37 | 87.99 | 0.00 | 0.05 | 12.01 | 0.00 |

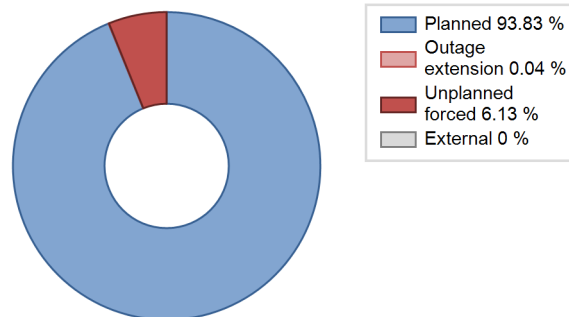
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 284 | |
| B. Refuelling without maintenance | | | | 40 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1011 | | | 574 | 2 | |
| D. Inspection, maintenance or repair without refuelling | | | | 17 | | |
| E. Testing of plant systems or components | | | | 1 | 12 | |
| L. Human factor related | | | | | 4 | |
| Z. Other | | | | | 43 | |
| Subtotal | 1011 | | | 632 | 345 | |
| Total | | 1011 | | | 977 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 12 |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 27 |
| 14. Safety Systems | | 11 |
| 15. Reactor Cooling Systems | | 154 |
| 16. Steam generation systems | | 16 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 5 |
| 31. Turbine and auxiliaries | | 14 |
| 32. Feedwater and Main Steam System | | 6 |
| 34. Miscellaneous Systems | | 18 |
| 35. All other I&C Systems | | 3 |
| 41. Main Generator Systems | | 13 |
| 42. Electrical Power Supply Systems | | 20 |
| Total | | 306 |

2023 Operating Experience

US-456 BRAIDWOOD-1 UNITED STATES OF AMERICA

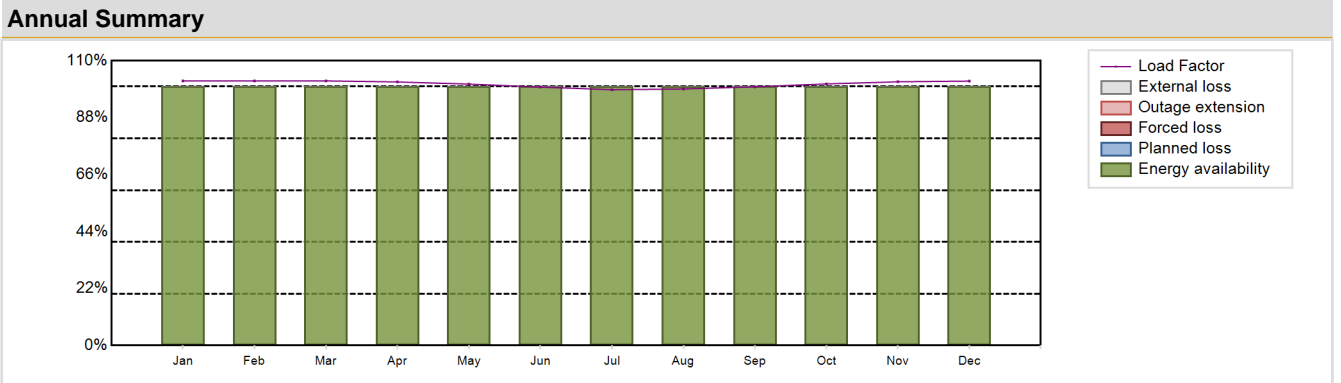
Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 4LP (DRYAMB) | Construction Date | : 1975-08-01 |
| Thermal power | : 3645 MWth | Grid Date | : 1987-07-12 |
| Gross electrical power | : 1270 MWe | Commercial Date | : 1988-07-29 |
| Reference unit power (net) | : 1194 MWe | Age at end of year | : 36 years |

| Design Characteristics | | | |
|---|------------|--|-------------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 326 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.42 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 43 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 49000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.37 | HP cylinder inlet steam pressure [MPa] | : 6.63 |
| Active core height/length [m] | : 3.65 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 193 | Primary means of condenser cooling | : Cooling Pond (closed-cycle) |
| Fuel linear heat generation rate [kW/m] | : 18.3 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 25 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|-----------|
| Net Energy Production | : 10562.93 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 100 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 100 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 100.99 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

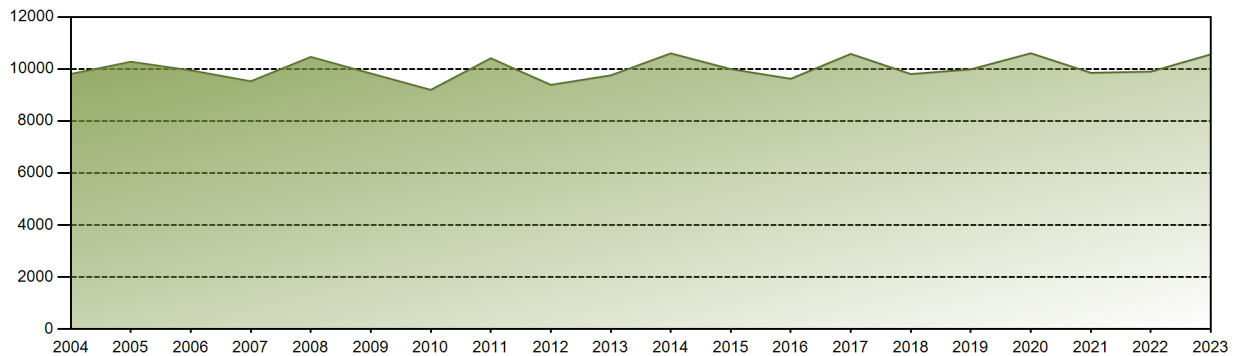


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 907.79 | 819.96 | 906.66 | 875.10 | 897.00 | 857.97 | 877.73 | 880.20 | 859.00 | 897.51 | 876.83 | 907.17 | 10562.93 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| LF [%] | 102.19 | 102.19 | 102.20 | 101.79 | 100.98 | 99.80 | 98.81 | 99.08 | 99.92 | 101.03 | 101.85 | 102.12 | 100.99 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

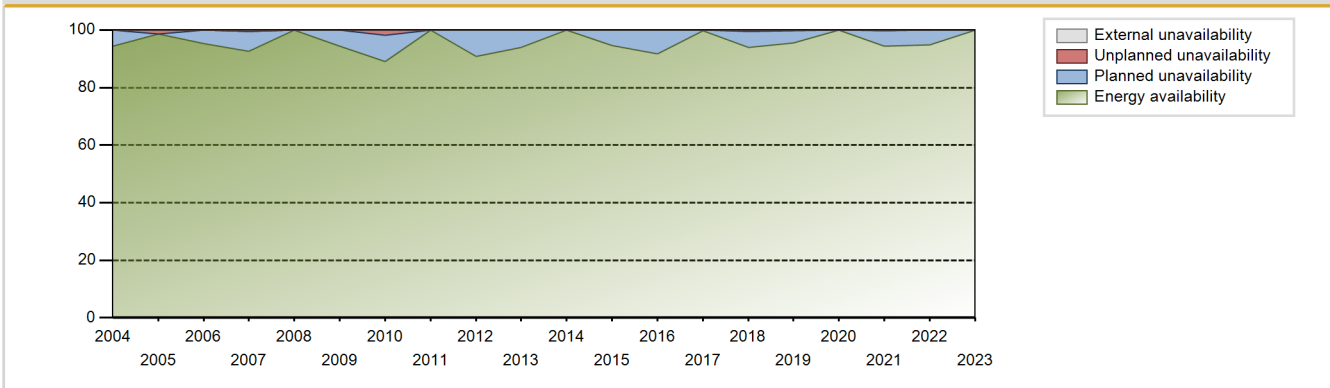
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 323286.56 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.36 % |
| Cumulative Energy Availability Factor (EAF) | : 90.97 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.2 % |
| Cumulative Unit Capability Factor (UCF) | : 90.98 % | Cumulative Planned Unavailability Factor (PUF) | : 6.82 % |
| Cumulative Load Factor (LF) | : 90.07 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 90.7 % | | |

Electricity Production (net) [GWh]

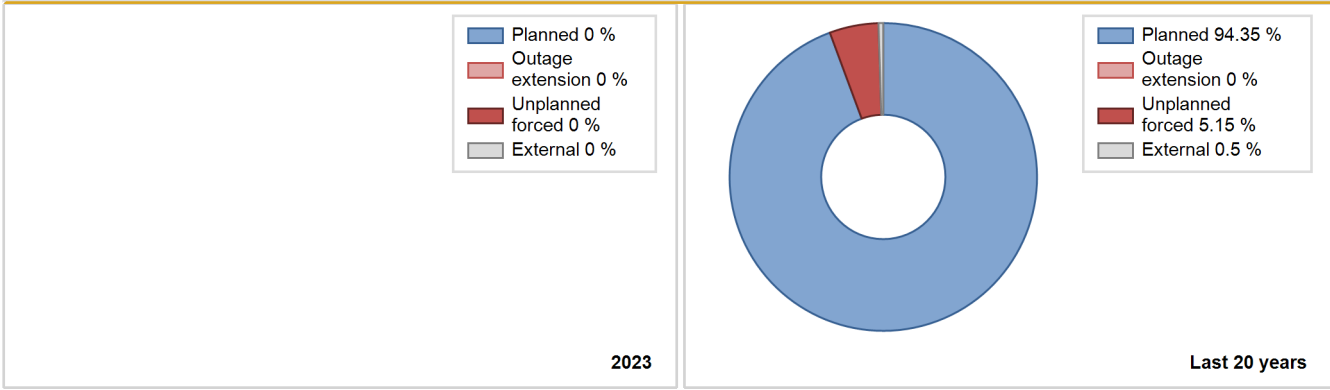


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 3424.22 | 3409 | 1105 | 91.55 | 91.55 | 81.78 | 91.29 | 8.45 | 8.45 | 0.00 | 0.00 |
| 1989 | 4649.10 | 5435 | 1120 | 62.25 | 62.25 | 47.39 | 62.04 | 2.74 | 1.76 | 35.99 | 0.00 |
| 1990 | 8264.58 | 7778 | 1120 | 89.11 | 89.11 | 84.24 | 88.79 | 10.89 | 10.89 | 0.00 | 0.00 |
| 1991 | 5018.62 | 5198 | 1120 | 59.37 | 59.37 | 51.15 | 59.34 | 40.63 | 40.63 | 0.00 | 0.00 |
| 1992 | 7157.93 | 7142 | 1120 | 81.36 | 81.36 | 72.76 | 81.31 | 1.13 | 0.93 | 17.71 | 0.00 |
| 1993 | 8693.12 | 8048 | 1120 | 92.10 | 92.10 | 88.60 | 91.87 | 7.48 | 7.44 | 0.46 | 0.00 |
| 1994 | 7398.15 | 6940 | 1120 | 79.81 | 79.81 | 75.41 | 79.22 | 1.70 | 1.38 | 18.81 | 0.00 |
| 1995 | 6614.28 | 6214 | 1120 | 71.75 | 71.75 | 67.42 | 70.94 | 2.77 | 2.04 | 26.21 | 0.00 |
| 1996 | 7618.88 | 7021 | 1120 | 80.50 | 80.50 | 77.44 | 79.93 | 6.43 | 5.53 | 13.97 | 0.00 |
| 1997 | 8096.33 | 7339 | 1120 | 84.03 | 84.03 | 82.52 | 83.78 | 0.00 | 0.00 | 15.97 | 0.00 |
| 1998 | 7578.79 | 6976 | 1118 | 79.93 | 79.93 | 77.36 | 79.63 | 1.20 | 0.97 | 19.10 | 0.00 |
| 1999 | 9904.81 | 8680 | 1120 | 99.11 | 99.11 | 100.95 | 99.09 | 0.89 | 0.89 | 0.00 | 0.00 |
| 2000 | 9311.32 | 8335 | 1100 | 94.95 | 94.95 | 96.08 | 94.89 | 0.00 | 0.00 | 5.05 | 0.00 |
| 2001 | 9557.87 | 8247 | 1168 | 94.05 | 94.05 | 97.70 | 94.14 | 0.00 | 0.00 | 5.95 | 0.00 |
| 2002 | 10612.24 | 8760 | 1161 | 100.00 | 100.00 | 104.08 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 10094.77 | 8353 | 1161 | 95.26 | 95.26 | 99.26 | 95.35 | 0.00 | 0.00 | 4.74 | 0.00 |
| 2004 | 9807.19 | 8310 | 1161 | 94.49 | 94.49 | 96.17 | 94.60 | 0.00 | 0.00 | 5.51 | 0.00 |
| 2005 | 10276.96 | 8630 | 1185 | 98.53 | 98.53 | 98.99 | 98.50 | 1.47 | 1.47 | 0.00 | 0.00 |
| 2006 | 9945.95 | 8352 | 1178 | 95.35 | 95.35 | 96.38 | 95.34 | 0.00 | 0.00 | 4.65 | 0.00 |
| 2007 | 9526.68 | 8119 | 1178 | 92.70 | 93.13 | 92.32 | 92.68 | 0.00 | 0.00 | 6.87 | 0.43 |
| 2008 | 10462.94 | 8784 | 1178 | 100.00 | 100.00 | 101.12 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 9826.25 | 8259 | 1178 | 94.29 | 94.29 | 95.22 | 94.28 | 0.00 | 0.00 | 5.71 | 0.00 |
| 2010 | 9196.69 | 7806 | 1178 | 89.13 | 89.13 | 89.12 | 89.11 | 1.99 | 1.81 | 9.06 | 0.00 |
| 2011 | 10411.70 | 8760 | 1178 | 100.00 | 100.00 | 100.90 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 9388.44 | 7969 | 1178 | 90.73 | 90.73 | 90.73 | 90.72 | 0.00 | 0.00 | 9.27 | 0.00 |
| 2013 | 9754.57 | 8238 | 1178 | 94.04 | 94.04 | 94.52 | 94.03 | 0.00 | 0.00 | 5.96 | 0.00 |
| 2014 | 10599.62 | 8760 | 1194 | 100.00 | 100.00 | 101.34 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 9994.36 | 8298 | 1194 | 94.72 | 94.72 | 95.55 | 94.73 | 0.00 | 0.00 | 5.28 | 0.00 |
| 2016 | 9622.74 | 8058 | 1194 | 91.73 | 91.73 | 91.75 | 91.73 | 0.00 | 0.00 | 8.27 | 0.00 |
| 2017 | 10579.19 | 8737 | 1194 | 99.73 | 99.73 | 101.14 | 99.74 | 0.00 | 0.00 | 0.27 | 0.00 |
| 2018 | 9803.97 | 8208 | 1194 | 93.84 | 93.84 | 93.73 | 93.70 | 0.58 | 0.54 | 5.61 | 0.00 |
| 2019 | 9986.33 | 8360 | 1194 | 95.45 | 95.45 | 95.48 | 95.43 | 0.27 | 0.26 | 4.29 | 0.00 |
| 2020 | 10604.45 | 8783 | 1194 | 100.00 | 100.00 | 101.11 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 9853.70 | 8264 | 1194 | 94.33 | 94.33 | 94.21 | 94.34 | 0.37 | 0.35 | 5.31 | 0.00 |
| 2022 | 9898.29 | 8308 | 1194 | 94.84 | 94.84 | 94.63 | 94.84 | 0.00 | 0.00 | 5.16 | 0.00 |
| 2023 | 10562.93 | 8760 | 1194 | 100.00 | 100.00 | 100.99 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 178 | |
| B. Refuelling without maintenance | | | | 26 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 511 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 74 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 13 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 5 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | 0 | 3 | |
| Subtotal | | | | 612 | 199 | 3 |
| Total | | 0 | | | 814 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 3 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 3 |
| 15. Reactor Cooling Systems | | 5 |
| 16. Steam generation systems | | 14 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 20 |
| 31. Turbine and auxiliaries | | 1 |
| 32. Feedwater and Main Steam System | | 19 |
| 34. Miscellaneous Systems | | 12 |
| 41. Main Generator Systems | | 93 |
| 42. Electrical Power Supply Systems | | 7 |
| Total | | 179 |

2023 Operating Experience

US-457

BRAIDWOOD-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3645 MWth
 Gross electrical power : 1230 MWe
 Reference unit power (net) : 1160 MWe

Key Dates

Construction Date : 1975-08-01
 Grid Date : 1988-05-25
 Commercial Date : 1988-10-17
 Age at end of year : 35 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 43
 Average discharge burnup [MWd/t] : 49000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.65
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 20.8
 Number of control rod assemblies : 25
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 326
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.42

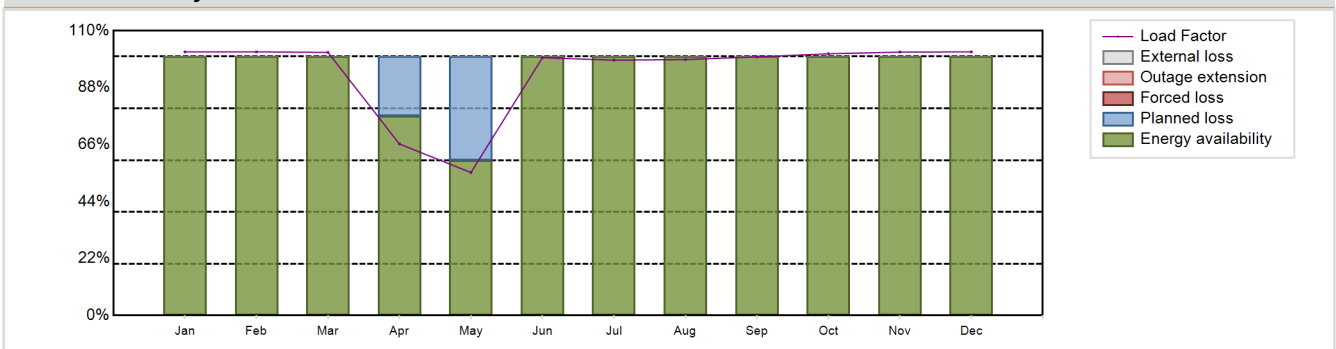
Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.63
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Pond (closed-cycle)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9550.66 GW(e).h
 Energy Availability Factor (EAF) : 94.71 %
 Unit Capability Factor (UCF) : 94.71 %
 Load Factor (LF) : 93.99 %
 Operating Factor (OF) : 94.63 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 5.29 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 470 hours

Annual Summary

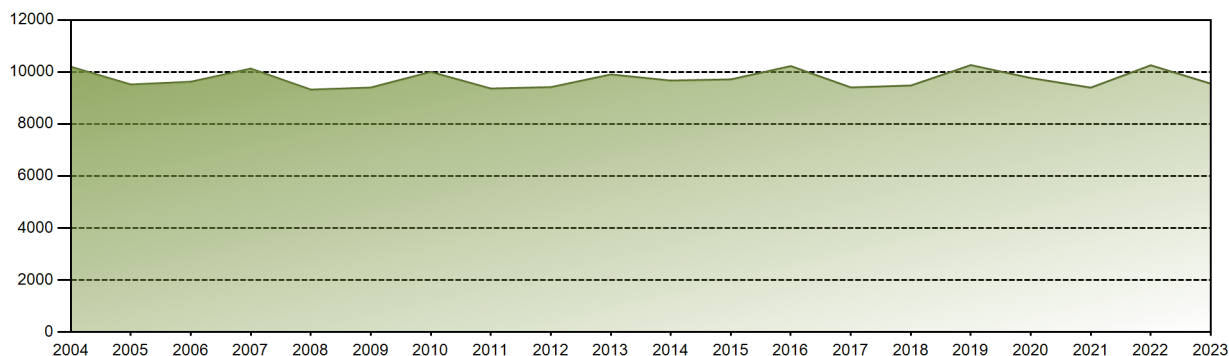


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 878.68 | 793.86 | 875.87 | 553.23 | 476.63 | 831.66 | 851.15 | 853.14 | 834.36 | 872.35 | 850.95 | 878.78 | 9550.66 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 77.13 | 59.83 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.71 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 77.13 | 59.83 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.71 |
| LF [%] | 101.81 | 101.84 | 101.62 | 66.24 | 55.23 | 99.58 | 98.62 | 98.85 | 99.90 | 101.08 | 101.74 | 101.82 | 93.99 |
| OF [%] | 100.00 | 100.00 | 100.00 | 76.81 | 59.27 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.63 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 22.87 | 40.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.29 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

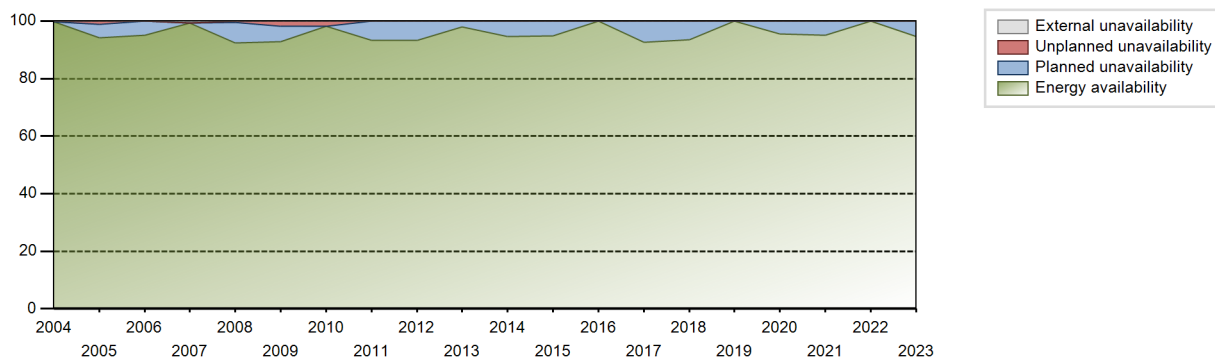
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 321766.66 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.26 % |
| Cumulative Energy Availability Factor (EAF) | : 92.78 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.18 % |
| Cumulative Unit Capability Factor (UCF) | : 92.8 % | Cumulative Planned Unavailability Factor (PUF) | : 6.01 % |
| Cumulative Load Factor (LF) | : 91.41 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 92.64 % | | |

Electricity Production (net) [GWh]

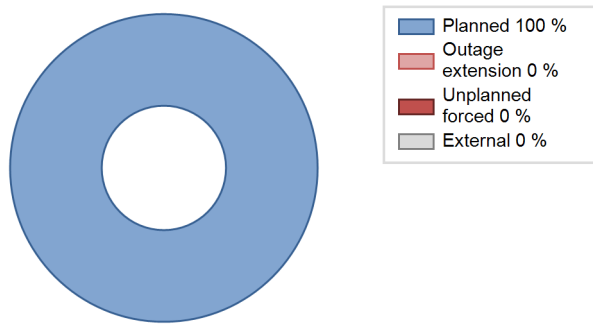


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 1350.94 | 1476 | 1097 | 87.43 | 87.43 | 72.73 | 87.30 | 12.57 | 12.57 | 0.00 | 0.00 |
| 1989 | 7142.04 | 7581 | 1120 | 86.89 | 86.89 | 72.79 | 86.54 | 1.71 | 1.51 | 11.60 | 0.00 |
| 1990 | 6353.59 | 6849 | 1120 | 78.79 | 78.79 | 64.76 | 78.18 | 2.04 | 1.64 | 19.56 | 0.00 |
| 1991 | 6545.52 | 6626 | 1120 | 75.72 | 75.72 | 66.71 | 75.64 | 4.73 | 3.76 | 20.51 | 0.00 |
| 1992 | 8751.14 | 8346 | 1120 | 95.06 | 95.06 | 88.95 | 95.01 | 2.20 | 2.14 | 2.80 | 0.00 |
| 1993 | 7362.34 | 7098 | 1120 | 81.46 | 81.46 | 75.04 | 81.03 | 3.37 | 2.84 | 15.70 | 0.00 |
| 1994 | 6636.15 | 6454 | 1120 | 74.13 | 74.13 | 67.64 | 73.68 | 16.56 | 14.71 | 11.16 | 0.00 |
| 1995 | 9533.04 | 8583 | 1120 | 98.06 | 98.06 | 97.16 | 97.98 | 1.94 | 1.94 | 0.00 | 0.00 |
| 1996 | 8011.80 | 7349 | 1120 | 84.12 | 84.12 | 81.44 | 83.66 | 0.00 | 0.00 | 15.88 | 0.00 |
| 1997 | 8234.75 | 7563 | 1120 | 86.46 | 86.46 | 83.93 | 86.34 | 0.00 | 0.00 | 13.54 | 0.00 |
| 1998 | 9694.64 | 8552 | 1118 | 97.71 | 97.71 | 98.96 | 97.63 | 2.29 | 2.29 | 0.00 | 0.00 |
| 1999 | 9030.88 | 8070 | 1120 | 92.35 | 92.35 | 92.05 | 92.12 | 0.91 | 0.84 | 6.81 | 0.00 |
| 2000 | 9510.95 | 8303 | 1100 | 94.60 | 94.60 | 98.14 | 94.52 | 1.23 | 1.18 | 4.23 | 0.00 |
| 2001 | 9647.86 | 8481 | 1122 | 96.74 | 96.74 | 98.96 | 96.82 | 0.49 | 0.48 | 2.78 | 0.00 |
| 2002 | 9449.48 | 8099 | 1154 | 92.48 | 92.48 | 94.28 | 92.45 | 0.54 | 0.50 | 7.02 | 0.00 |
| 2003 | 9932.17 | 8337 | 1154 | 95.08 | 95.08 | 98.25 | 95.17 | 0.61 | 0.58 | 4.34 | 0.00 |
| 2004 | 10200.98 | 8757 | 1129 | 99.68 | 99.68 | 102.67 | 99.69 | 0.32 | 0.32 | 0.00 | 0.00 |
| 2005 | 9519.42 | 8244 | 1177 | 94.11 | 94.11 | 92.32 | 94.10 | 1.27 | 1.21 | 4.68 | 0.00 |
| 2006 | 9624.59 | 8335 | 1152 | 95.16 | 95.16 | 95.37 | 95.15 | 0.00 | 0.00 | 4.84 | 0.00 |
| 2007 | 10131.17 | 8706 | 1152 | 99.39 | 100.00 | 100.39 | 99.38 | 0.00 | 0.00 | 0.00 | 0.61 |
| 2008 | 9323.22 | 8106 | 1152 | 92.29 | 92.29 | 92.13 | 92.28 | 0.57 | 0.53 | 7.18 | 0.00 |
| 2009 | 9401.72 | 8121 | 1152 | 92.74 | 92.74 | 93.16 | 92.71 | 1.91 | 1.80 | 5.46 | 0.00 |
| 2010 | 10003.25 | 8599 | 1152 | 98.17 | 98.17 | 99.13 | 98.16 | 1.83 | 1.83 | 0.00 | 0.00 |
| 2011 | 9364.17 | 8177 | 1152 | 93.36 | 93.36 | 92.79 | 93.34 | 0.00 | 0.00 | 6.64 | 0.00 |
| 2012 | 9417.92 | 8188 | 1152 | 93.23 | 93.23 | 93.07 | 93.21 | 0.00 | 0.00 | 6.77 | 0.00 |
| 2013 | 9905.03 | 8580 | 1152 | 97.95 | 97.95 | 98.14 | 97.93 | 0.00 | 0.00 | 2.05 | 0.00 |
| 2014 | 9670.45 | 8276 | 1160 | 94.52 | 94.52 | 95.17 | 94.47 | 0.06 | 0.06 | 5.43 | 0.00 |
| 2015 | 9715.53 | 8312 | 1160 | 94.88 | 94.88 | 95.61 | 94.89 | 0.00 | 0.00 | 5.12 | 0.00 |
| 2016 | 10226.53 | 8784 | 1160 | 100.00 | 100.00 | 100.36 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 9406.23 | 8117 | 1160 | 92.67 | 92.67 | 92.57 | 92.66 | 0.00 | 0.00 | 7.33 | 0.00 |
| 2018 | 9479.35 | 8175 | 1160 | 93.42 | 93.42 | 93.29 | 93.32 | 0.00 | 0.00 | 6.58 | 0.00 |
| 2019 | 10264.82 | 8760 | 1160 | 100.00 | 100.00 | 101.02 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 9767.22 | 8394 | 1160 | 95.57 | 95.57 | 95.86 | 95.56 | 0.00 | 0.00 | 4.43 | 0.00 |
| 2021 | 9398.28 | 8319 | 1160 | 94.96 | 94.96 | 92.49 | 94.97 | 0.00 | 0.00 | 5.04 | 0.00 |
| 2022 | 10257.34 | 8760 | 1160 | 100.00 | 100.00 | 100.94 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 9550.66 | 8290 | 1160 | 94.71 | 94.71 | 93.99 | 94.63 | 0.00 | 0.00 | 5.29 | 0.00 |

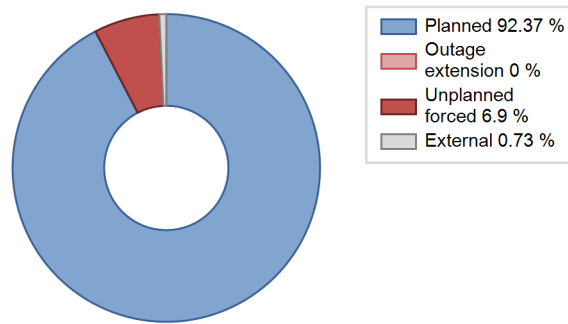
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 94 | |
| B. Refuelling without maintenance | | | | 24 | | |
| C. Inspection, maintenance or repair combined with refuelling | 470 | | | 461 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 51 | | |
| L. Human factor related | | | | | 8 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 3 |
| Z. Other | | | | | 8 | |
| Subtotal | 470 | | | 536 | 110 | 3 |
| Total | | 470 | | | 649 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 5 |
| 12. Reactor I&C Systems | | 9 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 6 |
| 15. Reactor Cooling Systems | | 6 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 8 |
| 32. Feedwater and Main Steam System | | 10 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 3 |
| 41. Main Generator Systems | | 12 |
| 42. Electrical Power Supply Systems | | 37 |
| Total | | 99 |

2023 Operating Experience

US-259 BROWNS FERRY-1 UNITED STATES OF AMERICA

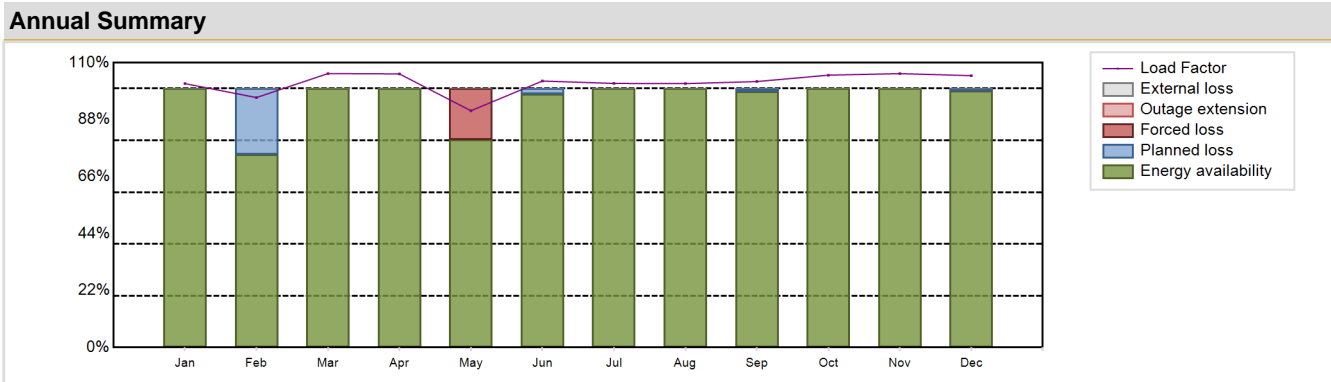
Status at end of year : **Operational**
 Operator : TVA (Tennessee Valley Authority)
 Owner : TVA (Tennessee Valley Authority)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 1) | Construction Date | : 1967-05-01 |
| Thermal power | : 3458 MWth | Grid Date | : 1973-10-15 |
| Gross electrical power | : 1256 MWe | Commercial Date | : 1974-12-20 |
| Reference unit power (net) | : 1200 MWe | Age at end of year | : 50 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.2 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 285 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.39 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 28 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 38000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.8 | HP cylinder inlet steam pressure [MPa] | : 6.8 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 154 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.25 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|-------------|
| Net Energy Production | : 10750.38 GW(e).h | Forced Loss Rate (FLR) | : 1.72 % |
| Energy Availability Factor (EAF) | : 96 % | Unplanned Capability Loss Factor (UCL) | : 1.68 % |
| Unit Capability Factor (UCF) | : 96 % | Planned Unavailability Factor (PUF) | : 2.32 % |
| Load Factor (LF) | : 102.27 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 98.48 % | Total off-line time | : 133 hours |

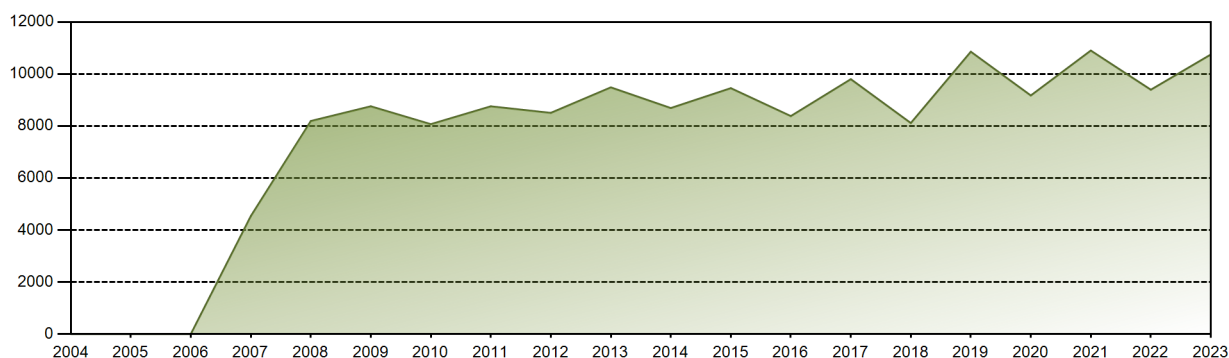


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 909.96 | 778.43 | 943.40 | 912.97 | 816.52 | 889.26 | 910.58 | 909.87 | 887.56 | 939.13 | 915.18 | 937.51 | 10750.38 |
| EAF [%] | 100.00 | 74.43 | 100.00 | 100.00 | 80.20 | 97.78 | 100.00 | 100.00 | 98.91 | 100.00 | 100.00 | 99.01 | 96.00 |
| UCF [%] | 100.00 | 74.43 | 100.00 | 100.00 | 80.20 | 97.78 | 100.00 | 100.00 | 98.91 | 100.00 | 100.00 | 99.01 | 96.00 |
| LF [%] | 101.92 | 96.53 | 105.81 | 105.67 | 91.46 | 102.92 | 101.99 | 101.91 | 102.73 | 105.19 | 105.78 | 105.01 | 102.27 |
| OF [%] | 96.64 | 94.64 | 100.00 | 100.00 | 90.32 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.48 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 19.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.72 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 19.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.68 |
| PUF [%] | 0.00 | 25.57 | 0.00 | 0.00 | 0.00 | 2.22 | 0.00 | 0.00 | 1.09 | 0.00 | 0.00 | 0.99 | 2.32 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 205603.18 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 9.93 % |
| Cumulative Energy Availability Factor (EAF) | : 79.33 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.77 % |
| Cumulative Unit Capability Factor (UCF) | : 79.57 % | Cumulative Planned Unavailability Factor (PUF) | : 11.66 % |
| Cumulative Load Factor (LF) | : 78.32 % | Cumulative Externally cause unavailability (XUF) | : 0.24 % |
| Cumulative Operating Factor (OF) | : 80.9 % | | |

Electricity Production (net) [GWh]

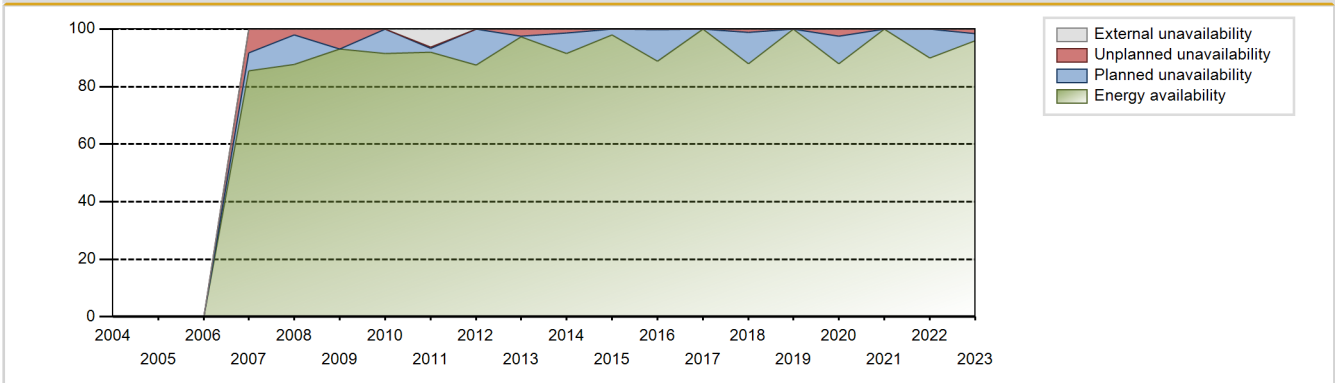


Performance for Years of Commercial Operation

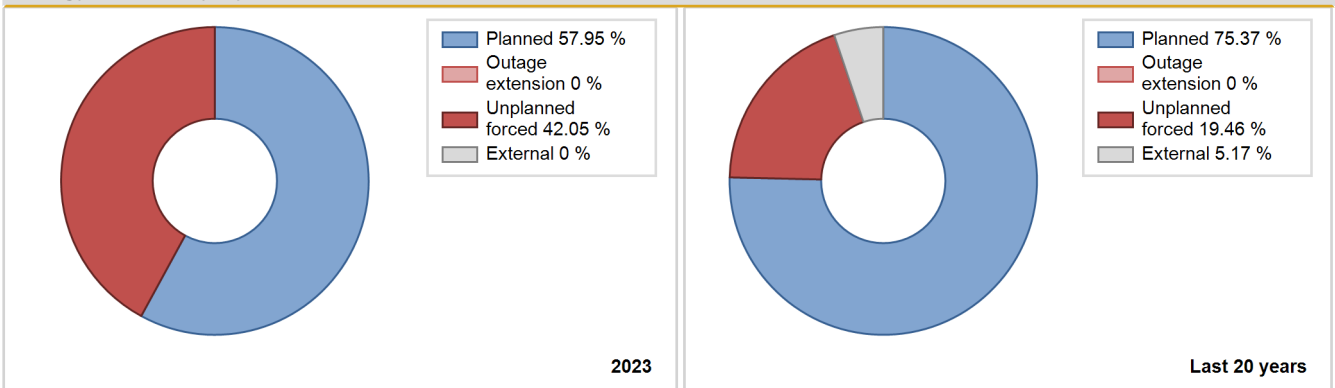
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|--|---------------------------|---------------------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1974 | 5168.70 | 6523 | 1065 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1975 | 1378.50 | 1535 | 1065 | 14.79 | 14.79 | 14.78 | 17.52 | 84.64 | 81.48 | 3.73 | 0.00 |
| 1976 | 1301.10 | 2174 | 1065 | 13.94 | 13.94 | 13.91 | 24.75 | 83.55 | 70.84 | 15.22 | 0.00 |
| 1977 | 5043.10 | 5817 | 1065 | 54.09 | 54.09 | 54.06 | 66.40 | 18.68 | 12.42 | 33.49 | 0.00 |
| 1978 | 5817.80 | 7042 | 1065 | 62.37 | 62.37 | 62.36 | 80.39 | 16.54 | 12.36 | 25.26 | 0.00 |
| 1979 | 7495.70 | 7918 | 1065 | 80.35 | 80.35 | 80.34 | 90.39 | 10.30 | 9.23 | 10.42 | 0.00 |
| 1980 | 6061.30 | 6376 | 1065 | 73.34 | 73.47 | 64.79 | 72.59 | 6.41 | 5.03 | 21.49 | 0.13 |
| 1981 | 4405.30 | 4435 | 1065 | 50.95 | 50.95 | 47.22 | 50.63 | 3.11 | 1.64 | 47.41 | 0.00 |
| 1982 | 7880.90 | 7967 | 1065 | 91.25 | 91.25 | 84.47 | 90.95 | 8.20 | 8.16 | 0.60 | 0.00 |
| 1983 | 2175.50 | 2316 | 1065 | 26.51 | 26.51 | 23.32 | 26.44 | 7.92 | 2.28 | 71.21 | 0.00 |
| 1984 | 7848.49 | 7930 | 1065 | 90.30 | 90.30 | 83.90 | 90.28 | 9.37 | 9.34 | 0.36 | 0.00 |
| 1985 | 1603.03 | 1626 | 1065 | 74.94 | 74.94 | 69.68 | 75.28 | 25.06 | 25.06 | 0.00 | 0.00 |
| 1986 | Data not available - Suspended Operation | | | | | | | | | | |
| 1987 | | | | | | | | | | | |
| 1988 | | | | | | | | | | | |
| 1989 | | | | | | | | | | | |
| 1990 | | | | | | | | | | | |
| 1991 | | | | | | | | | | | |
| 1992 | | | | | | | | | | | |
| 1993 | | | | | | | | | | | |
| 1994 | | | | | | | | | | | |
| 1995 | | | | | | | | | | | |
| 1996 | | | | | | | | | | | |
| 1997 | | | | | | | | | | | |
| 1998 | | | | | | | | | | | |
| 1999 | | | | | | | | | | | |
| 2000 | | | | | | | | | | | |
| 2001 | | | | | | | | | | | |
| 2002 | | | | | | | | | | | |
| 2003 | | | | | | | | | | | |
| 2004 | | | | | | | | | | | |
| 2005 | | | | | | | | | | | |
| 2006 | | | | | | | | | | | |
| 2007 | 4535.28 | 4452 | 1065 | 85.43 | 85.43 | 82.90 | 86.67 | 8.84 | 8.28 | 6.29 | 0.00 |
| 2008 | 8193.05 | 7693 | 1065 | 87.60 | 87.60 | 87.58 | 87.58 | 2.22 | 1.99 | 10.41 | 0.00 |
| 2009 | 8758.70 | 8147 | 1065 | 93.03 | 93.03 | 93.88 | 93.00 | 6.97 | 6.97 | 0.00 | 0.00 |
| 2010 | 8072.30 | 8007 | 1093 | 91.45 | 91.45 | 86.15 | 91.40 | 0.00 | 0.00 | 8.55 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|--------|--------|--------|--------|------|------|-------|------|
| 2011 | 8757.41 | 8048 | 1101 | 91.95 | 98.21 | 90.80 | 91.87 | 0.49 | 0.48 | 1.31 | 6.26 |
| 2012 | 8505.98 | 7691 | 1101 | 87.57 | 87.57 | 87.95 | 87.56 | 0.00 | 0.00 | 12.43 | 0.00 |
| 2013 | 9485.99 | 8516 | 1101 | 97.22 | 97.22 | 98.34 | 97.20 | 2.49 | 2.48 | 0.30 | 0.00 |
| 2014 | 8691.41 | 8021 | 1101 | 91.56 | 91.56 | 90.12 | 91.56 | 1.42 | 1.32 | 7.11 | 0.00 |
| 2015 | 9455.32 | 8575 | 1101 | 97.88 | 97.88 | 98.04 | 97.89 | 0.00 | 0.00 | 2.12 | 0.00 |
| 2016 | 8382.89 | 7799 | 1101 | 88.79 | 88.79 | 86.68 | 88.79 | 0.25 | 0.22 | 10.99 | 0.00 |
| 2017 | 9801.35 | 8760 | 1101 | 100.00 | 100.00 | 101.62 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 8114.12 | 7702 | 1101 | 87.92 | 87.92 | 84.13 | 87.92 | 1.39 | 1.24 | 10.84 | 0.00 |
| 2019 | 10857.30 | 8760 | 1200 | 100.00 | 100.00 | 103.28 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 9174.12 | 7718 | 1200 | 87.86 | 87.86 | 87.03 | 87.86 | 2.63 | 2.37 | 9.76 | 0.00 |
| 2021 | 10902.22 | 8760 | 1200 | 100.00 | 100.00 | 103.71 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 9396.07 | 7886 | 1200 | 90.02 | 90.02 | 89.38 | 90.02 | 0.00 | 0.00 | 9.98 | 0.00 |
| 2023 | 10750.38 | 8627 | 1200 | 96.00 | 96.00 | 102.27 | 98.48 | 1.72 | 1.68 | 2.32 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1974 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 144 | | | 249 | |
| B. Refuelling without maintenance | | | | 56 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 996 | 80 | |
| D. Inspection, maintenance or repair without refuelling | 192 | | | 3373 | | |
| E. Testing of plant systems or components | | | | 11 | 16 | |
| H. Nuclear regulatory requirements | | | | 327 | 2593 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 21 |
| L. Human factor related | | | | | 8 | |
| P. Fire | | | | | 492 | |
| Z. Other | | | | | 10 | |
| Subtotal | 192 | 144 | | 4763 | 3448 | 21 |
| Total | | 336 | | | 8232 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1974 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 144 | 8 |
| 12. Reactor I&C Systems | | 10 |
| 13. Reactor Auxiliary Systems | | 13 |
| 14. Safety Systems | | 15 |
| 15. Reactor Cooling Systems | | 70 |
| 31. Turbine and auxiliaries | | 56 |
| 32. Feedwater and Main Steam System | | 23 |
| 34. Miscellaneous Systems | | 23 |
| 41. Main Generator Systems | | 9 |
| 42. Electrical Power Supply Systems | | 25 |
| Total | 144 | 252 |

2023 Operating Experience

US-260 BROWNS FERRY-2 UNITED STATES OF AMERICA

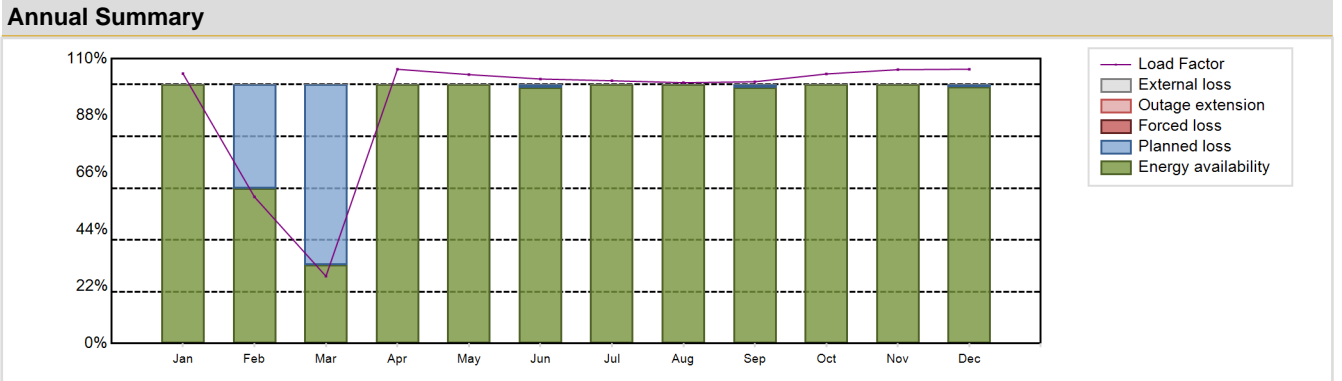
Status at end of year : **Operational**
 Operator : TVA (Tennessee Valley Authority)
 Owner : TVA (Tennessee Valley Authority)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 1) | Construction Date | : 1967-05-01 |
| Thermal power | : 3458 MWth | Grid Date | : 1974-08-28 |
| Gross electrical power | : 1259 MWe | Commercial Date | : 1975-03-01 |
| Reference unit power (net) | : 1200 MWe | Age at end of year | : 49 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.2 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 285 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.39 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 28 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 38000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.8 | HP cylinder inlet steam pressure [MPa] | : 6.8 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 764 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.49 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 9813.14 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 90.75 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 90.75 % | Planned Unavailability Factor (PUF) | : 9.25 % |
| Load Factor (LF) | : 93.35 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 91.08 % | Total off-line time | : 781 hours |

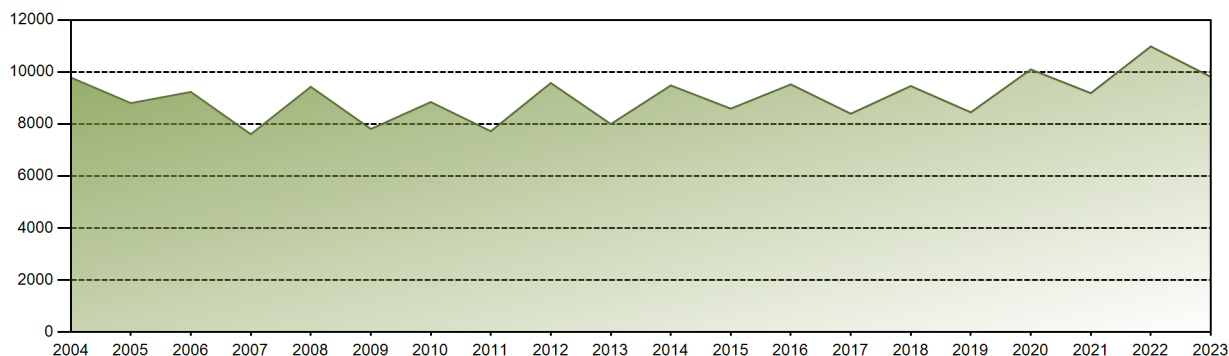


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 930.49 | 456.65 | 231.72 | 915.16 | 927.25 | 882.60 | 906.08 | 899.42 | 873.45 | 929.46 | 915.09 | 945.77 | 9813.14 |
| EAF [%] | 100.00 | 60.01 | 30.36 | 100.00 | 100.00 | 98.76 | 100.00 | 100.00 | 98.93 | 100.00 | 100.00 | 99.03 | 90.75 |
| UCF [%] | 100.00 | 60.01 | 30.36 | 100.00 | 100.00 | 98.76 | 100.00 | 100.00 | 98.93 | 100.00 | 100.00 | 99.03 | 90.75 |
| LF [%] | 104.22 | 56.63 | 25.99 | 105.92 | 103.86 | 102.15 | 101.49 | 100.74 | 101.09 | 104.11 | 105.77 | 105.93 | 93.35 |
| OF [%] | 100.00 | 60.27 | 30.82 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 91.08 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 39.99 | 69.64 | 0.00 | 0.00 | 1.24 | 0.00 | 0.00 | 1.07 | 0.00 | 0.00 | 0.97 | 9.25 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 334305.13 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.18 % |
| Cumulative Energy Availability Factor (EAF) | : 83.77 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.59 % |
| Cumulative Unit Capability Factor (UCF) | : 83.96 % | Cumulative Planned Unavailability Factor (PUF) | : 10.45 % |
| Cumulative Load Factor (LF) | : 81.38 % | Cumulative Externally cause unavailability (XUF) | : 0.19 % |
| Cumulative Operating Factor (OF) | : 84.47 % | | |

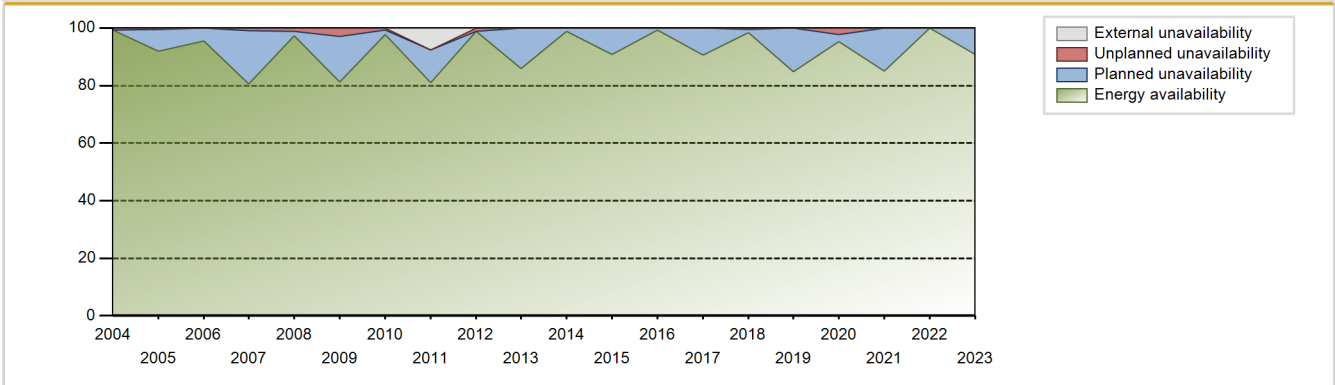
Electricity Production (net) [GWh]



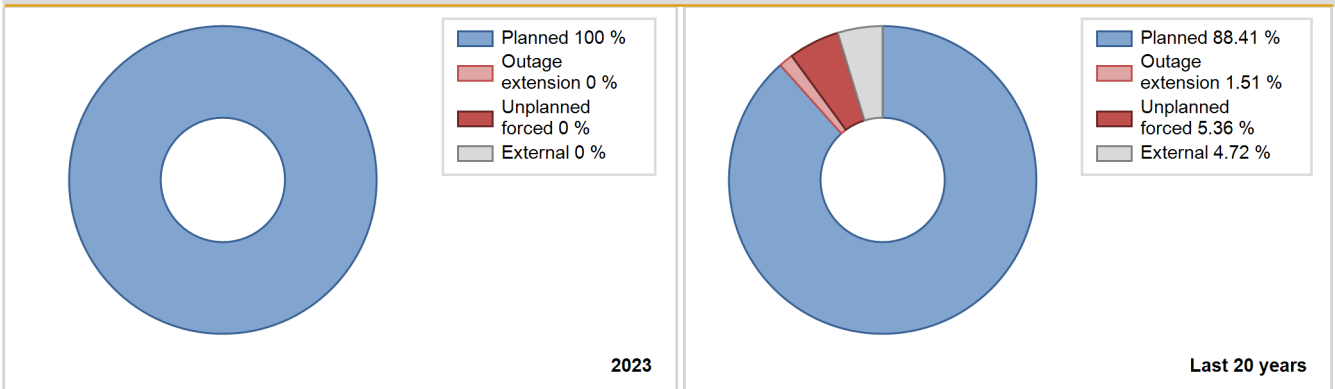
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|--|---------------------------|---------------------------------|---|-------|-------|-------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 1425.70 | 1578 | 1065 | 7.04 | 7.04 | 7.04 | 7.04 | 92.96 | 92.96 | 0.00 | 0.00 |
| 1976 | 1567.20 | 2547 | 1065 | 16.78 | 16.78 | 16.75 | 29.00 | 78.21 | 60.26 | 22.96 | 0.00 |
| 1977 | 6225.00 | 6963 | 1065 | 66.78 | 66.78 | 66.72 | 79.49 | 31.21 | 30.29 | 2.93 | 0.00 |
| 1978 | 5547.50 | 6032 | 1065 | 59.45 | 59.45 | 59.46 | 68.86 | 12.86 | 8.77 | 31.78 | 0.00 |
| 1979 | 7441.40 | 7593 | 1065 | 79.76 | 79.76 | 79.76 | 86.68 | 8.98 | 7.87 | 12.37 | 0.00 |
| 1980 | 5618.40 | 6073 | 1065 | 69.46 | 69.78 | 60.06 | 69.14 | 10.06 | 7.81 | 22.42 | 0.32 |
| 1981 | 7471.90 | 7452 | 1065 | 85.24 | 85.24 | 80.09 | 85.07 | 9.56 | 9.01 | 5.74 | 0.00 |
| 1982 | 4450.90 | 4778 | 1065 | 54.92 | 54.92 | 47.71 | 54.54 | 4.91 | 2.84 | 42.25 | 0.00 |
| 1983 | 6385.60 | 6514 | 1065 | 74.81 | 74.81 | 68.45 | 74.36 | 4.85 | 3.81 | 21.38 | 0.00 |
| 1984 | 4044.37 | 5844 | 1065 | 66.55 | 66.55 | 43.23 | 66.53 | 4.09 | 2.84 | 30.61 | 0.00 |
| 1985 | 0.00 | 0 | 1065 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1986 | Data not available - Suspended Operation | | | | | | | | | | |
| 1987 | | | | | | | | | | | |
| 1988 | | | | | | | | | | | |
| 1989 | | | | | | | | | | | |
| 1990 | | | | | | | | | | | |
| 1991 | 3804.01 | 4125 | 1065 | 80.36 | 80.36 | 69.53 | 80.30 | 15.46 | 14.70 | 4.94 | 0.00 |
| 1992 | 8388.77 | 8401 | 1065 | 95.69 | 95.69 | 89.67 | 95.64 | 2.05 | 2.00 | 2.31 | 0.00 |
| 1993 | 5776.84 | 5753 | 1065 | 65.68 | 65.68 | 61.92 | 65.67 | 0.00 | 0.00 | 34.32 | 0.00 |
| 1994 | 7345.17 | 7234 | 1065 | 82.58 | 82.58 | 78.73 | 82.58 | 2.24 | 1.89 | 15.53 | 0.00 |
| 1995 | 9197.03 | 8629 | 1065 | 98.50 | 98.50 | 98.58 | 98.50 | 1.50 | 1.50 | 0.00 | 0.00 |
| 1996 | 8046.29 | 7795 | 1065 | 88.74 | 88.74 | 86.01 | 88.74 | 2.76 | 2.52 | 8.74 | 0.00 |
| 1997 | 8372.93 | 8130 | 1065 | 92.82 | 92.82 | 89.75 | 92.81 | 1.29 | 1.21 | 5.97 | 0.00 |
| 1998 | 9301.04 | 8730 | 1065 | 99.66 | 99.66 | 99.70 | 99.66 | 0.34 | 0.34 | 0.00 | 0.00 |
| 1999 | 8586.32 | 7985 | 1100 | 91.02 | 91.02 | 89.06 | 91.15 | 1.28 | 1.18 | 7.80 | 0.00 |
| 2000 | 9733.46 | 8727 | 1118 | 99.36 | 99.36 | 99.11 | 99.35 | 0.64 | 0.64 | 0.00 | 0.00 |
| 2001 | 8414.56 | 7636 | 1118 | 87.18 | 87.18 | 85.92 | 87.17 | 0.49 | 0.43 | 12.39 | 0.00 |
| 2002 | 8911.26 | 8269 | 1118 | 94.40 | 94.40 | 90.99 | 94.39 | 0.78 | 0.75 | 4.85 | 0.00 |
| 2003 | 8369.22 | 7888 | 1118 | 90.06 | 90.06 | 85.46 | 90.05 | 1.82 | 1.67 | 8.28 | 0.00 |
| 2004 | 9785.98 | 8715 | 1118 | 99.21 | 99.21 | 99.65 | 99.21 | 0.79 | 0.79 | 0.00 | 0.00 |
| 2005 | 8802.16 | 8052 | 1118 | 91.94 | 91.94 | 89.88 | 91.92 | 0.62 | 0.57 | 7.49 | 0.00 |
| 2006 | 9232.64 | 8365 | 1118 | 95.50 | 95.50 | 94.27 | 95.49 | 0.00 | 0.00 | 4.50 | 0.00 |
| 2007 | 7606.63 | 7229 | 1104 | 80.66 | 80.66 | 78.65 | 82.52 | 1.12 | 0.91 | 18.43 | 0.00 |
| 2008 | 9429.92 | 8545 | 1104 | 97.29 | 97.29 | 97.24 | 97.28 | 1.17 | 1.15 | 1.56 | 0.00 |
| 2009 | 7808.51 | 7122 | 1103 | 81.31 | 81.31 | 80.81 | 81.30 | 3.37 | 2.84 | 15.85 | 0.00 |
| 2010 | 8842.51 | 8568 | 1104 | 97.82 | 97.82 | 91.43 | 97.81 | 0.66 | 0.65 | 1.53 | 0.00 |
| 2011 | 7720.39 | 7092 | 1104 | 80.98 | 88.55 | 79.83 | 80.96 | 0.05 | 0.04 | 11.40 | 7.57 |

| | | | | | | | | | | | |
|------|----------|------|------|--------|--------|--------|--------|------|------|-------|------|
| 2012 | 9576.00 | 8685 | 1104 | 98.88 | 98.88 | 98.75 | 98.87 | 1.12 | 1.12 | 0.00 | 0.00 |
| 2013 | 7997.82 | 7527 | 1104 | 85.93 | 85.93 | 82.69 | 85.91 | 0.00 | 0.00 | 14.07 | 0.00 |
| 2014 | 9481.43 | 8657 | 1104 | 98.83 | 98.83 | 98.04 | 98.82 | 0.00 | 0.00 | 1.17 | 0.00 |
| 2015 | 8591.32 | 7947 | 1104 | 90.72 | 90.72 | 88.84 | 90.72 | 0.00 | 0.00 | 9.28 | 0.00 |
| 2016 | 9523.24 | 8722 | 1104 | 99.29 | 99.29 | 98.20 | 99.29 | 0.00 | 0.00 | 0.71 | 0.00 |
| 2017 | 8395.47 | 7940 | 1104 | 90.64 | 90.64 | 86.81 | 90.64 | 0.00 | 0.00 | 9.36 | 0.00 |
| 2018 | 9460.54 | 8622 | 1104 | 98.42 | 98.42 | 97.82 | 98.42 | 0.50 | 0.49 | 1.09 | 0.00 |
| 2019 | 8448.74 | 7399 | 1200 | 84.84 | 84.84 | 83.12 | 84.46 | 0.00 | 0.00 | 15.16 | 0.00 |
| 2020 | 10098.92 | 8368 | 1200 | 95.27 | 95.27 | 95.81 | 95.26 | 0.00 | 2.22 | 2.50 | 0.00 |
| 2021 | 9186.32 | 7440 | 1200 | 84.93 | 84.93 | 87.39 | 84.93 | 0.00 | 0.00 | 15.07 | 0.00 |
| 2022 | 10981.47 | 8760 | 1200 | 100.00 | 100.00 | 104.47 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 9813.14 | 7979 | 1200 | 90.75 | 90.75 | 93.35 | 91.08 | 0.00 | 0.00 | 9.25 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 162 | |
| B. Refuelling without maintenance | | | | 31 | | |
| C. Inspection, maintenance or repair combined with refuelling | 781 | | | 905 | 51 | |
| D. Inspection, maintenance or repair without refuelling | | | | 92 | | |
| E. Testing of plant systems or components | | | | 7 | 2 | |
| H. Nuclear regulatory requirements | | | | | 1079 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 16 |
| L. Human factor related | | | | | 19 | |
| P. Fire | | | | | 302 | |
| Z. Other | | | | | 2 | 5 |
| Subtotal | 781 | | | 1035 | 1617 | 21 |
| Total | | 781 | | | 2673 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 4 |
| 12. Reactor I&C Systems | | 26 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 8 |
| 15. Reactor Cooling Systems | | 24 |
| 31. Turbine and auxiliaries | | 42 |
| 32. Feedwater and Main Steam System | | 8 |
| 34. Miscellaneous Systems | | 5 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 14 |
| 42. Electrical Power Supply Systems | | 20 |
| Total | | 162 |

2023 Operating Experience

US-296 BROWNS FERRY-3 UNITED STATES OF AMERICA

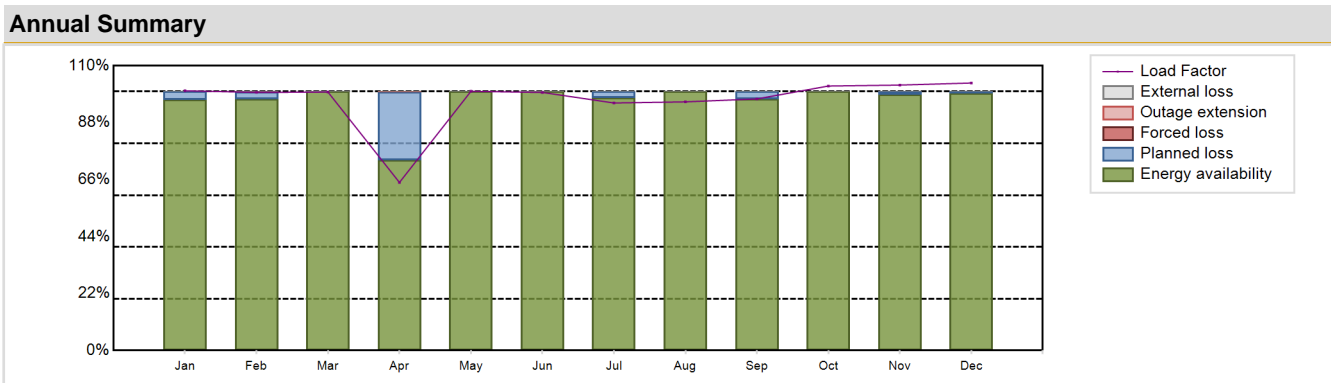
Status at end of year : **Operational**
 Operator : TVA (Tennessee Valley Authority)
 Owner : TVA (Tennessee Valley Authority)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 1) | Construction Date | : 1968-07-01 |
| Thermal power | : 3458 MWth | Grid Date | : 1976-09-12 |
| Gross electrical power | : 1260 MWe | Commercial Date | : 1977-03-01 |
| Reference unit power (net) | : 1210 MWe | Age at end of year | : 47 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.2 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 285 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.39 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 32 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 38000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.8 | HP cylinder inlet steam pressure [MPa] | : 6.8 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 149 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|-------------|
| Net Energy Production | : 10261.99 GW(e).h | Forced Loss Rate (FLR) | : 0.01 % |
| Energy Availability Factor (EAF) | : 96.75 % | Unplanned Capability Loss Factor (UCL) | : 0.02 % |
| Unit Capability Factor (UCF) | : 96.75 % | Planned Unavailability Factor (PUF) | : 3.23 % |
| Load Factor (LF) | : 96.81 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 97.87 % | Total off-line time | : 187 hours |

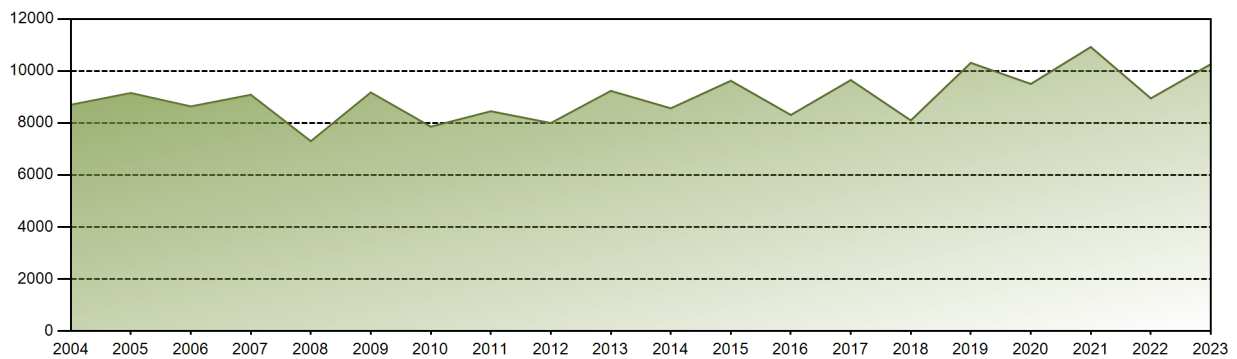


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 903.16 | 810.51 | 897.45 | 565.45 | 901.24 | 868.37 | 860.71 | 864.64 | 846.55 | 919.56 | 894.35 | 930.00 | 10261.99 |
| EAF [%] | 96.83 | 97.14 | 100.00 | 73.62 | 100.00 | 100.00 | 97.51 | 100.00 | 97.03 | 100.00 | 98.95 | 99.41 | 96.75 |
| UCF [%] | 96.83 | 97.14 | 100.00 | 73.62 | 100.00 | 100.00 | 97.51 | 100.00 | 97.03 | 100.00 | 98.95 | 99.41 | 96.75 |
| LF [%] | 100.32 | 99.68 | 99.82 | 64.90 | 100.11 | 99.68 | 95.61 | 96.05 | 97.17 | 102.15 | 102.51 | 103.31 | 96.81 |
| OF [%] | 100.00 | 100.00 | 100.00 | 74.03 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.87 |
| FLR [%] | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| UCL [%] | 0.00 | 0.18 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| PUF [%] | 3.17 | 2.68 | 0.00 | 26.31 | 0.00 | 0.00 | 2.49 | 0.00 | 2.97 | 0.00 | 1.05 | 0.59 | 3.23 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 298016.87 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.19 % |
| Cumulative Energy Availability Factor (EAF) | : 85.72 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.68 % |
| Cumulative Unit Capability Factor (UCF) | : 86.01 % | Cumulative Planned Unavailability Factor (PUF) | : 8.31 % |
| Cumulative Load Factor (LF) | : 83.91 % | Cumulative Externally cause unavailability (XUF) | : 0.29 % |
| Cumulative Operating Factor (OF) | : 86.25 % | | |

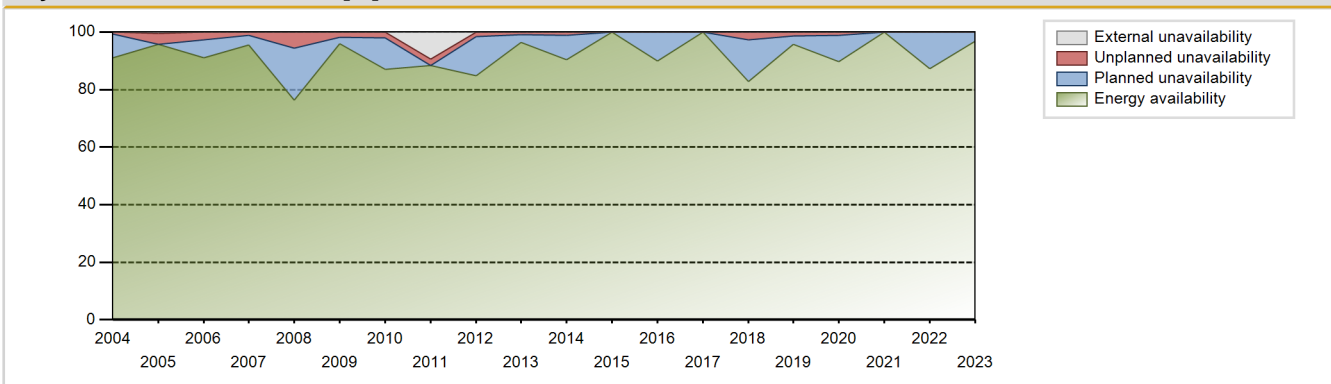
Electricity Production (net) [GWh]



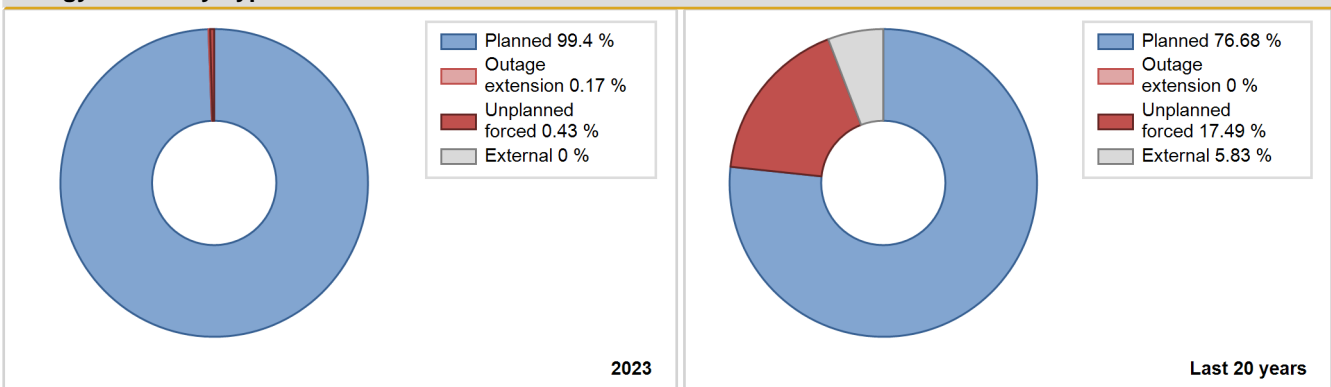
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1977 | 7247.50 | 7857 | 1065 | 74.81 | 74.81 | 74.81 | 88.49 | 25.19 | 25.19 | 0.00 | 0.00 |
| 1978 | 5554.30 | 6225 | 1065 | 59.52 | 59.52 | 59.54 | 71.06 | 20.60 | 15.45 | 25.03 | 0.00 |
| 1979 | 5482.50 | 5704 | 1065 | 58.77 | 58.77 | 58.77 | 65.11 | 12.99 | 8.77 | 32.46 | 0.00 |
| 1980 | 6936.10 | 6949 | 1065 | 79.26 | 79.89 | 74.14 | 79.11 | 10.83 | 9.71 | 10.41 | 0.63 |
| 1981 | 6264.80 | 6358 | 1065 | 72.62 | 72.62 | 67.15 | 72.58 | 7.11 | 5.56 | 21.82 | 0.00 |
| 1982 | 4892.80 | 5022 | 1065 | 57.43 | 57.43 | 52.44 | 57.33 | 20.46 | 14.77 | 27.80 | 0.00 |
| 1983 | 5394.30 | 5417 | 1065 | 61.87 | 61.87 | 57.82 | 61.84 | 9.33 | 6.37 | 31.76 | 0.00 |
| 1984 | 290.50 | 503 | 1065 | 5.75 | 5.75 | 3.11 | 5.73 | 94.19 | 93.15 | 1.10 | 0.00 |
| 1985 | 1526.47 | 1496 | 1065 | 90.78 | 90.78 | 86.95 | 90.75 | 9.22 | 9.22 | 0.00 | 0.00 |
| 1986 | | | | Data not available - Suspended Operation | | | | | | | |
| 1987 | | | | | | | | | | | |
| 1988 | | | | | | | | | | | |
| 1989 | | | | | | | | | | | |
| 1990 | | | | | | | | | | | |
| 1991 | | | | | | | | | | | |
| 1992 | | | | | | | | | | | |
| 1993 | | | | | | | | | | | |
| 1994 | | | | | | | | | | | |
| 1995 | 764.62 | 810 | 1065 | 79.51 | 79.51 | 70.39 | 79.41 | 0.98 | 0.78 | 19.71 | 0.00 |
| 1996 | 8803.50 | 8412 | 1065 | 95.81 | 95.81 | 94.11 | 95.77 | 2.65 | 2.61 | 1.58 | 0.00 |
| 1997 | 8523.36 | 8302 | 1065 | 94.78 | 94.78 | 91.36 | 94.77 | 0.00 | 0.00 | 5.22 | 0.00 |
| 1998 | 7884.88 | 7863 | 1078 | 89.90 | 89.90 | 83.46 | 89.76 | 3.56 | 3.32 | 6.79 | 0.00 |
| 1999 | 9730.59 | 8760 | 1118 | 100.00 | 100.00 | 99.36 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2000 | 9097.37 | 8311 | 1118 | 94.62 | 94.62 | 92.64 | 94.62 | 0.65 | 0.62 | 4.76 | 0.00 |
| 2001 | 9803.36 | 8760 | 1118 | 100.00 | 100.00 | 100.10 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2002 | 9260.08 | 8407 | 1118 | 95.99 | 95.99 | 94.55 | 95.97 | 0.00 | 0.00 | 4.01 | 0.00 |
| 2003 | 9325.73 | 8463 | 1118 | 96.62 | 96.62 | 95.22 | 96.61 | 0.00 | 0.00 | 3.38 | 0.00 |
| 2004 | 8701.83 | 8000 | 1118 | 91.12 | 91.12 | 88.61 | 91.07 | 0.68 | 0.62 | 8.26 | 0.00 |
| 2005 | 9153.72 | 8384 | 1114 | 95.73 | 96.18 | 93.80 | 95.71 | 3.82 | 3.82 | 0.00 | 0.45 |
| 2006 | 8638.83 | 7974 | 1114 | 91.08 | 91.08 | 88.29 | 91.03 | 2.94 | 2.76 | 6.16 | 0.00 |
| 2007 | 9086.06 | 8372 | 1105 | 95.57 | 95.57 | 93.87 | 95.57 | 1.14 | 1.10 | 3.33 | 0.00 |
| 2008 | 7300.59 | 6794 | 1104 | 76.35 | 76.35 | 75.27 | 77.35 | 6.87 | 5.63 | 18.02 | 0.00 |
| 2009 | 9175.41 | 8433 | 1104 | 95.86 | 95.86 | 94.88 | 96.27 | 1.96 | 1.92 | 2.22 | 0.00 |
| 2010 | 7858.11 | 7625 | 1105 | 87.08 | 87.08 | 81.18 | 87.04 | 2.22 | 1.97 | 10.95 | 0.00 |
| 2011 | 8451.13 | 7731 | 1105 | 88.27 | 97.64 | 87.31 | 88.25 | 2.36 | 2.36 | 0.00 | 9.37 |
| 2012 | 7999.54 | 7455 | 1105 | 84.89 | 84.89 | 82.42 | 84.87 | 1.77 | 1.53 | 13.58 | 0.00 |
| 2013 | 9234.30 | 8443 | 1105 | 96.38 | 96.38 | 95.39 | 96.37 | 0.90 | 0.87 | 2.75 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|--------|--------|--------|--------|------|------|-------|------|
| 2014 | 8565.45 | 7911 | 1105 | 90.31 | 90.31 | 88.49 | 90.31 | 1.22 | 1.11 | 8.58 | 0.00 |
| 2015 | 9623.05 | 8760 | 1105 | 100.00 | 100.00 | 99.41 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 8308.77 | 7906 | 1105 | 90.01 | 90.01 | 85.60 | 90.00 | 0.00 | 0.00 | 9.99 | 0.00 |
| 2017 | 9651.06 | 8760 | 1105 | 100.00 | 100.00 | 99.70 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 8099.12 | 7243 | 1105 | 82.69 | 82.69 | 83.67 | 82.68 | 3.26 | 2.79 | 14.52 | 0.00 |
| 2019 | 10313.85 | 8390 | 1210 | 95.79 | 95.79 | 97.30 | 95.78 | 1.48 | 1.43 | 2.78 | 0.00 |
| 2020 | 9501.81 | 7870 | 1210 | 89.61 | 89.61 | 89.40 | 89.59 | 1.31 | 1.19 | 9.21 | 0.00 |
| 2021 | 10922.05 | 8760 | 1210 | 100.00 | 100.00 | 103.04 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 8947.91 | 7645 | 1210 | 87.29 | 87.29 | 84.42 | 87.27 | 0.00 | 0.00 | 12.71 | 0.00 |
| 2023 | 10261.99 | 8573 | 1210 | 96.75 | 96.75 | 96.81 | 97.87 | 0.01 | 0.02 | 3.23 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1977 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 72 | | | 217 | |
| B. Refuelling without maintenance | | | | 47 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 627 | 215 | |
| D. Inspection, maintenance or repair without refuelling | 48 | | | 489 | | |
| E. Testing of plant systems or components | | | | 6 | 1 | |
| H. Nuclear regulatory requirements | | | | | 2112 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 23 |
| L. Human factor related | | | | | 11 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 5 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 3 | | |
| Z. Other | | | | | 12 | |
| Subtotal | 48 | 72 | | 1172 | 2568 | 28 |
| Total | | 120 | | | 3768 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1977 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 16 |
| 13. Reactor Auxiliary Systems | | 13 |
| 14. Safety Systems | | 14 |
| 15. Reactor Cooling Systems | | 37 |
| 31. Turbine and auxiliaries | | 66 |
| 32. Feedwater and Main Steam System | 72 | 25 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 248 |
| 41. Main Generator Systems | | 16 |
| 42. Electrical Power Supply Systems | | 25 |
| Total | 72 | 464 |

2023 Operating Experience

US-325 BRUNSWICK-1 UNITED STATES OF AMERICA

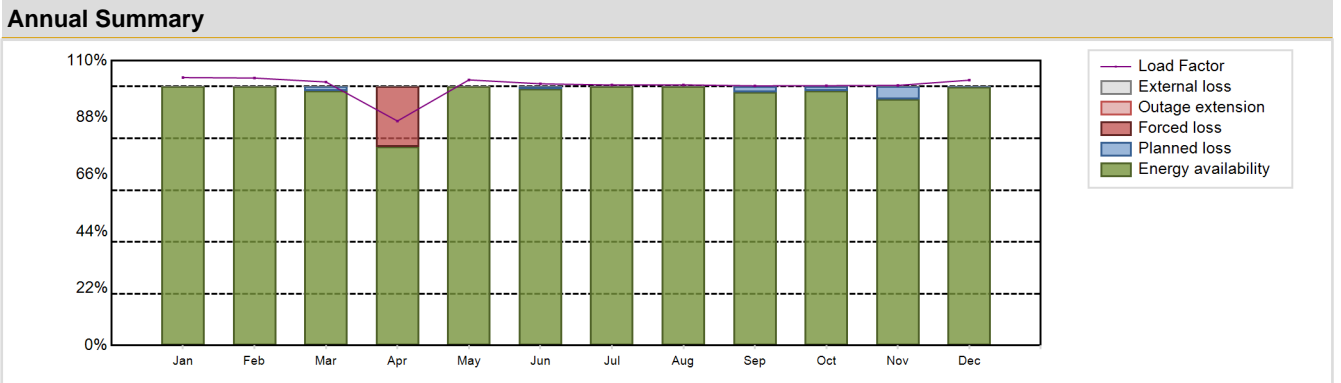
Status at end of year : **Operational**
 Operator : PROGRESS (Progress Energy)
 Owner : PROG_E_C (PROGRESS ENERGY Carolinas, Inc.)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 1) | Construction Date | : 1970-02-07 |
| Thermal power | : 2923 MWth | Grid Date | : 1976-12-04 |
| Gross electrical power | : 990 MWe | Commercial Date | : 1977-03-18 |
| Reference unit power (net) | : 938 MWe | Age at end of year | : 47 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.07 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 285 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.44 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 25 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 27800 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.1 | HP cylinder inlet steam pressure [MPa] | : 6.8 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 560 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.42 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 137 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : - | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 8243.54 GW(e).h | Forced Loss Rate (FLR) | : 1.94 % |
| Energy Availability Factor (EAF) | : 97.14 % | Unplanned Capability Loss Factor (UCL) | : 1.92 % |
| Unit Capability Factor (UCF) | : 97.14 % | Planned Unavailability Factor (PUF) | : 0.94 % |
| Load Factor (LF) | : 100.32 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 98.84 % | Total off-line time | : 102 hours |

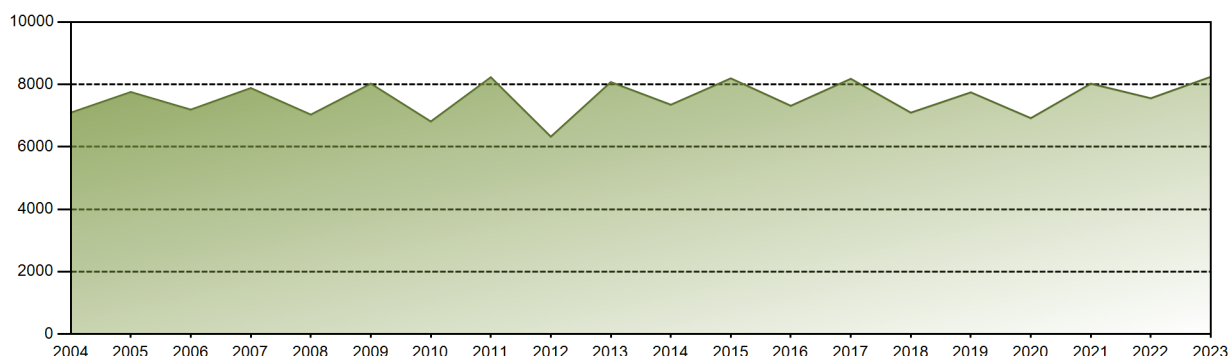


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 722.17 | 651.07 | 709.29 | 585.53 | 715.93 | 682.66 | 702.20 | 702.52 | 677.26 | 700.34 | 679.35 | 715.20 | 8243.54 |
| EAF [%] | 100.00 | 100.00 | 98.26 | 76.67 | 100.00 | 99.00 | 100.00 | 100.00 | 97.80 | 98.48 | 95.21 | 99.90 | 97.14 |
| UCF [%] | 100.00 | 100.00 | 98.26 | 76.67 | 100.00 | 99.00 | 100.00 | 100.00 | 97.80 | 98.48 | 95.21 | 99.90 | 97.14 |
| LF [%] | 103.48 | 103.29 | 101.77 | 86.70 | 102.59 | 101.08 | 100.62 | 100.67 | 100.28 | 100.35 | 100.45 | 102.48 | 100.32 |
| OF [%] | 100.00 | 100.00 | 100.00 | 85.83 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.84 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 23.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.94 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 23.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.92 |
| PUF [%] | 0.00 | 0.00 | 1.74 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 2.20 | 1.52 | 4.79 | 0.10 | 0.94 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 274774.6 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.32 % |
| Cumulative Energy Availability Factor (EAF) | : 80.09 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.51 % |
| Cumulative Unit Capability Factor (UCF) | : 80.36 % | Cumulative Planned Unavailability Factor (PUF) | : 15.12 % |
| Cumulative Load Factor (LF) | : 78.69 % | Cumulative Externally cause unavailability (XUF) | : 0.28 % |
| Cumulative Operating Factor (OF) | : 79.4 % | | |

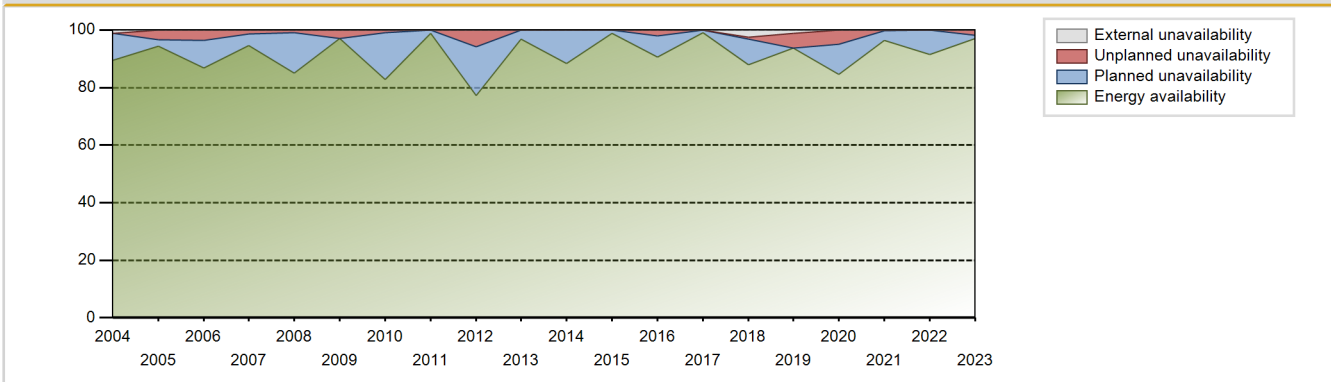
Electricity Production (net) [GWh]



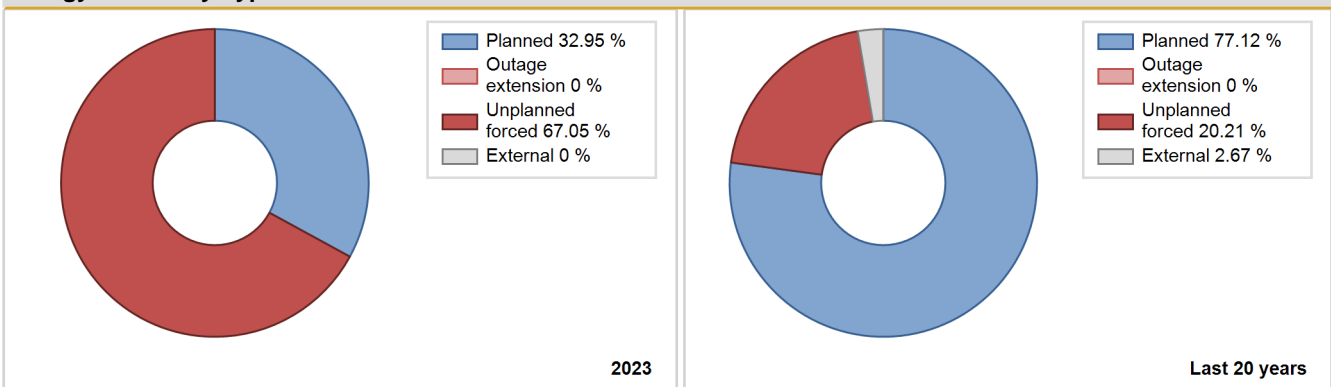
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1977 | 2984.50 | 4949 | 790 | 43.63 | 43.63 | 43.63 | 54.61 | 56.37 | 56.37 | 0.00 | 0.00 |
| 1978 | 5122.90 | 7624 | 790 | 74.11 | 74.11 | 74.03 | 87.03 | 16.75 | 14.91 | 10.99 | 0.00 |
| 1979 | 3169.20 | 4778 | 790 | 45.79 | 45.79 | 45.80 | 54.54 | 25.42 | 15.61 | 38.59 | 0.00 |
| 1980 | 3939.20 | 6045 | 790 | 69.75 | 69.75 | 56.77 | 68.82 | 7.13 | 5.36 | 24.90 | 0.00 |
| 1981 | 2574.80 | 4155 | 790 | 48.98 | 48.98 | 37.21 | 47.43 | 12.80 | 7.19 | 43.83 | 0.00 |
| 1982 | 2935.40 | 5428 | 790 | 62.93 | 62.93 | 42.42 | 61.96 | 31.61 | 29.09 | 7.98 | 0.00 |
| 1983 | 1419.10 | 2116 | 790 | 26.40 | 26.40 | 20.51 | 24.16 | 5.51 | 1.54 | 72.06 | 0.00 |
| 1984 | 5037.71 | 6797 | 790 | 79.77 | 81.45 | 72.60 | 77.38 | 5.30 | 4.56 | 13.99 | 1.68 |
| 1985 | 1942.51 | 3247 | 790 | 38.92 | 38.92 | 28.07 | 37.07 | 3.99 | 1.62 | 59.46 | 0.00 |
| 1986 | 5973.81 | 8068 | 790 | 92.23 | 92.23 | 86.32 | 92.10 | 7.77 | 7.77 | 0.00 | 0.00 |
| 1987 | 4057.95 | 5651 | 790 | 65.57 | 65.57 | 58.64 | 64.51 | 3.78 | 2.57 | 31.86 | 0.00 |
| 1988 | 4458.42 | 6514 | 790 | 74.45 | 74.45 | 64.25 | 74.16 | 3.73 | 2.89 | 22.66 | 0.00 |
| 1989 | 4193.76 | 5568 | 790 | 64.63 | 64.63 | 60.60 | 63.56 | 10.52 | 7.60 | 27.77 | 0.00 |
| 1990 | 4340.35 | 5909 | 790 | 68.40 | 68.40 | 62.72 | 67.45 | 8.16 | 6.07 | 25.52 | 0.00 |
| 1991 | 4400.35 | 5849 | 780 | 67.35 | 67.35 | 64.37 | 66.77 | 20.44 | 17.30 | 15.35 | 0.00 |
| 1992 | 1874.55 | 2486 | 767 | 28.31 | 28.31 | 27.82 | 28.30 | 31.05 | 12.75 | 58.94 | 0.00 |
| 1993 | 0.00 | 0 | 767 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1994 | 5956.34 | 7755 | 767 | 88.56 | 88.56 | 88.65 | 88.53 | 0.22 | 0.19 | 11.24 | 0.00 |
| 1995 | 5780.71 | 7391 | 767 | 84.42 | 84.42 | 86.04 | 84.37 | 2.04 | 1.76 | 13.82 | 0.00 |
| 1996 | 5708.15 | 7490 | 767 | 85.33 | 88.57 | 84.72 | 85.27 | 2.52 | 2.29 | 9.14 | 3.24 |
| 1997 | 6857.03 | 8558 | 767 | 97.71 | 97.71 | 102.06 | 97.69 | 2.29 | 2.29 | 0.00 | 0.00 |
| 1998 | 6360.44 | 7811 | 820 | 89.89 | 91.39 | 88.55 | 89.17 | 0.10 | 0.10 | 8.51 | 1.51 |
| 1999 | 6998.16 | 8481 | 820 | 96.82 | 98.97 | 97.42 | 96.82 | 1.03 | 1.03 | 0.00 | 2.16 |
| 2000 | 6746.48 | 8122 | 820 | 92.46 | 92.46 | 93.66 | 92.46 | 0.00 | 0.00 | 7.54 | 0.00 |
| 2001 | 7303.12 | 8760 | 820 | 100.00 | 100.00 | 101.67 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2002 | 6697.34 | 7874 | 820 | 89.89 | 89.89 | 93.24 | 89.89 | 0.03 | 0.03 | 10.08 | 0.00 |
| 2003 | 7701.83 | 8653 | 872 | 98.85 | 98.85 | 100.83 | 98.78 | 1.15 | 1.15 | 0.00 | 0.00 |
| 2004 | 7093.38 | 7853 | 872 | 89.42 | 90.53 | 92.61 | 89.40 | 0.00 | 0.00 | 9.47 | 1.11 |
| 2005 | 7755.05 | 8275 | 872 | 94.47 | 94.47 | 101.51 | 94.45 | 3.37 | 3.29 | 2.24 | 0.00 |
| 2006 | 7190.78 | 7601 | 938 | 86.80 | 86.80 | 87.51 | 86.77 | 3.94 | 3.56 | 9.63 | 0.00 |
| 2007 | 7881.91 | 8290 | 938 | 94.64 | 94.64 | 95.92 | 94.63 | 1.45 | 1.39 | 3.97 | 0.00 |
| 2008 | 7030.63 | 7458 | 938 | 84.92 | 84.92 | 85.33 | 84.90 | 0.99 | 0.85 | 14.22 | 0.00 |
| 2009 | 8022.67 | 8493 | 938 | 96.96 | 96.96 | 97.64 | 96.95 | 3.04 | 3.04 | 0.00 | 0.00 |
| 2010 | 6810.87 | 7255 | 938 | 82.84 | 82.84 | 82.89 | 82.82 | 1.16 | 0.98 | 16.19 | 0.00 |
| 2011 | 8228.37 | 8663 | 938 | 98.90 | 98.90 | 100.14 | 98.89 | 0.00 | 0.00 | 1.10 | 0.00 |
| 2012 | 6323.87 | 6778 | 938 | 77.20 | 77.20 | 76.75 | 77.16 | 7.03 | 5.83 | 16.97 | 0.00 |
| 2013 | 8074.21 | 8483 | 938 | 96.83 | 96.83 | 98.25 | 96.83 | 0.00 | 0.00 | 3.17 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|--------|-------|------|------|-------|------|
| 2014 | 7347.75 | 7751 | 938 | 88.48 | 88.48 | 89.42 | 88.48 | 0.00 | 0.00 | 11.52 | 0.00 |
| 2015 | 8192.60 | 8653 | 938 | 98.78 | 98.78 | 99.70 | 98.78 | 0.00 | 0.00 | 1.22 | 0.00 |
| 2016 | 7313.54 | 7959 | 938 | 90.60 | 90.60 | 88.76 | 90.61 | 2.18 | 2.01 | 7.39 | 0.00 |
| 2017 | 8179.12 | 8685 | 938 | 99.14 | 99.14 | 99.54 | 99.14 | 0.00 | 0.00 | 0.86 | 0.00 |
| 2018 | 7094.07 | 7700 | 938 | 87.90 | 90.31 | 86.34 | 87.90 | 0.78 | 0.71 | 8.98 | 2.41 |
| 2019 | 7744.25 | 8211 | 938 | 93.75 | 94.79 | 94.25 | 93.73 | 5.21 | 5.21 | 0.00 | 1.04 |
| 2020 | 6917.77 | 7432 | 938 | 84.62 | 84.62 | 83.96 | 84.61 | 5.57 | 4.99 | 10.39 | 0.00 |
| 2021 | 8022.51 | 8447 | 938 | 96.43 | 96.43 | 97.63 | 96.43 | 0.29 | 0.29 | 3.28 | 0.00 |
| 2022 | 7555.39 | 8023 | 938 | 91.59 | 91.59 | 91.95 | 91.59 | 0.00 | 0.00 | 8.41 | 0.00 |
| 2023 | 8243.54 | 8658 | 938 | 97.14 | 97.14 | 100.32 | 98.84 | 1.94 | 1.92 | 0.94 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1977 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 168 | | | 287 | |
| B. Refuelling without maintenance | | | | 30 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1005 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 352 | | |
| E. Testing of plant systems or components | | | | 5 | 46 | |
| H. Nuclear regulatory requirements | | | | | 10 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 27 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 25 |
| Z. Other | | | | | 15 | |
| Subtotal | | 168 | | 1392 | 385 | 28 |
| Total | | 168 | | | 1805 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1977 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 11 |
| 12. Reactor I&C Systems | 168 | 20 |
| 13. Reactor Auxiliary Systems | | 7 |
| 14. Safety Systems | | 25 |
| 15. Reactor Cooling Systems | | 45 |
| 31. Turbine and auxiliaries | | 26 |
| 32. Feedwater and Main Steam System | | 10 |
| 33. Circulating Water System | | 5 |
| 34. Miscellaneous Systems | | 60 |
| 41. Main Generator Systems | | 86 |
| 42. Electrical Power Supply Systems | | 41 |
| Total | 168 | 336 |

2023 Operating Experience

US-324

BRUNSWICK-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : PROGRESS (Progress Energy)
 Owner : PROG_E_C (PROGRESS ENERGY Carolinas, Inc.)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : BWR / BWR-4 (Mark 1)
 Thermal power : 2923 MWth
 Gross electrical power : 960 MWe
 Reference unit power (net) : 932 MWe

Key Dates

Construction Date : 1970-02-07
 Grid Date : 1975-04-29
 Commercial Date : 1975-11-03
 Age at end of year : 48 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 27800
 Active core diameter [m] : 4.1
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 560
 Fuel linear heat generation rate [kW/m] : 18.61
 Number of control rod assemblies : 137
 Number of external reactor coolant loops : -
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.07
 Reactor outlet temperature [°C] : 285
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : 0.44

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.8
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

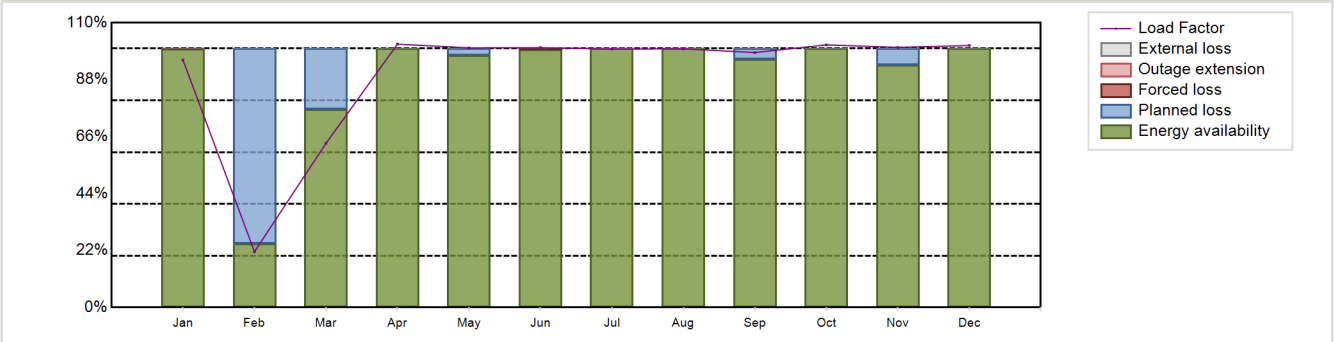
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7414.54 GW(e).h
 Energy Availability Factor (EAF) : 91.1 %
 Unit Capability Factor (UCF) : 91.1 %
 Load Factor (LF) : 90.82 %
 Operating Factor (OF) : 92.23 %

Forced Loss Rate (FLR) : 0.05 %
 Unplanned Capability Loss Factor (UCL) : 0.05 %
 Planned Unavailability Factor (PUF) : 8.85 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 681 hours

Annual Summary

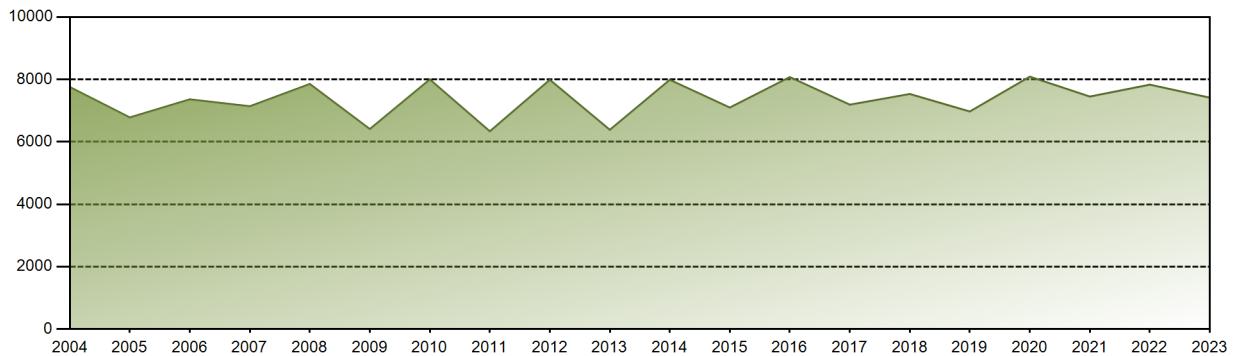


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 662.94 | 135.09 | 439.07 | 682.60 | 695.39 | 673.49 | 692.04 | 692.87 | 660.83 | 703.38 | 675.15 | 701.70 | 7414.54 |
| EAF [%] | 99.87 | 24.55 | 76.63 | 100.00 | 97.42 | 99.53 | 100.00 | 100.00 | 95.90 | 100.00 | 93.61 | 100.00 | 91.10 |
| UCF [%] | 99.87 | 24.55 | 76.63 | 100.00 | 97.42 | 99.53 | 100.00 | 100.00 | 95.90 | 100.00 | 93.61 | 100.00 | 91.10 |
| LF [%] | 95.61 | 21.57 | 63.41 | 101.72 | 100.29 | 100.37 | 99.80 | 99.92 | 98.48 | 101.44 | 100.47 | 101.20 | 90.82 |
| OF [%] | 100.00 | 24.55 | 76.58 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.23 |
| FLR [%] | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| UCL [%] | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| PUF [%] | 0.00 | 75.45 | 23.37 | 0.00 | 2.58 | 0.00 | 0.00 | 0.00 | 4.10 | 0.00 | 6.39 | 0.00 | 8.85 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 271710.82 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.21 % |
| Cumulative Energy Availability Factor (EAF) | : 79.2 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.27 % |
| Cumulative Unit Capability Factor (UCF) | : 79.49 % | Cumulative Planned Unavailability Factor (PUF) | : 15.25 % |
| Cumulative Load Factor (LF) | : 76.55 % | Cumulative Externally cause unavailability (XUF) | : 0.29 % |
| Cumulative Operating Factor (OF) | : 79.1 % | | |

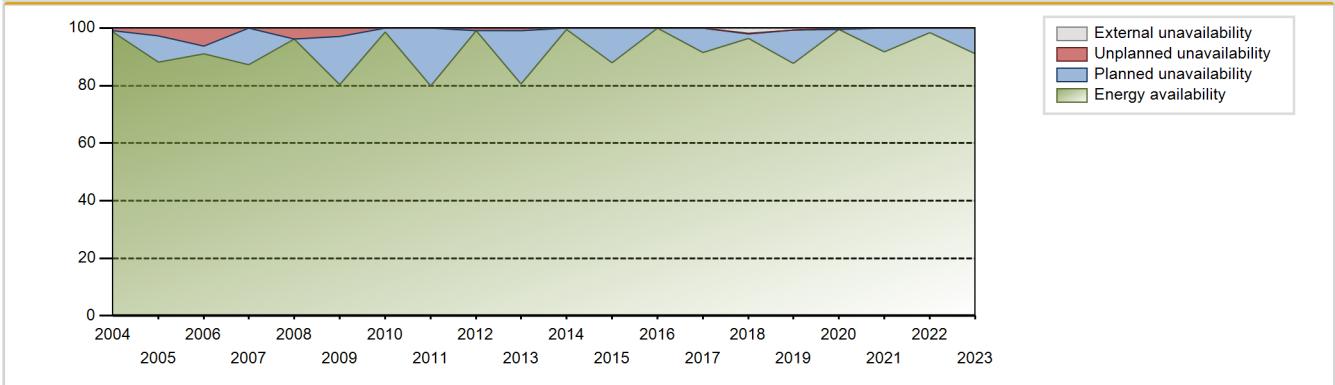
Electricity Production (net) [GWh]



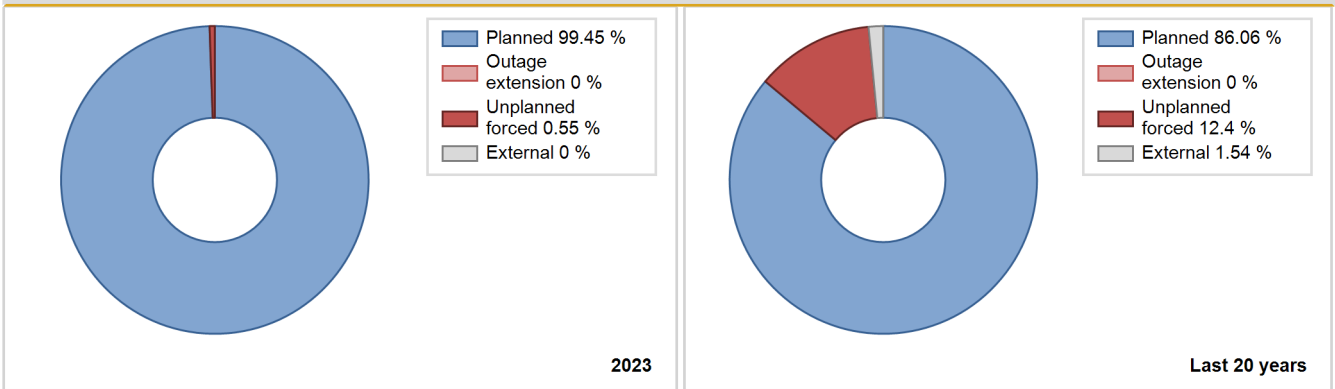
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 1423.80 | 3254 | 804 | 93.19 | 93.19 | 58.80 | 93.17 | 6.81 | 6.81 | 0.00 | 0.00 |
| 1976 | 2486.60 | 4911 | 789 | 35.81 | 35.81 | 35.88 | 55.91 | 48.62 | 33.89 | 30.30 | 0.00 |
| 1977 | 2436.60 | 4872 | 790 | 35.26 | 35.26 | 35.21 | 55.62 | 38.79 | 22.35 | 42.39 | 0.00 |
| 1978 | 4794.60 | 7018 | 790 | 69.26 | 69.26 | 69.28 | 80.11 | 25.55 | 23.77 | 6.97 | 0.00 |
| 1979 | 3652.10 | 5741 | 790 | 52.78 | 52.78 | 52.77 | 65.54 | 16.97 | 10.79 | 36.44 | 0.00 |
| 1980 | 1864.60 | 3086 | 790 | 38.13 | 38.13 | 26.87 | 35.13 | 21.96 | 10.73 | 51.14 | 0.00 |
| 1981 | 3283.90 | 5800 | 790 | 67.96 | 67.96 | 47.45 | 66.21 | 29.31 | 28.17 | 3.86 | 0.00 |
| 1982 | 1942.10 | 3378 | 790 | 41.42 | 41.42 | 28.06 | 38.56 | 27.98 | 16.09 | 42.48 | 0.00 |
| 1983 | 3941.70 | 5630 | 790 | 65.29 | 65.29 | 56.96 | 64.27 | 28.98 | 26.64 | 8.07 | 0.00 |
| 1984 | 1429.01 | 2236 | 790 | 28.90 | 28.90 | 20.59 | 25.46 | 28.94 | 11.77 | 59.33 | 0.00 |
| 1985 | 5021.91 | 6983 | 790 | 80.01 | 84.09 | 72.57 | 79.71 | 4.59 | 4.05 | 11.86 | 4.08 |
| 1986 | 2933.07 | 4027 | 790 | 48.47 | 48.47 | 42.38 | 45.97 | 2.96 | 1.48 | 50.05 | 0.00 |
| 1987 | 5694.10 | 8203 | 790 | 93.96 | 93.96 | 82.28 | 93.64 | 5.00 | 4.94 | 1.10 | 0.00 |
| 1988 | 3929.22 | 5361 | 790 | 62.80 | 62.80 | 56.62 | 61.03 | 6.30 | 4.22 | 32.98 | 0.00 |
| 1989 | 4195.43 | 5763 | 790 | 67.36 | 67.36 | 60.62 | 65.79 | 4.03 | 2.83 | 29.81 | 0.00 |
| 1990 | 4067.43 | 5616 | 790 | 66.07 | 66.07 | 58.77 | 64.11 | 16.62 | 13.17 | 20.76 | 0.00 |
| 1991 | 3664.18 | 4959 | 775 | 57.79 | 57.79 | 53.98 | 56.61 | 17.90 | 12.60 | 29.61 | 0.00 |
| 1992 | 1315.10 | 2200 | 754 | 25.06 | 25.06 | 19.86 | 25.05 | 18.45 | 5.67 | 69.27 | 0.00 |
| 1993 | 4000.88 | 5525 | 754 | 63.07 | 63.07 | 60.57 | 63.07 | 0.00 | 0.00 | 36.93 | 0.00 |
| 1994 | 4823.21 | 6436 | 754 | 73.49 | 73.49 | 73.02 | 73.47 | 0.00 | 0.00 | 26.51 | 0.00 |
| 1995 | 6215.96 | 8760 | 754 | 100.00 | 100.00 | 94.11 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1996 | 5188.12 | 7277 | 754 | 82.90 | 86.90 | 78.33 | 82.84 | 2.68 | 2.39 | 10.71 | 4.00 |
| 1997 | 6055.38 | 7816 | 754 | 89.25 | 89.25 | 91.68 | 89.22 | 0.00 | 0.00 | 10.75 | 0.00 |
| 1998 | 6963.48 | 8539 | 811 | 97.66 | 98.93 | 98.02 | 97.48 | 1.07 | 1.07 | 0.00 | 1.26 |
| 1999 | 6095.17 | 7577 | 811 | 86.50 | 89.24 | 85.79 | 86.50 | 7.18 | 6.90 | 3.86 | 2.74 |
| 2000 | 7055.01 | 8616 | 811 | 98.09 | 98.09 | 99.03 | 98.09 | 1.91 | 1.91 | 0.00 | 0.00 |
| 2001 | 6540.43 | 7996 | 811 | 91.29 | 91.29 | 92.06 | 91.28 | 0.00 | 0.00 | 8.71 | 0.00 |
| 2002 | 7078.62 | 8609 | 811 | 98.28 | 98.28 | 99.64 | 98.28 | 0.00 | 0.00 | 1.72 | 0.00 |
| 2003 | 7028.09 | 7966 | 811 | 90.97 | 90.97 | 98.93 | 90.94 | 1.60 | 1.47 | 7.56 | 0.00 |
| 2004 | 7756.76 | 8639 | 900 | 98.53 | 98.53 | 98.12 | 98.35 | 0.86 | 0.85 | 0.62 | 0.00 |
| 2005 | 6781.70 | 7724 | 811 | 88.19 | 88.19 | 95.45 | 88.16 | 3.10 | 2.82 | 8.99 | 0.00 |
| 2006 | 7361.27 | 7972 | 937 | 91.02 | 91.02 | 89.68 | 91.00 | 6.35 | 6.17 | 2.81 | 0.00 |
| 2007 | 7140.26 | 7645 | 937 | 87.28 | 87.28 | 86.99 | 87.27 | 0.00 | 0.00 | 12.72 | 0.00 |
| 2008 | 7854.24 | 8448 | 937 | 96.18 | 96.18 | 95.43 | 96.17 | 3.82 | 3.82 | 0.00 | 0.00 |
| 2009 | 6410.20 | 7060 | 920 | 80.27 | 80.27 | 79.54 | 80.59 | 3.43 | 2.85 | 16.88 | 0.00 |
| 2010 | 8000.04 | 8639 | 920 | 98.63 | 98.63 | 99.27 | 98.62 | 0.09 | 0.09 | 1.28 | 0.00 |
| 2011 | 6336.69 | 6995 | 920 | 79.88 | 79.88 | 78.63 | 79.85 | 0.00 | 0.00 | 20.12 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|-------|--------|------|------|-------|------|
| 2012 | 7987.81 | 8704 | 920 | 99.10 | 99.10 | 98.84 | 99.09 | 0.90 | 0.90 | 0.00 | 0.00 |
| 2013 | 6385.33 | 7059 | 920 | 80.58 | 80.58 | 79.22 | 80.57 | 1.25 | 1.02 | 18.40 | 0.00 |
| 2014 | 7987.55 | 8715 | 920 | 99.48 | 99.48 | 99.11 | 99.49 | 0.00 | 0.00 | 0.52 | 0.00 |
| 2015 | 7098.43 | 7704 | 920 | 87.92 | 87.92 | 88.08 | 87.95 | 0.00 | 0.00 | 12.08 | 0.00 |
| 2016 | 8075.19 | 8784 | 920 | 100.00 | 100.00 | 99.92 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 7191.04 | 8010 | 920 | 91.44 | 91.44 | 89.23 | 91.44 | 0.00 | 0.00 | 8.56 | 0.00 |
| 2018 | 7532.90 | 8453 | 932 | 96.50 | 98.23 | 92.27 | 96.50 | 0.41 | 0.41 | 1.36 | 1.74 |
| 2019 | 6972.51 | 7689 | 932 | 87.79 | 88.42 | 85.40 | 87.77 | 0.00 | 0.00 | 11.58 | 0.64 |
| 2020 | 8088.45 | 8740 | 932 | 99.51 | 99.51 | 98.80 | 99.50 | 0.49 | 0.49 | 0.00 | 0.00 |
| 2021 | 7450.71 | 8035 | 932 | 91.73 | 91.73 | 91.26 | 91.72 | 0.00 | 0.00 | 8.27 | 0.00 |
| 2022 | 7831.71 | 8625 | 932 | 98.46 | 98.46 | 95.93 | 98.46 | 0.00 | 0.00 | 1.54 | 0.00 |
| 2023 | 7414.54 | 8079 | 932 | 91.10 | 91.10 | 90.82 | 92.23 | 0.05 | 0.05 | 8.85 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 481 | |
| B. Refuelling without maintenance | | | | 15 | | |
| C. Inspection, maintenance or repair combined with refuelling | 896 | | | 993 | | |
| D. Inspection, maintenance or repair without refuelling | 48 | | | 297 | | |
| E. Testing of plant systems or components | | | | 10 | 3 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 0 | | |
| H. Nuclear regulatory requirements | | | | | 5 | |
| L. Human factor related | | | | | 37 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 26 |
| Z. Other | | | | | 5 | 1 |
| Subtotal | 944 | | | 1315 | 531 | 27 |
| Total | | 944 | | | 1873 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 12 |
| 12. Reactor I&C Systems | | 17 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 28 |
| 15. Reactor Cooling Systems | | 183 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 5 |
| 21. Fuel Handling and Storage Facilities | | 22 |
| 31. Turbine and auxiliaries | | 64 |
| 32. Feedwater and Main Steam System | | 39 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 13 |
| 41. Main Generator Systems | | 30 |
| 42. Electrical Power Supply Systems | | 57 |
| Total | | 481 |

2023 Operating Experience

US-454

BYRON-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3645 MWth
 Gross electrical power : 1242 MWe
 Reference unit power (net) : 1164 MWe

Key Dates

Construction Date : 1975-04-01
 Grid Date : 1985-03-01
 Commercial Date : 1985-09-16
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 43
 Average discharge burnup [MWd/t] : 49000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.65
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 18.3
 Number of control rod assemblies : 25
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 326
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.42

Secondary systems

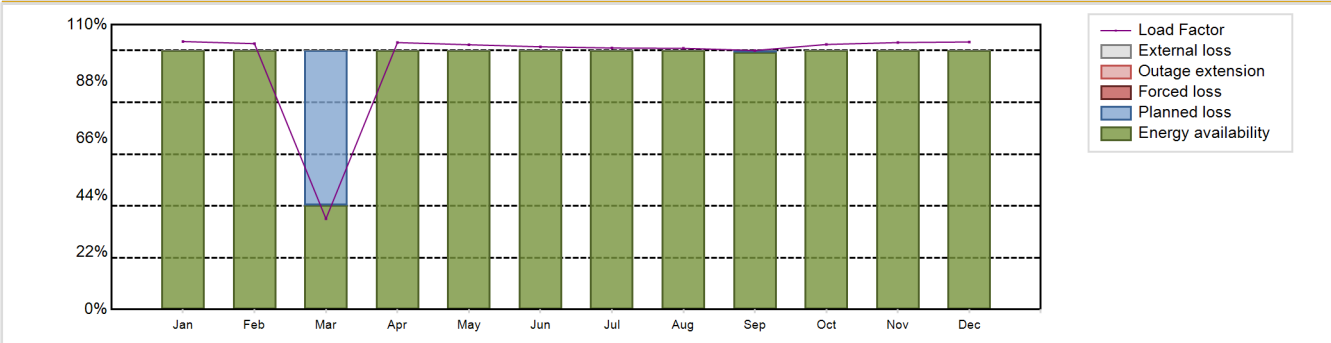
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.63
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9835.73 GW(e).h
 Energy Availability Factor (EAF) : 94.89 %
 Unit Capability Factor (UCF) : 94.89 %
 Load Factor (LF) : 96.46 %
 Operating Factor (OF) : 94.92 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 5.11 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 445 hours

Annual Summary

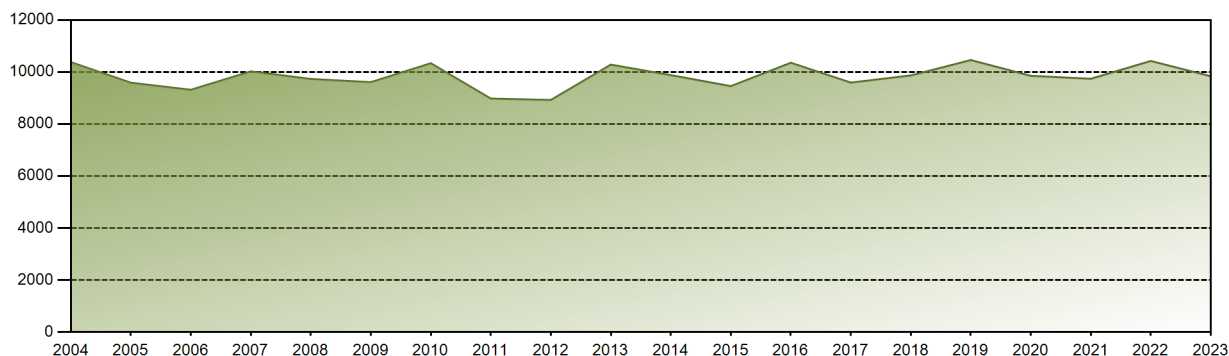


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 896.34 | 803.09 | 303.10 | 864.01 | 885.63 | 850.31 | 874.69 | 873.57 | 838.29 | 886.55 | 865.24 | 894.91 | 9835.73 |
| EAF [%] | 100.00 | 100.00 | 40.43 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.27 | 100.00 | 100.00 | 100.00 | 94.89 |
| UCF [%] | 100.00 | 100.00 | 40.43 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.27 | 100.00 | 100.00 | 100.00 | 94.89 |
| LF [%] | 103.50 | 102.67 | 35.05 | 103.09 | 102.27 | 101.46 | 101.00 | 100.87 | 100.02 | 102.37 | 103.10 | 103.34 | 96.46 |
| OF [%] | 100.00 | 100.00 | 40.11 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.92 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 59.57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.73 | 0.00 | 0.00 | 0.00 | 5.11 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 339778.62 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.74 % |
| Cumulative Energy Availability Factor (EAF) | : 90.59 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.68 % |
| Cumulative Unit Capability Factor (UCF) | : 90.66 % | Cumulative Planned Unavailability Factor (PUF) | : 8.66 % |
| Cumulative Load Factor (LF) | : 88.72 % | Cumulative Externally cause unavailability (XUF) | : 0.07 % |
| Cumulative Operating Factor (OF) | : 90.49 % | | |

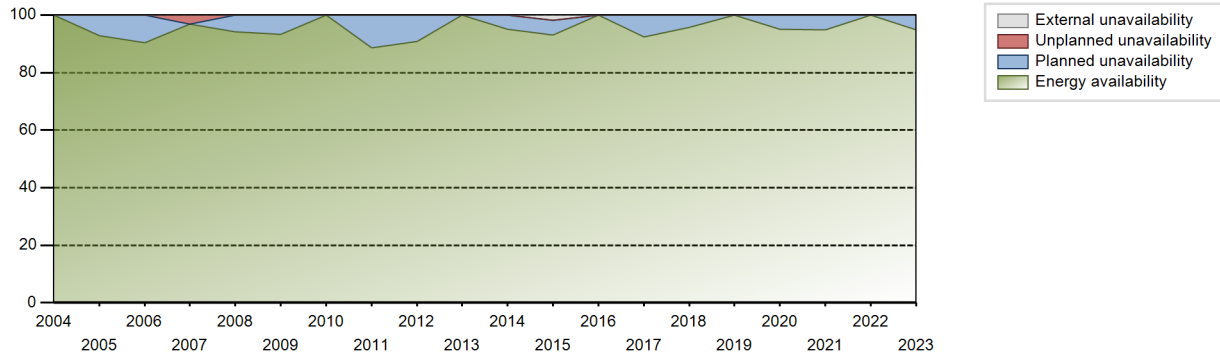
Electricity Production (net) [GWh]



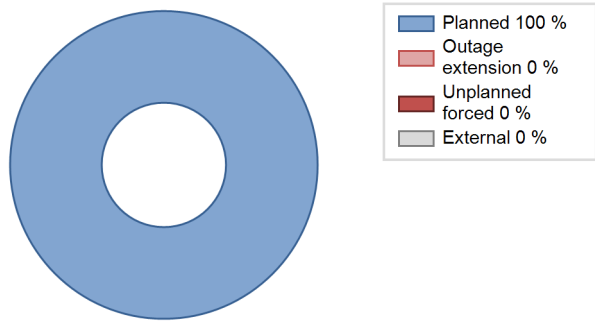
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 1696.12 | 2025 | 1124 | 41.27 | 41.27 | 31.22 | 40.74 | 3.54 | 1.51 | 57.21 | 0.00 |
| 1986 | 7396.00 | 7760 | 1129 | 89.09 | 89.09 | 74.78 | 88.58 | 7.52 | 7.24 | 3.67 | 0.00 |
| 1987 | 5355.66 | 6005 | 1125 | 68.74 | 69.62 | 54.33 | 68.55 | 0.92 | 0.64 | 29.74 | 0.89 |
| 1988 | 6303.67 | 6393 | 1112 | 72.90 | 72.90 | 64.51 | 72.78 | 1.88 | 1.40 | 25.71 | 0.00 |
| 1989 | 8945.52 | 8737 | 1105 | 99.74 | 99.74 | 92.41 | 99.74 | 0.26 | 0.26 | 0.00 | 0.00 |
| 1990 | 6951.66 | 7059 | 1105 | 80.33 | 80.33 | 71.82 | 80.58 | 2.95 | 2.44 | 17.23 | 0.00 |
| 1991 | 6318.07 | 7148 | 1105 | 81.35 | 81.35 | 65.27 | 81.60 | 1.07 | 0.88 | 17.77 | 0.00 |
| 1992 | 8986.36 | 8723 | 1105 | 99.30 | 99.30 | 92.58 | 99.31 | 0.70 | 0.70 | 0.00 | 0.00 |
| 1993 | 7366.86 | 7104 | 1105 | 80.85 | 80.85 | 76.11 | 81.10 | 1.34 | 1.10 | 18.05 | 0.00 |
| 1994 | 6801.55 | 7136 | 1105 | 81.24 | 81.24 | 70.27 | 81.46 | 4.04 | 3.42 | 15.33 | 0.00 |
| 1995 | 7706.54 | 7228 | 1105 | 82.30 | 82.30 | 79.61 | 82.51 | 0.00 | 0.00 | 17.70 | 0.00 |
| 1996 | 6871.06 | 6588 | 1105 | 74.70 | 74.70 | 70.79 | 75.00 | 0.58 | 0.44 | 24.87 | 0.00 |
| 1997 | 7161.73 | 6737 | 1105 | 76.78 | 76.78 | 73.99 | 76.91 | 2.97 | 2.35 | 20.87 | 0.00 |
| 1998 | 7804.60 | 7145 | 1105 | 81.54 | 81.54 | 80.63 | 81.56 | 0.00 | 0.00 | 18.46 | 0.00 |
| 1999 | 8908.49 | 7944 | 1105 | 90.59 | 90.59 | 92.03 | 90.68 | 1.47 | 1.35 | 8.06 | 0.00 |
| 2000 | 9291.86 | 8284 | 1105 | 94.24 | 94.24 | 95.73 | 94.31 | 0.00 | 0.00 | 5.76 | 0.00 |
| 2001 | 10389.90 | 8760 | 1163 | 100.00 | 100.00 | 104.13 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2002 | 9827.85 | 8256 | 1163 | 94.08 | 94.08 | 96.47 | 94.25 | 0.76 | 0.72 | 5.20 | 0.00 |
| 2003 | 9858.83 | 8248 | 1163 | 94.01 | 94.01 | 96.77 | 94.16 | 0.00 | 0.00 | 5.99 | 0.00 |
| 2004 | 10381.33 | 8784 | 1152 | 100.00 | 100.00 | 102.19 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 9589.71 | 8135 | 1194 | 92.88 | 92.88 | 91.67 | 92.85 | 0.00 | 0.00 | 7.12 | 0.00 |
| 2006 | 9317.03 | 7914 | 1164 | 90.35 | 90.35 | 91.37 | 90.34 | 0.00 | 0.00 | 9.65 | 0.00 |
| 2007 | 10024.16 | 8482 | 1164 | 96.83 | 96.83 | 98.31 | 96.83 | 3.17 | 3.17 | 0.00 | 0.00 |
| 2008 | 9733.36 | 8266 | 1164 | 94.11 | 94.11 | 95.20 | 94.10 | 0.00 | 0.00 | 5.89 | 0.00 |
| 2009 | 9609.39 | 8169 | 1164 | 93.26 | 93.26 | 94.24 | 93.25 | 0.00 | 0.00 | 6.74 | 0.00 |
| 2010 | 10337.29 | 8760 | 1164 | 100.00 | 100.00 | 101.38 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 8978.80 | 7759 | 1164 | 88.58 | 88.58 | 88.06 | 88.57 | 0.00 | 0.00 | 11.42 | 0.00 |
| 2012 | 8925.08 | 7984 | 1164 | 90.91 | 90.91 | 87.29 | 90.89 | 0.00 | 0.00 | 9.09 | 0.00 |
| 2013 | 10283.27 | 8760 | 1164 | 100.00 | 100.00 | 100.84 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 9879.89 | 8328 | 1164 | 95.06 | 95.06 | 96.89 | 95.07 | 0.00 | 0.00 | 4.94 | 0.00 |
| 2015 | 9456.59 | 8158 | 1164 | 93.12 | 94.88 | 92.74 | 93.13 | 0.00 | 0.00 | 5.12 | 1.76 |
| 2016 | 10356.72 | 8784 | 1164 | 100.00 | 100.00 | 101.29 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 9593.03 | 8098 | 1164 | 92.45 | 92.45 | 94.08 | 92.44 | 0.00 | 0.00 | 7.55 | 0.00 |
| 2018 | 9868.77 | 8385 | 1164 | 95.74 | 95.74 | 96.78 | 95.72 | 0.00 | 0.00 | 4.26 | 0.00 |
| 2019 | 10459.12 | 8760 | 1164 | 100.00 | 100.00 | 102.57 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 9853.74 | 8339 | 1164 | 94.95 | 94.95 | 96.37 | 94.93 | 0.00 | 0.00 | 5.05 | 0.00 |
| 2021 | 9739.71 | 8315 | 1164 | 94.92 | 94.92 | 95.52 | 94.92 | 0.00 | 0.00 | 5.08 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|--------|--------|--------|--------|------|------|------|------|
| 2022 | 10425.57 | 8760 | 1164 | 100.00 | 100.00 | 102.25 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 9835.73 | 8315 | 1164 | 94.89 | 94.89 | 96.46 | 94.92 | 0.00 | 0.00 | 5.11 | 0.00 |

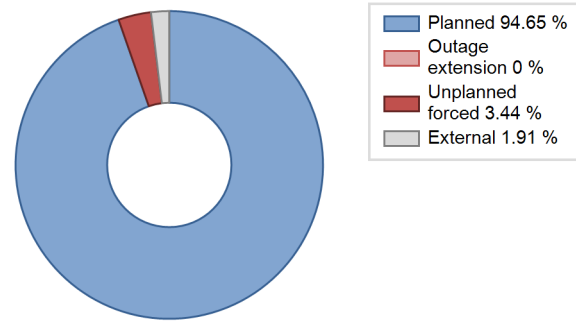
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 43 | |
| B. Refuelling without maintenance | | | | 33 | | |
| C. Inspection, maintenance or repair combined with refuelling | 445 | | | 615 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 115 | | |
| E. Testing of plant systems or components | | | | | 0 | |
| H. Nuclear regulatory requirements | | | | | 9 | |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 7 |
| Z. Other | | | | 2 | 2 | |
| Subtotal | 445 | | | 765 | 60 | 7 |
| Total | | 445 | | | 832 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 13 |
| 12. Reactor I&C Systems | | 2 |
| 13. Reactor Auxiliary Systems | | 2 |
| 15. Reactor Cooling Systems | | 4 |
| 31. Turbine and auxiliaries | | 10 |
| 32. Feedwater and Main Steam System | | 7 |
| 34. Miscellaneous Systems | | 3 |
| 41. Main Generator Systems | | 0 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | | 45 |

2023 Operating Experience

US-455

BYRON-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3645 MWth
 Gross electrical power : 1210 MWe
 Reference unit power (net) : 1136 MWe

Key Dates

Construction Date : 1975-04-01
 Grid Date : 1987-02-06
 Commercial Date : 1987-08-02
 Age at end of year : 36 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 43
 Average discharge burnup [MWd/t] : 49000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.65
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 18.3
 Number of control rod assemblies : 25
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 326
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.42

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.63
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

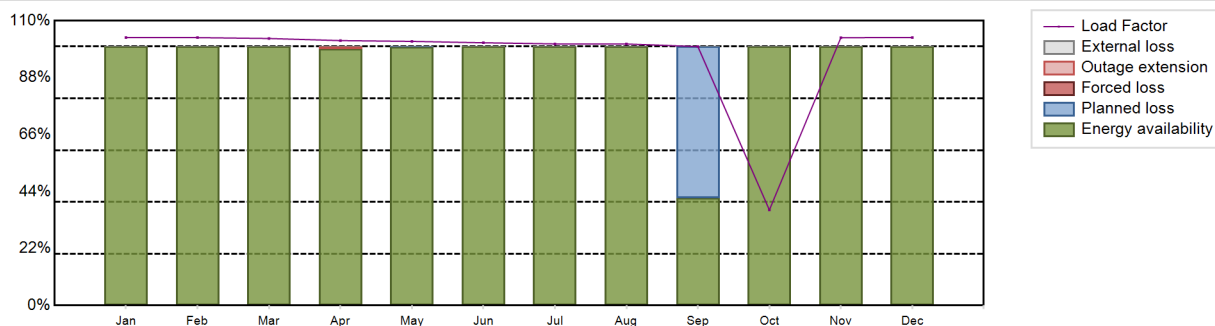
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9623.79 GW(e).h
 Energy Availability Factor (EAF) : 95.11 %
 Unit Capability Factor (UCF) : 95.11 %
 Load Factor (LF) : 96.71 %
 Operating Factor (OF) : 95.17 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0.08 %
 Planned Unavailability Factor (PUF) : 4.81 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 423 hours

Annual Summary

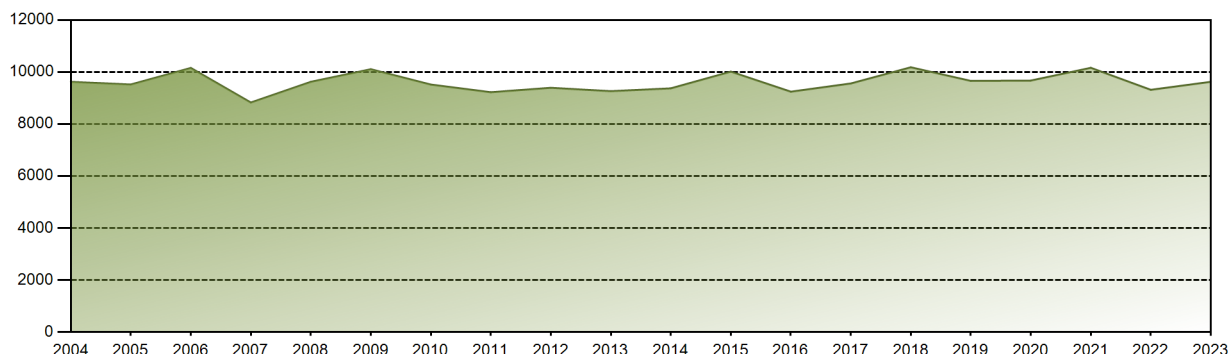


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 874.87 | 789.88 | 870.47 | 836.85 | 862.20 | 830.01 | 853.94 | 853.82 | 817.92 | 311.83 | 847.29 | 874.72 | 9623.79 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 99.01 | 99.87 | 100.00 | 100.00 | 100.00 | 41.66 | 100.00 | 100.00 | 100.00 | 95.11 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 99.01 | 99.87 | 100.00 | 100.00 | 100.00 | 41.66 | 100.00 | 100.00 | 100.00 | 95.11 |
| LF [%] | 103.51 | 103.47 | 103.13 | 102.31 | 102.01 | 101.48 | 101.04 | 101.02 | 100.00 | 36.89 | 103.45 | 103.49 | 96.71 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 43.15 | 100.00 | 100.00 | 95.17 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.99 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 0.00 | 58.34 | 0.00 | 0.00 | 0.00 | 4.81 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

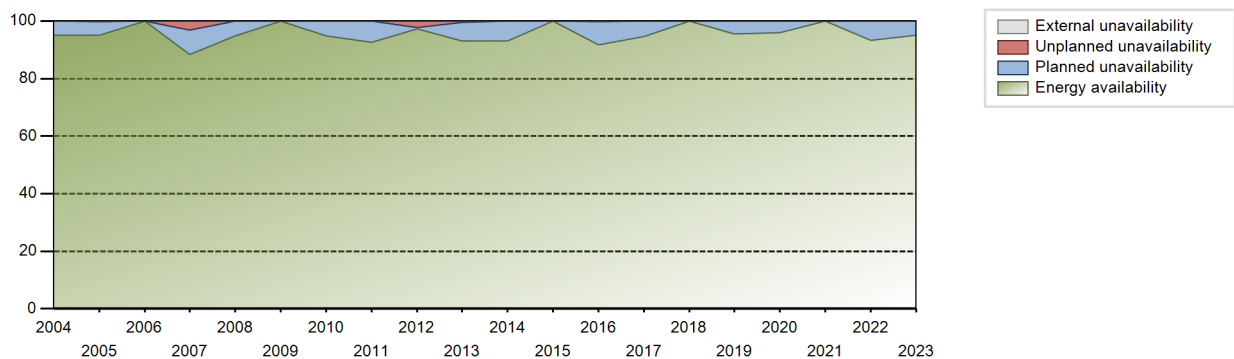
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 327900.01 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.78 % |
| Cumulative Energy Availability Factor (EAF) | : 93.35 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.73 % |
| Cumulative Unit Capability Factor (UCF) | : 93.35 % | Cumulative Planned Unavailability Factor (PUF) | : 5.92 % |
| Cumulative Load Factor (LF) | : 91.33 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 92.94 % | | |

Electricity Production (net) [GWh]

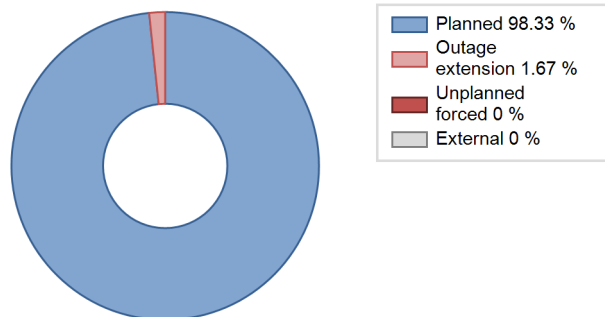


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 3876.06 | 5071 | 1128 | 100.00 | 100.00 | 47.54 | 62.91 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1988 | 6357.92 | 8419 | 1112 | 95.86 | 95.86 | 65.06 | 95.84 | 2.04 | 1.99 | 2.14 | 0.00 |
| 1989 | 6069.54 | 6981 | 1105 | 79.46 | 79.46 | 62.70 | 79.69 | 4.88 | 4.08 | 16.46 | 0.00 |
| 1990 | 6052.68 | 6598 | 1105 | 75.00 | 75.00 | 62.53 | 75.32 | 1.02 | 0.78 | 24.23 | 0.00 |
| 1991 | 8772.68 | 8489 | 1105 | 96.89 | 96.89 | 90.63 | 96.91 | 3.11 | 3.11 | 0.00 | 0.00 |
| 1992 | 7000.34 | 7027 | 1105 | 79.76 | 79.76 | 72.12 | 80.00 | 1.27 | 1.03 | 19.21 | 0.00 |
| 1993 | 7622.47 | 7399 | 1105 | 84.26 | 84.26 | 78.75 | 84.46 | 1.35 | 1.16 | 14.58 | 0.00 |
| 1994 | 9504.17 | 8704 | 1105 | 99.36 | 99.36 | 98.19 | 99.36 | 0.64 | 0.64 | 0.00 | 0.00 |
| 1995 | 8183.77 | 7710 | 1105 | 87.87 | 87.87 | 84.54 | 88.01 | 0.00 | 0.00 | 12.13 | 0.00 |
| 1996 | 7830.62 | 7225 | 1105 | 82.05 | 82.05 | 80.68 | 82.25 | 5.51 | 4.79 | 13.17 | 0.00 |
| 1997 | 9102.89 | 8344 | 1105 | 95.21 | 95.21 | 94.04 | 95.25 | 0.44 | 0.42 | 4.37 | 0.00 |
| 1998 | 8592.83 | 7855 | 1105 | 89.54 | 89.54 | 88.76 | 89.66 | 0.00 | 0.00 | 10.46 | 0.00 |
| 1999 | 9174.10 | 8182 | 1105 | 93.32 | 93.32 | 94.78 | 93.40 | 0.00 | 0.00 | 6.68 | 0.00 |
| 2000 | 10005.38 | 8724 | 1105 | 99.32 | 99.32 | 103.08 | 99.32 | 0.68 | 0.68 | 0.00 | 0.00 |
| 2001 | 9826.73 | 8353 | 1131 | 95.30 | 95.30 | 100.14 | 95.35 | 0.33 | 0.31 | 4.38 | 0.00 |
| 2002 | 9537.62 | 8119 | 1131 | 92.31 | 92.31 | 96.27 | 92.68 | 1.72 | 1.62 | 6.07 | 0.00 |
| 2003 | 10298.69 | 8760 | 1131 | 100.00 | 100.00 | 103.95 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 9623.24 | 8360 | 1125 | 95.04 | 95.04 | 97.17 | 95.17 | 0.00 | 0.00 | 4.96 | 0.00 |
| 2005 | 9521.05 | 8328 | 1162 | 95.08 | 95.08 | 93.54 | 95.07 | 0.35 | 0.33 | 4.59 | 0.00 |
| 2006 | 10158.74 | 8760 | 1136 | 100.00 | 100.00 | 102.08 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 8828.60 | 7736 | 1136 | 88.33 | 88.33 | 88.72 | 88.31 | 3.34 | 3.05 | 8.62 | 0.00 |
| 2008 | 9624.16 | 8339 | 1136 | 94.94 | 94.94 | 96.45 | 94.93 | 0.00 | 0.00 | 5.06 | 0.00 |
| 2009 | 10108.89 | 8760 | 1136 | 100.00 | 100.00 | 101.58 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 9518.42 | 8300 | 1136 | 94.76 | 94.76 | 95.65 | 94.75 | 0.00 | 0.00 | 5.24 | 0.00 |
| 2011 | 9223.94 | 8115 | 1136 | 92.65 | 92.65 | 92.69 | 92.64 | 0.00 | 0.00 | 7.35 | 0.00 |
| 2012 | 9393.22 | 8536 | 1136 | 97.19 | 97.19 | 94.13 | 97.18 | 2.19 | 2.17 | 0.64 | 0.00 |
| 2013 | 9263.79 | 8160 | 1136 | 93.15 | 93.15 | 93.08 | 93.14 | 0.52 | 0.49 | 6.36 | 0.00 |
| 2014 | 9372.50 | 8158 | 1136 | 93.13 | 93.13 | 94.18 | 93.13 | 0.00 | 0.00 | 6.87 | 0.00 |
| 2015 | 10015.44 | 8760 | 1136 | 100.00 | 100.00 | 100.64 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 9243.53 | 8064 | 1136 | 91.80 | 91.80 | 92.63 | 91.80 | 0.23 | 0.21 | 7.99 | 0.00 |
| 2017 | 9560.01 | 8295 | 1136 | 94.69 | 94.69 | 96.07 | 94.69 | 0.00 | 0.00 | 5.31 | 0.00 |
| 2018 | 10182.25 | 8760 | 1136 | 100.00 | 100.00 | 102.32 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 9658.86 | 8372 | 1136 | 95.58 | 95.58 | 97.06 | 95.57 | 0.00 | 0.00 | 4.42 | 0.00 |
| 2020 | 9671.16 | 8430 | 1136 | 95.98 | 95.98 | 96.92 | 95.97 | 0.00 | 0.00 | 4.02 | 0.00 |
| 2021 | 10162.04 | 8760 | 1136 | 100.00 | 100.00 | 102.12 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 9316.18 | 8178 | 1136 | 93.36 | 93.36 | 93.62 | 93.36 | 0.00 | 0.00 | 6.64 | 0.00 |
| 2023 | 9623.79 | 8337 | 1136 | 95.11 | 95.11 | 96.71 | 95.17 | 0.00 | 0.08 | 4.81 | 0.00 |

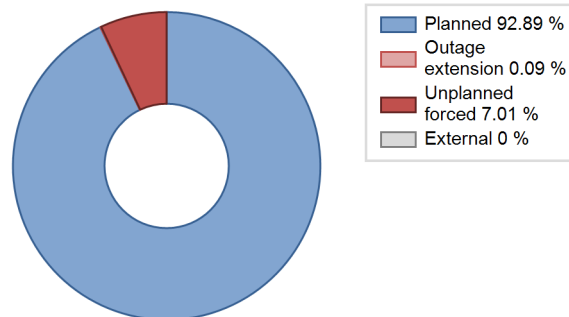
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 53 | |
| B. Refuelling without maintenance | | | | 26 | | |
| C. Inspection, maintenance or repair combined with refuelling | 442 | | | 468 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 29 | | |
| H. Nuclear regulatory requirements | | | | | 7 | |
| Z. Other | | | | | 5 | |
| Subtotal | 442 | | | 523 | 65 | |
| Total | | 442 | | | 588 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 3 |
| 15. Reactor Cooling Systems | | 6 |
| 16. Steam generation systems | | 12 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 32. Feedwater and Main Steam System | | 5 |
| 34. Miscellaneous Systems | | 9 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 7 |
| 42. Electrical Power Supply Systems | | 5 |
| Total | | 52 |

2023 Operating Experience

US-483

CALLAWAY-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : AmerenUE (AMEREN UE, Union Electric Company)
 Owner : AmerenUE (AMEREN UE, Union Electric Company)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3565 MWth
 Gross electrical power : 1275 MWe
 Reference unit power (net) : 1215 MWe

Key Dates

Construction Date : 1975-09-01
 Grid Date : 1984-10-24
 Commercial Date : 1984-12-19
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 42000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.65
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 19.13
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 329
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.34

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.78
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

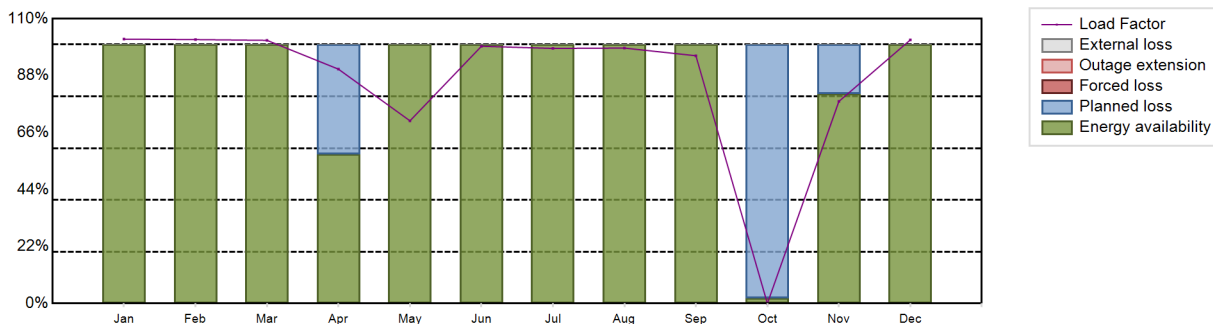
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9195.58 GW(e).h
 Energy Availability Factor (EAF) : 86.64 %
 Unit Capability Factor (UCF) : 86.64 %
 Load Factor (LF) : 86.4 %
 Operating Factor (OF) : 86.45 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 13.36 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1187 hours

Annual Summary

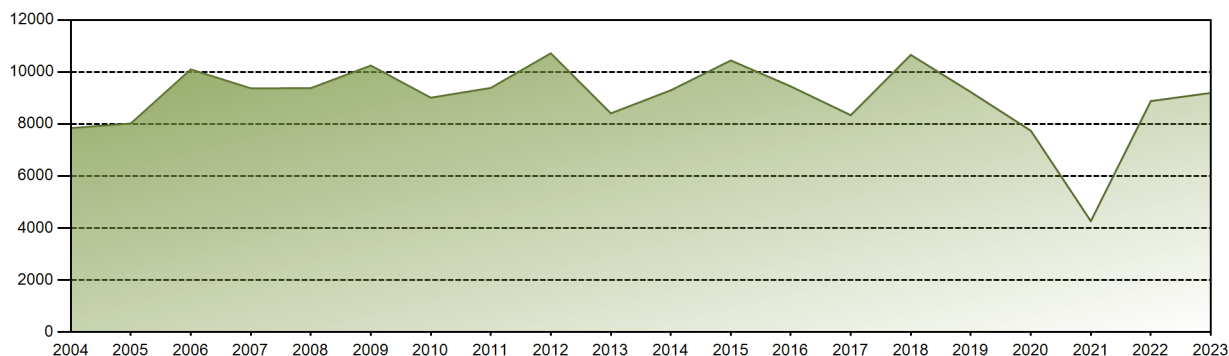


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 923.03 | 832.24 | 917.64 | 791.82 | 637.87 | 869.22 | 890.61 | 891.83 | 837.16 | 0.00 | 683.74 | 920.43 | 9195.58 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 57.56 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 2.06 | 81.11 | 100.00 | 86.64 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 57.56 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 2.06 | 81.11 | 100.00 | 86.64 |
| LF [%] | 102.11 | 101.93 | 101.65 | 90.51 | 70.56 | 99.36 | 98.52 | 98.66 | 95.70 | 0.00 | 78.05 | 101.82 | 86.40 |
| OF [%] | 100.00 | 100.00 | 100.00 | 90.00 | 72.04 | 100.00 | 100.00 | 100.00 | 96.67 | 0.00 | 80.72 | 100.00 | 86.45 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 42.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 97.94 | 18.89 | 0.00 | 13.36 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 343239.64 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.72 % |
| Cumulative Energy Availability Factor (EAF) | : 86.94 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.36 % |
| Cumulative Unit Capability Factor (UCF) | : 86.94 % | Cumulative Planned Unavailability Factor (PUF) | : 9.69 % |
| Cumulative Load Factor (LF) | : 86.14 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 86.75 % | | |

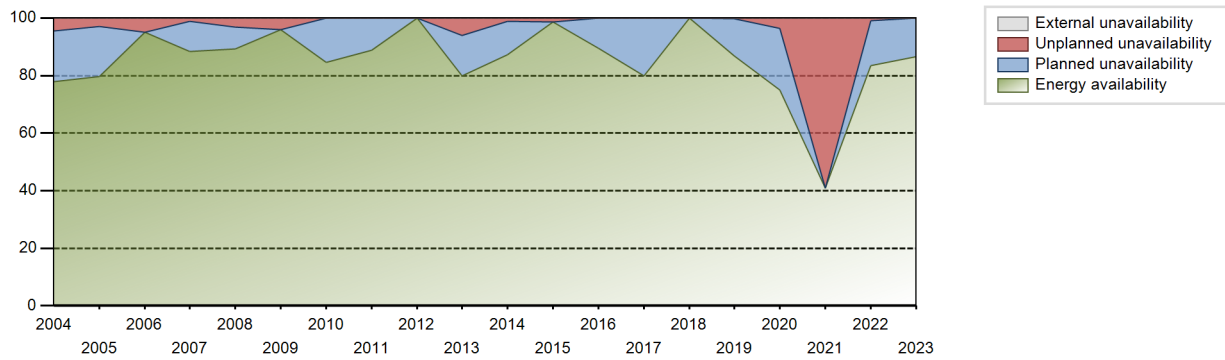
Electricity Production (net) [GWh]



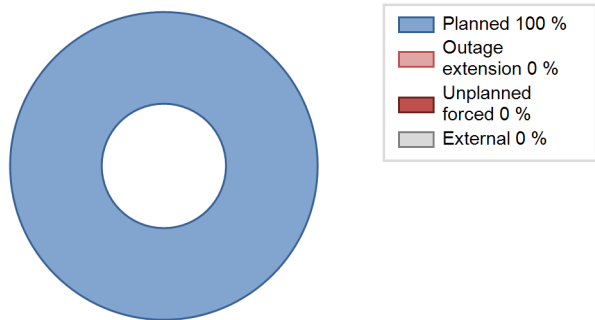
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 577.21 | 863 | 1140 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1985 | 8045.76 | 7882 | 1120 | 89.99 | 89.99 | 82.01 | 89.98 | 6.38 | 6.14 | 3.87 | 0.00 |
| 1986 | 7199.11 | 7121 | 1120 | 81.57 | 81.57 | 73.38 | 81.29 | 3.29 | 2.78 | 15.65 | 0.00 |
| 1987 | 6321.78 | 6141 | 1120 | 70.02 | 70.02 | 64.43 | 70.10 | 1.98 | 1.42 | 28.56 | 0.00 |
| 1988 | 8144.18 | 7413 | 1120 | 92.53 | 92.53 | 82.75 | 84.39 | 3.18 | 3.03 | 4.44 | 0.00 |
| 1989 | 8350.92 | 7368 | 1118 | 84.04 | 84.04 | 85.27 | 84.11 | 1.04 | 0.89 | 15.08 | 0.00 |
| 1990 | 8005.06 | 7167 | 1125 | 81.84 | 81.84 | 81.23 | 81.82 | 3.49 | 2.96 | 15.21 | 0.00 |
| 1991 | 9979.37 | 8726 | 1125 | 99.61 | 99.61 | 101.26 | 99.61 | 0.39 | 0.39 | 0.00 | 0.00 |
| 1992 | 8094.55 | 7204 | 1125 | 82.04 | 82.04 | 81.91 | 82.01 | 1.95 | 1.63 | 16.34 | 0.00 |
| 1993 | 8389.95 | 7498 | 1120 | 85.53 | 85.53 | 85.51 | 85.59 | 0.00 | 0.00 | 14.47 | 0.00 |
| 1994 | 10006.49 | 8726 | 1115 | 99.62 | 99.62 | 102.45 | 99.61 | 0.00 | 0.00 | 0.38 | 0.00 |
| 1995 | 8252.83 | 7356 | 1125 | 83.98 | 83.98 | 83.74 | 83.97 | 3.29 | 2.85 | 13.16 | 0.00 |
| 1996 | 8890.38 | 7864 | 1125 | 89.56 | 89.56 | 89.97 | 89.53 | 2.01 | 1.83 | 8.61 | 0.00 |
| 1997 | 8954.60 | 8760 | 1125 | 100.00 | 100.00 | 90.86 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1998 | 8516.77 | 7913 | 1125 | 90.36 | 90.36 | 86.42 | 90.33 | 1.19 | 1.09 | 8.55 | 0.00 |
| 1999 | 8596.43 | 7707 | 1125 | 87.79 | 87.79 | 87.23 | 87.98 | 2.75 | 2.48 | 9.73 | 0.00 |
| 2000 | 9991.84 | 8762 | 1125 | 99.75 | 100.00 | 101.11 | 99.75 | 0.00 | 0.00 | 0.00 | 0.25 |
| 2001 | 8384.12 | 7500 | 1125 | 85.39 | 85.39 | 85.07 | 85.62 | 2.48 | 2.17 | 12.44 | 0.00 |
| 2002 | 8386.58 | 7484 | 1125 | 85.20 | 85.20 | 85.10 | 85.43 | 5.84 | 5.29 | 9.51 | 0.00 |
| 2003 | 9699.74 | 8397 | 1125 | 95.81 | 95.81 | 98.42 | 95.86 | 0.98 | 0.95 | 3.25 | 0.00 |
| 2004 | 7842.38 | 6856 | 1125 | 77.93 | 77.93 | 79.36 | 78.05 | 5.38 | 4.43 | 17.64 | 0.00 |
| 2005 | 8021.18 | 6966 | 1137 | 79.57 | 79.57 | 80.53 | 79.52 | 3.65 | 3.01 | 17.42 | 0.00 |
| 2006 | 10098.88 | 8324 | 1190 | 95.04 | 95.04 | 96.88 | 95.02 | 4.96 | 4.96 | 0.00 | 0.00 |
| 2007 | 9371.96 | 7742 | 1190 | 88.40 | 88.40 | 89.90 | 88.38 | 1.25 | 1.12 | 10.48 | 0.00 |
| 2008 | 9378.23 | 7834 | 1190 | 89.20 | 89.20 | 89.72 | 89.18 | 3.43 | 3.16 | 7.64 | 0.00 |
| 2009 | 10247.12 | 8408 | 1190 | 96.01 | 96.01 | 98.30 | 95.98 | 3.99 | 3.99 | 0.00 | 0.00 |
| 2010 | 9011.04 | 7412 | 1190 | 84.63 | 84.63 | 86.44 | 84.61 | 0.00 | 0.00 | 15.37 | 0.00 |
| 2011 | 9387.87 | 7771 | 1215 | 88.74 | 88.74 | 89.90 | 88.71 | 0.00 | 0.00 | 11.26 | 0.00 |
| 2012 | 10718.32 | 8784 | 1215 | 100.00 | 100.00 | 100.43 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 8408.87 | 7008 | 1215 | 79.99 | 79.99 | 79.00 | 79.99 | 7.13 | 6.14 | 13.87 | 0.00 |
| 2014 | 9297.34 | 7649 | 1215 | 87.31 | 87.31 | 87.35 | 87.32 | 1.19 | 1.05 | 11.64 | 0.00 |
| 2015 | 10443.55 | 8648 | 1215 | 98.73 | 98.73 | 98.12 | 98.72 | 1.27 | 1.27 | 0.00 | 0.00 |
| 2016 | 9445.58 | 7859 | 1215 | 89.48 | 89.48 | 88.50 | 89.47 | 0.00 | 0.00 | 10.52 | 0.00 |
| 2017 | 8338.45 | 6995 | 1215 | 79.85 | 79.85 | 78.34 | 79.85 | 0.00 | 0.00 | 20.15 | 0.00 |
| 2018 | 10657.75 | 8760 | 1215 | 100.00 | 100.00 | 100.13 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 9227.76 | 7603 | 1215 | 86.81 | 86.81 | 86.70 | 86.79 | 0.18 | 0.15 | 13.04 | 0.00 |
| 2020 | 7742.12 | 6477 | 1215 | 74.93 | 74.93 | 72.54 | 73.74 | 4.68 | 3.68 | 21.39 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|-------|-------|-------|------|
| 2021 | 4265.82 | 3584 | 1215 | 40.91 | 40.91 | 40.08 | 40.91 | 59.09 | 59.09 | 0.00 | 0.00 |
| 2022 | 8882.15 | 7312 | 1215 | 83.47 | 83.47 | 83.45 | 83.47 | 1.16 | 0.98 | 15.55 | 0.00 |
| 2023 | 9195.58 | 7573 | 1215 | 86.64 | 86.64 | 86.40 | 86.45 | 0.00 | 0.00 | 13.36 | 0.00 |

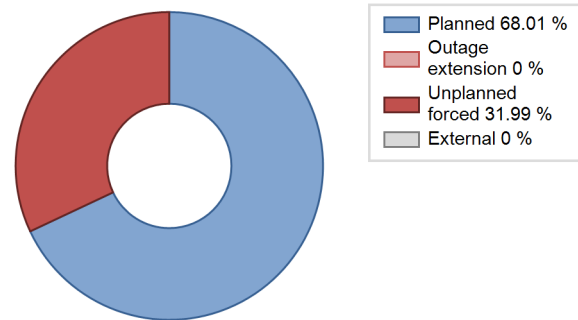
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 137 | |
| B. Refuelling without maintenance | | | | 83 | | |
| C. Inspection, maintenance or repair combined with refuelling | 907 | | | 702 | | |
| D. Inspection, maintenance or repair without refuelling | 312 | | | 65 | | |
| E. Testing of plant systems or components | | | | 0 | 1 | |
| H. Nuclear regulatory requirements | | | | | 0 | |
| L. Human factor related | | | | | 6 | |
| Z. Other | | | | | 129 | 1 |
| Subtotal | 1219 | | | 850 | 273 | 1 |
| Total | | 1219 | | | 1124 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 5 |
| 12. Reactor I&C Systems | | 6 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 12 |
| 16. Steam generation systems | | 3 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 22 |
| 32. Feedwater and Main Steam System | | 27 |
| 33. Circulating Water System | | 9 |
| 34. Miscellaneous Systems | | 5 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 9 |
| 42. Electrical Power Supply Systems | | 35 |
| Total | | 138 |

2023 Operating Experience

US-317

CALVERT CLIFFS-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : CE (COMBUSTION ENGINEERING CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / CE 2LP (DRYAMB)
 Thermal power : 2737 MWth
 Gross electrical power : 918 MWe
 Reference unit power (net) : 877 MWe

Key Dates

Construction Date : 1968-06-01
 Grid Date : 1975-01-03
 Commercial Date : 1975-05-08
 Age at end of year : 48 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 3.45
 Active core height/length [m] : 3.47
 Number of fissile fuel assemblies/bundles : 217
 Fuel linear heat generation rate [kW/m] : 20.62
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 314
 Number of SG : 2
 Containment type : -
 Containment design pressure [MPa] : 0.352

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

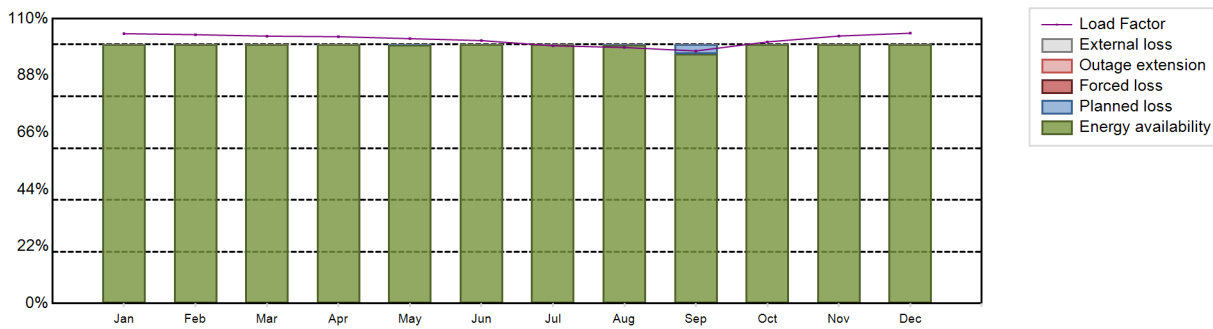
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7828.41 GW(e).h
 Energy Availability Factor (EAF) : 99.68 %
 Unit Capability Factor (UCF) : 99.68 %
 Load Factor (LF) : 101.9 %
 Operating Factor (OF) : 100 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.32 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

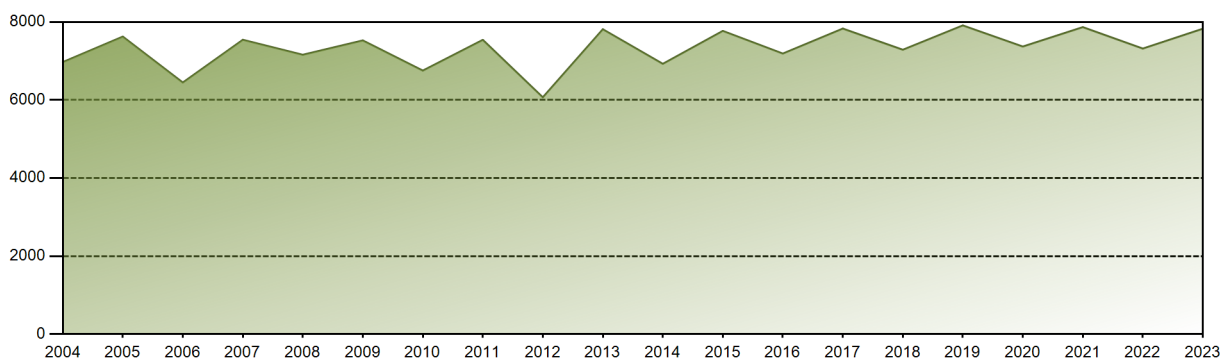


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 679.99 | 611.88 | 672.92 | 650.70 | 667.44 | 641.21 | 649.51 | 645.16 | 615.88 | 659.26 | 653.20 | 681.26 | 7828.41 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.81 | 100.00 | 100.00 | 99.97 | 96.33 | 100.00 | 100.00 | 100.00 | 99.68 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.81 | 100.00 | 100.00 | 99.97 | 96.33 | 100.00 | 100.00 | 100.00 | 99.68 |
| LF [%] | 104.22 | 103.82 | 103.27 | 103.05 | 102.29 | 101.55 | 99.54 | 98.88 | 97.54 | 101.04 | 103.30 | 104.41 | 101.90 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.03 | 3.67 | 0.00 | 0.00 | 0.00 | 0.32 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 302170.15 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.84 % |
| Cumulative Energy Availability Factor (EAF) | : 82.89 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.32 % |
| Cumulative Unit Capability Factor (UCF) | : 83.12 % | Cumulative Planned Unavailability Factor (PUF) | : 13.56 % |
| Cumulative Load Factor (LF) | : 83.97 % | Cumulative Externally cause unavailability (XUF) | : 0.23 % |
| Cumulative Operating Factor (OF) | : 83.23 % | | |

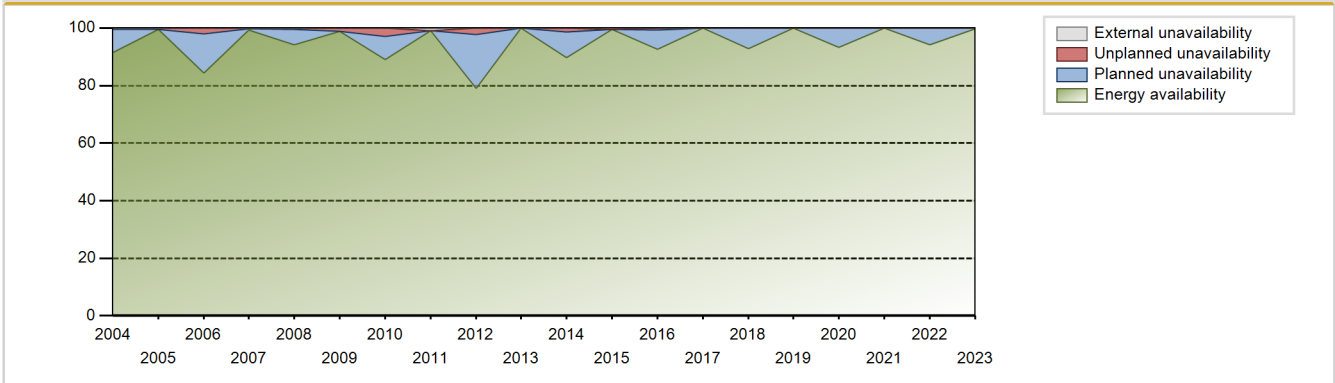
Electricity Production (net) [GWh]



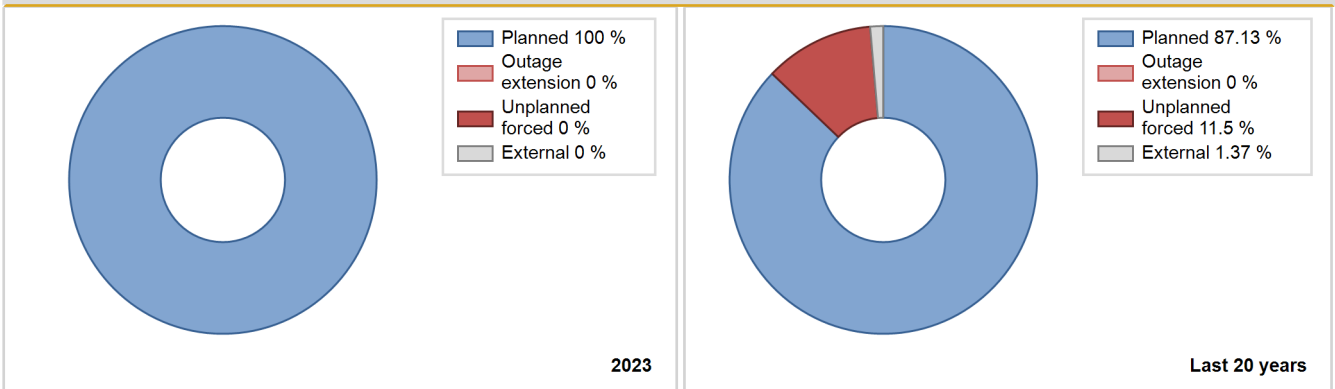
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 4381.60 | 6667 | 800 | 77.16 | 77.16 | 77.40 | 81.75 | 15.38 | 14.02 | 8.82 | 0.00 |
| 1976 | 6303.90 | 8356 | 800 | 89.70 | 89.70 | 89.71 | 95.13 | 2.27 | 2.08 | 8.22 | 0.00 |
| 1977 | 4882.00 | 6313 | 807 | 68.62 | 68.62 | 69.06 | 72.07 | 8.77 | 6.60 | 24.78 | 0.00 |
| 1978 | 4676.10 | 6150 | 810 | 65.91 | 65.91 | 65.90 | 70.21 | 16.09 | 12.64 | 21.45 | 0.00 |
| 1979 | 4194.10 | 6154 | 810 | 59.11 | 59.11 | 59.11 | 70.25 | 23.95 | 18.62 | 22.27 | 0.00 |
| 1980 | 4542.50 | 6349 | 810 | 72.20 | 77.03 | 63.84 | 72.28 | 4.97 | 4.03 | 18.94 | 4.84 |
| 1981 | 6109.60 | 7544 | 821 | 86.43 | 86.43 | 84.95 | 86.12 | 10.53 | 10.17 | 3.40 | 0.00 |
| 1982 | 5362.10 | 6419 | 825 | 73.86 | 73.86 | 74.20 | 73.28 | 0.64 | 0.48 | 25.66 | 0.00 |
| 1983 | 5570.70 | 6719 | 825 | 77.04 | 77.04 | 77.08 | 76.70 | 2.67 | 2.11 | 20.84 | 0.00 |
| 1984 | 6221.60 | 7422 | 825 | 84.35 | 86.67 | 85.85 | 84.49 | 13.33 | 13.33 | 0.00 | 2.32 |
| 1985 | 4359.73 | 5186 | 825 | 58.76 | 58.76 | 60.33 | 59.20 | 5.79 | 3.61 | 37.63 | 0.00 |
| 1986 | 5830.74 | 6855 | 825 | 78.24 | 78.24 | 80.68 | 78.25 | 1.66 | 1.32 | 20.44 | 0.00 |
| 1987 | 5268.48 | 6233 | 825 | 70.91 | 70.91 | 72.90 | 71.15 | 26.14 | 25.09 | 4.00 | 0.00 |
| 1988 | 5164.23 | 6263 | 825 | 71.01 | 71.01 | 71.26 | 71.30 | 2.39 | 1.74 | 27.25 | 0.00 |
| 1989 | 1345.62 | 1727 | 825 | 18.77 | 18.77 | 18.62 | 19.71 | 3.06 | 0.59 | 80.64 | 0.00 |
| 1990 | 1344.37 | 1840 | 825 | 20.06 | 20.06 | 18.60 | 21.00 | 1.87 | 0.38 | 79.56 | 0.00 |
| 1991 | 5465.33 | 6638 | 825 | 75.52 | 75.52 | 75.62 | 75.78 | 12.00 | 10.29 | 14.19 | 0.00 |
| 1992 | 4113.88 | 4927 | 825 | 55.58 | 55.58 | 56.77 | 56.09 | 3.87 | 2.24 | 42.18 | 0.00 |
| 1993 | 7334.90 | 8599 | 827 | 98.16 | 98.16 | 101.18 | 98.16 | 1.84 | 1.84 | 0.00 | 0.00 |
| 1994 | 4686.43 | 5656 | 832 | 64.56 | 64.56 | 64.23 | 64.57 | 11.21 | 8.15 | 27.29 | 0.00 |
| 1995 | 7030.23 | 8487 | 835 | 96.89 | 96.89 | 96.11 | 96.88 | 3.11 | 3.11 | 0.00 | 0.00 |
| 1996 | 4846.90 | 5762 | 835 | 65.65 | 65.65 | 66.08 | 65.60 | 13.65 | 10.38 | 23.96 | 0.00 |
| 1997 | 7158.40 | 8400 | 835 | 95.95 | 95.95 | 97.86 | 95.89 | 1.76 | 1.72 | 2.33 | 0.00 |
| 1998 | 6116.77 | 7184 | 835 | 82.01 | 82.01 | 83.62 | 82.01 | 0.00 | 0.00 | 17.99 | 0.00 |
| 1999 | 6994.34 | 8231 | 835 | 93.99 | 96.81 | 95.62 | 93.96 | 1.09 | 1.07 | 2.12 | 2.82 |
| 2000 | 6449.61 | 7580 | 825 | 86.18 | 86.18 | 88.73 | 86.29 | 1.01 | 0.88 | 12.94 | 0.00 |
| 2001 | 7454.78 | 8727 | 825 | 99.63 | 99.63 | 103.15 | 99.62 | 0.00 | 0.00 | 0.37 | 0.00 |
| 2002 | 4645.18 | 5506 | 825 | 62.76 | 62.76 | 64.28 | 62.85 | 2.08 | 1.33 | 35.91 | 0.00 |
| 2003 | 7532.45 | 8760 | 825 | 100.00 | 100.00 | 104.23 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 6973.98 | 8034 | 870 | 91.55 | 91.55 | 93.26 | 91.46 | 0.44 | 0.40 | 8.05 | 0.00 |
| 2005 | 7626.32 | 8726 | 845 | 99.62 | 99.62 | 103.02 | 99.60 | 0.38 | 0.38 | 0.00 | 0.00 |
| 2006 | 6449.83 | 7386 | 873 | 84.34 | 84.34 | 84.34 | 84.32 | 2.28 | 1.96 | 13.70 | 0.00 |
| 2007 | 7545.36 | 8701 | 873 | 99.35 | 99.35 | 98.66 | 99.33 | 0.31 | 0.31 | 0.35 | 0.00 |
| 2008 | 7161.09 | 8275 | 873 | 94.22 | 94.22 | 93.38 | 94.21 | 0.44 | 0.42 | 5.37 | 0.00 |
| 2009 | 7528.57 | 8661 | 873 | 98.87 | 98.87 | 98.45 | 98.87 | 1.13 | 1.13 | 0.00 | 0.00 |
| 2010 | 6755.04 | 7814 | 855 | 88.99 | 88.99 | 90.19 | 89.20 | 3.09 | 2.83 | 8.17 | 0.00 |
| 2011 | 7542.52 | 8676 | 855 | 99.05 | 100.00 | 100.70 | 99.04 | 0.00 | 0.00 | 0.00 | 0.95 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2012 | 6070.18 | 6930 | 866 | 79.08 | 79.08 | 80.13 | 78.89 | 2.84 | 2.31 | 18.61 | 0.00 |
| 2013 | 7815.24 | 8760 | 866 | 100.00 | 100.00 | 103.01 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 6928.82 | 7868 | 866 | 89.82 | 89.82 | 91.34 | 89.82 | 1.60 | 1.46 | 8.72 | 0.00 |
| 2015 | 7772.62 | 8718 | 866 | 99.52 | 100.00 | 102.46 | 99.52 | 0.00 | 0.00 | 0.00 | 0.48 |
| 2016 | 7191.74 | 8132 | 866 | 92.58 | 92.58 | 94.54 | 92.58 | 0.73 | 0.68 | 6.74 | 0.00 |
| 2017 | 7832.43 | 8760 | 863 | 100.00 | 100.00 | 103.49 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 7289.37 | 8128 | 877 | 92.83 | 92.83 | 95.90 | 92.79 | 0.00 | 0.00 | 7.17 | 0.00 |
| 2019 | 7913.33 | 8760 | 877 | 100.00 | 100.00 | 103.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 7371.35 | 8185 | 877 | 93.20 | 93.20 | 95.69 | 93.18 | 0.00 | 0.00 | 6.80 | 0.00 |
| 2021 | 7869.30 | 8760 | 877 | 100.00 | 100.00 | 102.43 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 7319.64 | 8257 | 877 | 94.26 | 94.26 | 95.28 | 94.26 | 0.00 | 0.00 | 5.74 | 0.00 |
| 2023 | 7828.41 | 8760 | 877 | 99.68 | 99.68 | 101.90 | 100.00 | 0.00 | 0.00 | 0.32 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 249 | |
| B. Refuelling without maintenance | | | | 23 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 772 | | |
| D. Inspection, maintenance or repair without refuelling | 96 | | | 348 | | |
| E. Testing of plant systems or components | | | | 33 | | |
| H. Nuclear regulatory requirements | | | | | 19 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 9 |
| Z. Other | | | | | 17 | |
| Subtotal | 96 | | | 1176 | 291 | 12 |
| Total | | 96 | | | 1479 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 9 |
| 12. Reactor I&C Systems | | 10 |
| 13. Reactor Auxiliary Systems | | 46 |
| 14. Safety Systems | | 27 |
| 15. Reactor Cooling Systems | | 48 |
| 16. Steam generation systems | | 1 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 21. Fuel Handling and Storage Facilities | | 5 |
| 31. Turbine and auxiliaries | | 46 |
| 32. Feedwater and Main Steam System | | 38 |
| 33. Circulating Water System | | 5 |
| 34. Miscellaneous Systems | | 3 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 5 |
| 42. Electrical Power Supply Systems | | 23 |
| Total | | 270 |

2023 Operating Experience

US-318

CALVERT CLIFFS-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : CE (COMBUSTION ENGINEERING CO.)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / CE 2LP (DRYAMB)
 Thermal power : 2737 MWth
 Gross electrical power : 911 MWe
 Reference unit power (net) : 855 MWe

Key Dates

Construction Date : 1968-06-01
 Grid Date : 1976-12-07
 Commercial Date : 1977-04-01
 Age at end of year : 47 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 3.45
 Active core height/length [m] : 3.47
 Number of fissile fuel assemblies/bundles : 217
 Fuel linear heat generation rate [kW/m] : 20.56
 Number of control rod assemblies : 37
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 314
 Number of SG : 2
 Containment type : -
 Containment design pressure [MPa] : 0.352

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

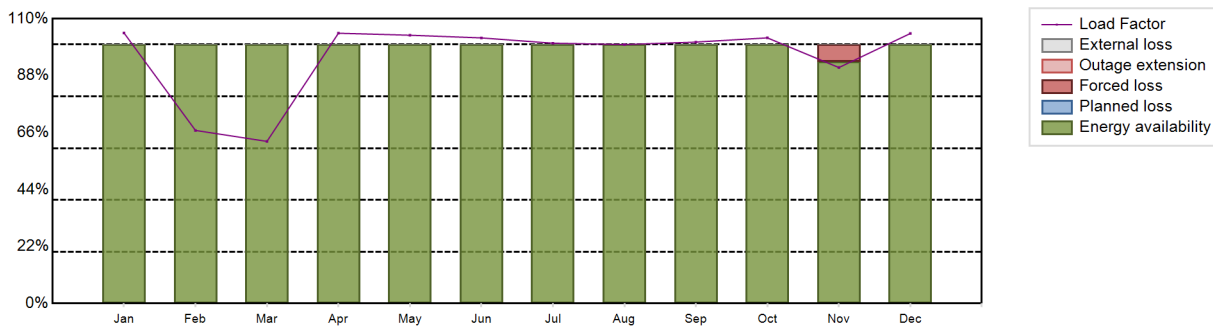
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7155.35 GW(e).h
 Energy Availability Factor (EAF) : 99.45 %
 Unit Capability Factor (UCF) : 99.45 %
 Load Factor (LF) : 95.53 %
 Operating Factor (OF) : 93.48 %
 Forced Loss Rate (FLR) : 0.55 %
 Unplanned Capability Loss Factor (UCL) : 0.55 %
 Planned Unavailability Factor (PUF) : 0 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 571 hours

Annual Summary

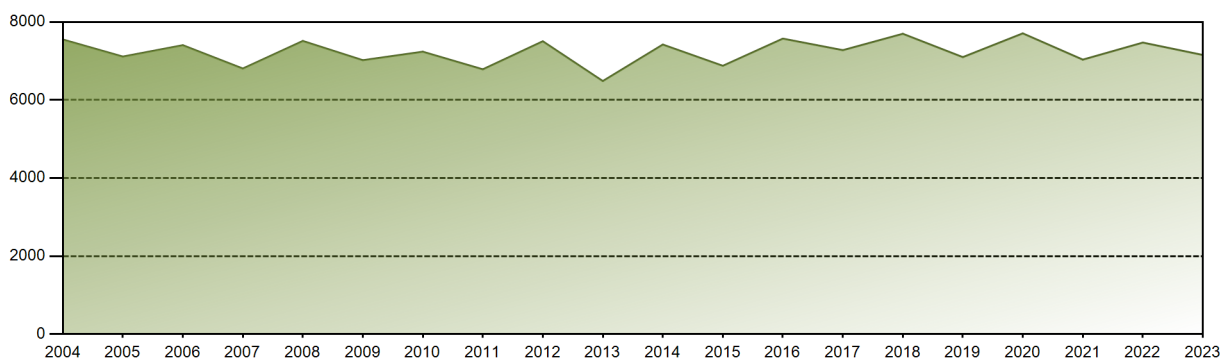


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 664.79 | 384.12 | 397.82 | 642.66 | 659.16 | 631.54 | 639.50 | 636.23 | 621.59 | 652.67 | 561.81 | 663.44 | 7155.35 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.34 | 100.00 | 99.45 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.34 | 100.00 | 99.45 |
| LF [%] | 104.51 | 66.86 | 62.62 | 104.40 | 103.62 | 102.59 | 100.53 | 100.02 | 100.97 | 102.60 | 91.14 | 104.30 | 95.53 |
| OF [%] | 100.00 | 67.86 | 62.18 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 89.74 | 100.00 | 93.48 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.66 | 0.00 | 0.55 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.66 | 0.00 | 0.55 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 295430.14 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.61 % |
| Cumulative Energy Availability Factor (EAF) | : 85.79 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.3 % |
| Cumulative Unit Capability Factor (UCF) | : 85.86 % | Cumulative Planned Unavailability Factor (PUF) | : 11.85 % |
| Cumulative Load Factor (LF) | : 85.89 % | Cumulative Externally cause unavailability (XUF) | : 0.07 % |
| Cumulative Operating Factor (OF) | : 85.52 % | | |

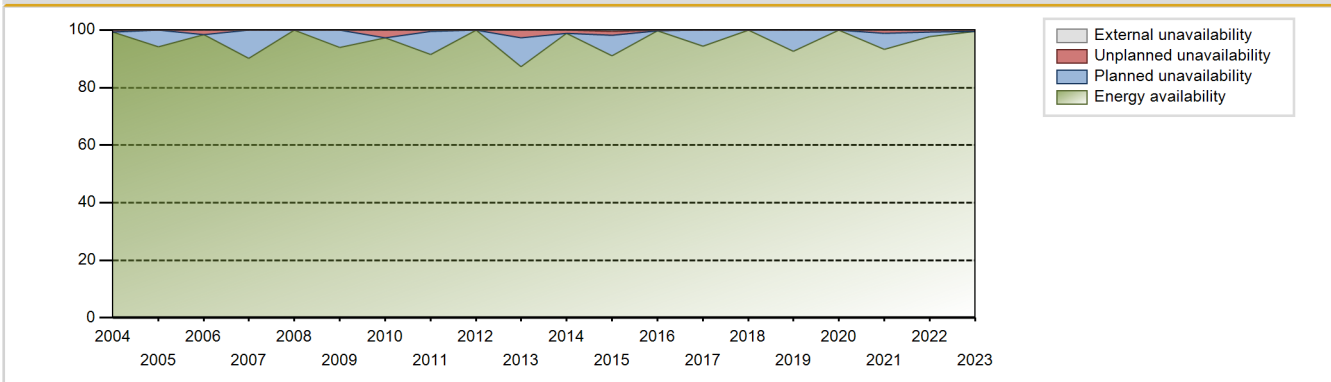
Electricity Production (net) [GWh]



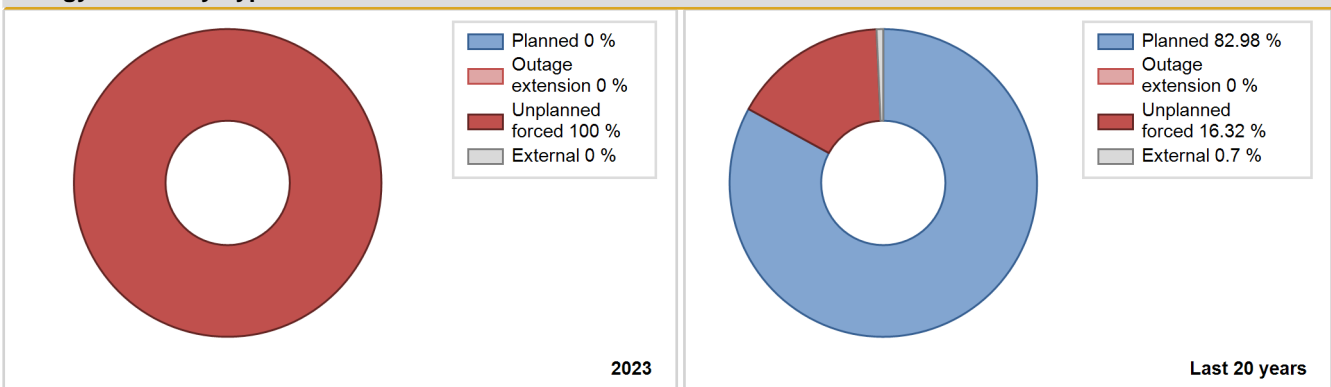
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1977 | 6009.80 | 7608 | 810 | 100.00 | 100.00 | 84.95 | 86.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1978 | 5226.60 | 7129 | 810 | 72.85 | 72.85 | 73.66 | 81.38 | 15.43 | 13.29 | 13.86 | 0.00 |
| 1979 | 5489.00 | 6792 | 812 | 76.60 | 76.60 | 77.17 | 77.53 | 10.07 | 8.58 | 14.82 | 0.00 |
| 1980 | 6412.30 | 8425 | 825 | 96.25 | 98.88 | 88.48 | 95.91 | 0.73 | 0.72 | 0.39 | 2.63 |
| 1981 | 5416.00 | 7005 | 825 | 80.08 | 80.08 | 74.94 | 79.97 | 5.48 | 4.65 | 15.27 | 0.00 |
| 1982 | 5005.20 | 6496 | 825 | 74.21 | 74.21 | 69.26 | 74.16 | 5.97 | 4.71 | 21.08 | 0.00 |
| 1983 | 6113.10 | 7567 | 825 | 86.39 | 86.39 | 84.59 | 86.38 | 7.89 | 7.40 | 6.21 | 0.00 |
| 1984 | 5338.45 | 6502 | 825 | 73.68 | 73.68 | 73.67 | 74.02 | 7.99 | 6.39 | 19.93 | 0.00 |
| 1985 | 5608.05 | 6789 | 825 | 77.41 | 77.41 | 77.60 | 77.50 | 5.72 | 4.70 | 17.89 | 0.00 |
| 1986 | 7006.67 | 8405 | 825 | 95.98 | 95.98 | 96.95 | 95.95 | 4.02 | 4.02 | 0.00 | 0.00 |
| 1987 | 4831.98 | 5859 | 825 | 66.35 | 66.35 | 66.86 | 66.88 | 4.10 | 2.84 | 30.81 | 0.00 |
| 1988 | 6602.69 | 7813 | 825 | 88.78 | 88.78 | 91.11 | 88.95 | 1.73 | 1.56 | 9.66 | 0.00 |
| 1989 | 1448.46 | 1731 | 825 | 18.32 | 18.32 | 20.04 | 19.76 | 12.14 | 2.53 | 79.15 | 0.00 |
| 1990 | 0.00 | 0 | 825 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1991 | 3635.58 | 4515 | 825 | 51.29 | 51.29 | 50.31 | 51.54 | 9.70 | 5.51 | 43.21 | 0.00 |
| 1992 | 6590.28 | 7855 | 825 | 89.30 | 89.30 | 90.94 | 89.42 | 10.70 | 10.70 | 0.00 | 0.00 |
| 1993 | 4975.19 | 5939 | 827 | 67.36 | 67.36 | 68.63 | 67.80 | 0.99 | 0.67 | 31.97 | 0.00 |
| 1994 | 6576.52 | 7925 | 835 | 90.56 | 90.56 | 89.82 | 90.47 | 7.88 | 7.74 | 1.70 | 0.00 |
| 1995 | 5911.11 | 7121 | 840 | 81.36 | 81.36 | 80.33 | 81.29 | 2.52 | 2.10 | 16.54 | 0.00 |
| 1996 | 7247.74 | 8561 | 840 | 97.50 | 97.50 | 98.23 | 97.46 | 2.50 | 2.50 | 0.00 | 0.00 |
| 1997 | 5979.88 | 7100 | 840 | 81.10 | 81.10 | 81.27 | 81.05 | 0.00 | 0.00 | 18.90 | 0.00 |
| 1998 | 7225.49 | 8393 | 840 | 95.83 | 95.83 | 98.19 | 95.81 | 4.17 | 4.17 | 0.00 | 0.00 |
| 1999 | 6332.72 | 7400 | 840 | 84.50 | 84.50 | 86.06 | 84.47 | 0.00 | 0.00 | 15.50 | 0.00 |
| 2000 | 7391.04 | 8614 | 835 | 98.05 | 98.05 | 100.72 | 98.06 | 0.00 | 0.00 | 1.95 | 0.00 |
| 2001 | 6201.52 | 7297 | 835 | 83.28 | 83.28 | 84.78 | 83.30 | 0.76 | 0.64 | 16.09 | 0.00 |
| 2002 | 7480.55 | 8760 | 835 | 100.00 | 100.00 | 102.27 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 6156.86 | 7124 | 835 | 81.37 | 81.37 | 84.17 | 81.32 | 0.44 | 0.36 | 18.27 | 0.00 |
| 2004 | 7552.20 | 8729 | 858 | 99.37 | 99.37 | 101.33 | 99.37 | 0.63 | 0.63 | 0.00 | 0.00 |
| 2005 | 7114.31 | 8249 | 858 | 94.18 | 94.18 | 94.64 | 94.16 | 0.00 | 0.00 | 5.82 | 0.00 |
| 2006 | 7406.34 | 8621 | 862 | 98.43 | 98.43 | 98.08 | 98.41 | 1.57 | 1.57 | 0.00 | 0.00 |
| 2007 | 6807.83 | 7902 | 862 | 90.22 | 90.22 | 90.16 | 90.21 | 0.00 | 0.00 | 9.78 | 0.00 |
| 2008 | 7514.73 | 8784 | 862 | 100.00 | 100.00 | 99.25 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 7021.55 | 8227 | 862 | 93.93 | 93.93 | 92.99 | 93.92 | 0.00 | 0.00 | 6.07 | 0.00 |
| 2010 | 7238.91 | 8528 | 850 | 97.32 | 97.32 | 97.22 | 97.35 | 2.68 | 2.68 | 0.00 | 0.00 |
| 2011 | 6787.88 | 8005 | 850 | 91.41 | 91.41 | 91.16 | 91.38 | 0.55 | 0.51 | 8.08 | 0.00 |
| 2012 | 7506.54 | 8784 | 850 | 100.00 | 100.00 | 100.54 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 6486.75 | 7652 | 850 | 87.35 | 87.35 | 87.11 | 87.34 | 3.02 | 2.72 | 9.93 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|------|------|
| 2014 | 7422.54 | 8662 | 850 | 98.88 | 98.88 | 99.68 | 98.88 | 1.12 | 1.12 | 0.00 | 0.00 |
| 2015 | 6877.67 | 7969 | 850 | 90.98 | 91.55 | 92.37 | 90.97 | 1.46 | 1.36 | 7.10 | 0.57 |
| 2016 | 7574.55 | 8753 | 850 | 99.64 | 99.64 | 101.45 | 99.65 | 0.36 | 0.36 | 0.00 | 0.00 |
| 2017 | 7278.30 | 8257 | 855 | 94.28 | 94.28 | 97.36 | 94.26 | 0.00 | 0.00 | 5.72 | 0.00 |
| 2018 | 7698.56 | 8760 | 855 | 100.00 | 100.00 | 102.79 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 7099.58 | 8107 | 855 | 92.56 | 92.56 | 94.79 | 92.55 | 0.00 | 0.00 | 7.44 | 0.00 |
| 2020 | 7709.21 | 8783 | 855 | 100.00 | 100.00 | 102.65 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 7035.82 | 8178 | 855 | 93.35 | 93.35 | 93.94 | 93.36 | 1.10 | 1.04 | 5.61 | 0.00 |
| 2022 | 7472.48 | 8554 | 855 | 97.65 | 97.65 | 99.77 | 97.65 | 0.73 | 0.72 | 1.63 | 0.00 |
| 2023 | 7155.35 | 8189 | 855 | 99.45 | 99.45 | 95.53 | 93.48 | 0.55 | 0.55 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1977 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 48 | | | 183 | |
| B. Refuelling without maintenance | | | | 11 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 948 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 62 | | |
| E. Testing of plant systems or components | | | | 7 | 1 | |
| H. Nuclear regulatory requirements | | | | | 6 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 12 | |
| Z. Other | | | | | 2 | |
| Subtotal | | 48 | | 1028 | 204 | 1 |
| Total | | 48 | | | 1233 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1977 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 48 | 4 |
| 12. Reactor I&C Systems | | 13 |
| 13. Reactor Auxiliary Systems | | 18 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 57 |
| 16. Steam generation systems | | 7 |
| 31. Turbine and auxiliaries | | 19 |
| 32. Feedwater and Main Steam System | | 30 |
| 34. Miscellaneous Systems | | 0 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 11 |
| 42. Electrical Power Supply Systems | | 25 |
| Total | 48 | 187 |

2023 Operating Experience

US-413

CATAWBA-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : DUKEENER (Duke Energy Corp.)
 Owner : NCEMCO (North Carolina Electric Membership Corp.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (ICECND)
 Thermal power : 3411 MWth
 Gross electrical power : 1188 MWe
 Reference unit power (net) : 1160 MWe

Key Dates

Construction Date : 1974-05-01
 Grid Date : 1985-01-22
 Commercial Date : 1985-06-29
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 39
 Average discharge burnup [MWd/t] : 40200
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 18.3
 Number of control rod assemblies : 25
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 325
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 0.204

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.83
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

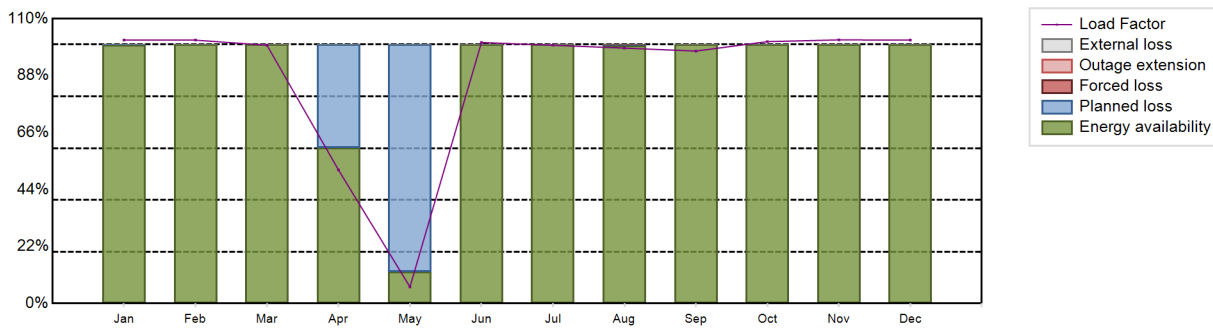
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8988.09 GW(e).h
 Energy Availability Factor (EAF) : 89.23 %
 Unit Capability Factor (UCF) : 89.23 %
 Load Factor (LF) : 88.45 %
 Operating Factor (OF) : 89.27 %

Forced Loss Rate (FLR) : 0.01 %
 Unplanned Capability Loss Factor (UCL) : 0.01 %
 Planned Unavailability Factor (PUF) : 10.76 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 940 hours

Annual Summary

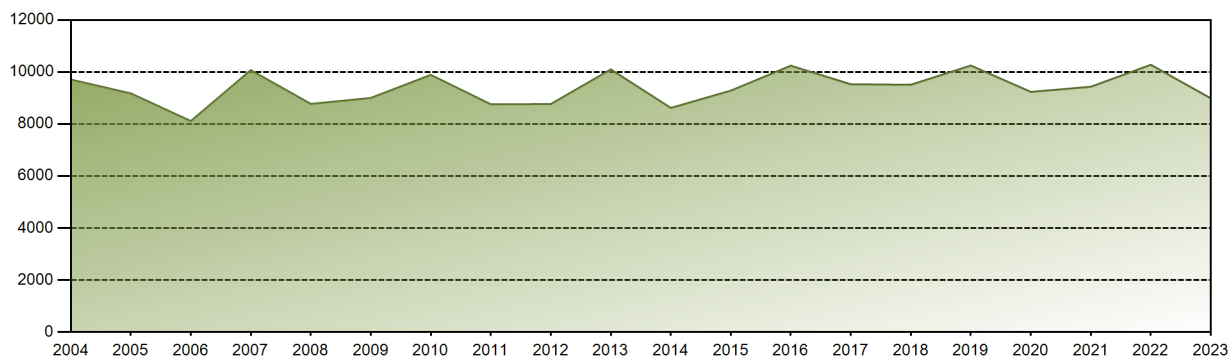


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 878.35 | 792.95 | 859.71 | 431.06 | 55.31 | 841.92 | 860.79 | 851.35 | 814.25 | 872.87 | 851.60 | 877.94 | 8988.09 |
| EAF [%] | 99.87 | 100.00 | 100.00 | 60.28 | 12.14 | 100.00 | 100.00 | 99.61 | 100.00 | 100.00 | 100.00 | 100.00 | 89.23 |
| UCF [%] | 99.87 | 100.00 | 100.00 | 60.28 | 12.14 | 100.00 | 100.00 | 99.61 | 100.00 | 100.00 | 100.00 | 100.00 | 89.23 |
| LF [%] | 101.77 | 101.72 | 99.75 | 51.61 | 6.41 | 100.80 | 99.74 | 98.65 | 97.49 | 101.14 | 101.82 | 101.73 | 88.45 |
| OF [%] | 100.00 | 100.00 | 100.00 | 60.28 | 12.10 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 89.27 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| PUF [%] | 0.13 | 0.00 | 0.00 | 39.72 | 87.86 | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 10.76 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 334809.47 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.95 % |
| Cumulative Energy Availability Factor (EAF) | : 87.63 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.66 % |
| Cumulative Unit Capability Factor (UCF) | : 87.63 % | Cumulative Planned Unavailability Factor (PUF) | : 9.7 % |
| Cumulative Load Factor (LF) | : 87.23 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 87.55 % | | |

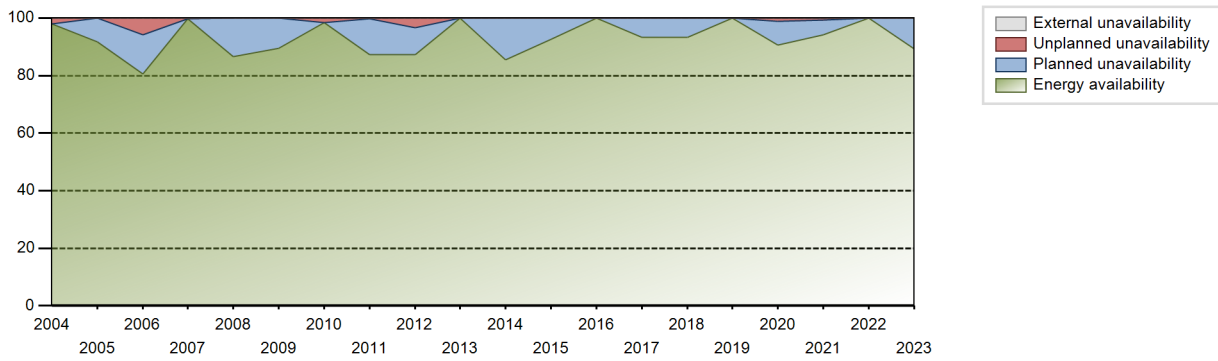
Electricity Production (net) [GWh]



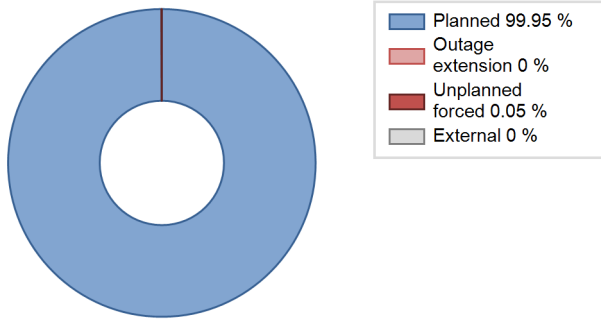
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 3440.51 | 3513 | 1138 | 78.55 | 78.55 | 66.98 | 78.45 | 21.45 | 21.45 | 0.00 | 0.00 |
| 1986 | 5199.12 | 5151 | 1145 | 58.88 | 58.88 | 51.83 | 58.80 | 18.75 | 13.59 | 27.53 | 0.00 |
| 1987 | 6405.97 | 5924 | 1145 | 68.00 | 68.00 | 63.87 | 67.63 | 15.46 | 12.43 | 19.57 | 0.00 |
| 1988 | 7639.97 | 7003 | 1129 | 79.75 | 79.75 | 77.04 | 79.72 | 8.32 | 7.24 | 13.00 | 0.00 |
| 1989 | 7775.42 | 7278 | 1129 | 84.67 | 84.67 | 78.62 | 83.08 | 4.00 | 3.52 | 11.81 | 0.00 |
| 1990 | 6900.50 | 6277 | 1129 | 71.67 | 71.67 | 69.77 | 71.66 | 9.05 | 7.13 | 21.20 | 0.00 |
| 1991 | 6681.05 | 6227 | 1129 | 71.11 | 71.11 | 67.55 | 71.08 | 4.10 | 3.04 | 25.86 | 0.00 |
| 1992 | 7050.94 | 6338 | 1129 | 72.14 | 72.14 | 71.10 | 72.15 | 7.46 | 5.82 | 22.04 | 0.00 |
| 1993 | 7597.13 | 6916 | 1129 | 78.97 | 78.97 | 76.82 | 78.95 | 4.65 | 3.85 | 17.18 | 0.00 |
| 1994 | 9778.83 | 8722 | 1129 | 99.58 | 99.58 | 98.88 | 99.57 | 0.41 | 0.41 | 0.01 | 0.00 |
| 1995 | 8721.63 | 7712 | 1129 | 88.07 | 88.07 | 88.19 | 88.04 | 0.53 | 0.47 | 11.46 | 0.00 |
| 1996 | 6341.10 | 5806 | 1129 | 66.17 | 66.17 | 63.94 | 66.10 | 4.16 | 2.87 | 30.97 | 0.00 |
| 1997 | 9192.55 | 7966 | 1129 | 90.68 | 90.68 | 92.95 | 90.94 | 0.00 | 0.00 | 9.32 | 0.00 |
| 1998 | 8903.65 | 7923 | 1129 | 90.47 | 90.47 | 90.03 | 90.45 | 8.31 | 8.20 | 1.34 | 0.00 |
| 1999 | 9073.74 | 7987 | 1129 | 91.20 | 91.20 | 91.75 | 91.18 | 0.00 | 0.00 | 8.80 | 0.00 |
| 2000 | 8923.00 | 7844 | 1129 | 89.32 | 89.32 | 89.98 | 89.30 | 0.45 | 0.41 | 10.28 | 0.00 |
| 2001 | 9976.97 | 8722 | 1129 | 99.57 | 99.57 | 100.88 | 99.57 | 0.43 | 0.43 | 0.00 | 0.00 |
| 2002 | 9481.61 | 8250 | 1129 | 94.20 | 94.20 | 95.87 | 94.18 | 0.00 | 0.00 | 5.80 | 0.00 |
| 2003 | 8198.52 | 7157 | 1129 | 81.72 | 81.72 | 82.90 | 81.70 | 8.02 | 7.12 | 11.15 | 0.00 |
| 2004 | 9711.07 | 8608 | 1129 | 98.01 | 98.01 | 97.92 | 98.00 | 1.98 | 1.98 | 0.02 | 0.00 |
| 2005 | 9177.33 | 8027 | 1129 | 91.66 | 91.66 | 92.78 | 91.62 | 0.00 | 0.00 | 8.34 | 0.00 |
| 2006 | 8114.96 | 7066 | 1129 | 80.68 | 80.68 | 82.05 | 80.66 | 6.75 | 5.84 | 13.47 | 0.00 |
| 2007 | 10070.89 | 8728 | 1129 | 99.65 | 99.65 | 101.83 | 99.63 | 0.35 | 0.35 | 0.00 | 0.00 |
| 2008 | 8773.30 | 7610 | 1129 | 86.64 | 86.64 | 88.47 | 86.63 | 0.00 | 0.00 | 13.36 | 0.00 |
| 2009 | 9002.04 | 7834 | 1129 | 89.45 | 89.45 | 91.02 | 89.43 | 0.00 | 0.00 | 10.55 | 0.00 |
| 2010 | 9889.07 | 8629 | 1129 | 98.51 | 98.51 | 99.99 | 98.50 | 1.49 | 1.49 | 0.00 | 0.00 |
| 2011 | 8758.04 | 7630 | 1146 | 87.23 | 87.23 | 87.78 | 87.10 | 0.32 | 0.28 | 12.49 | 0.00 |
| 2012 | 8767.33 | 7657 | 1146 | 87.19 | 87.19 | 87.09 | 87.17 | 3.73 | 3.38 | 9.43 | 0.00 |
| 2013 | 10100.41 | 8760 | 1146 | 100.00 | 100.00 | 100.60 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 8619.61 | 7493 | 1146 | 85.54 | 85.54 | 85.86 | 85.54 | 0.00 | 0.00 | 14.46 | 0.00 |
| 2015 | 9283.45 | 8104 | 1146 | 92.52 | 92.52 | 92.47 | 92.51 | 0.11 | 0.10 | 7.38 | 0.00 |
| 2016 | 10242.36 | 8784 | 1146 | 100.00 | 100.00 | 101.75 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 9529.31 | 8179 | 1146 | 93.36 | 93.36 | 94.92 | 93.37 | 0.00 | 0.00 | 6.64 | 0.00 |
| 2018 | 9510.49 | 8171 | 1160 | 93.28 | 93.28 | 93.59 | 93.28 | 0.00 | 0.00 | 6.72 | 0.00 |
| 2019 | 10249.75 | 8760 | 1160 | 100.00 | 100.00 | 100.87 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 9235.52 | 7955 | 1160 | 90.58 | 90.58 | 90.64 | 90.56 | 1.28 | 1.17 | 8.25 | 0.00 |
| 2021 | 9433.23 | 8241 | 1160 | 94.08 | 94.08 | 92.83 | 94.08 | 0.81 | 0.77 | 5.15 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|--------|--------|--------|--------|------|------|-------|------|
| 2022 | 10277.59 | 8760 | 1160 | 100.00 | 100.00 | 101.14 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 8988.09 | 7820 | 1160 | 89.23 | 89.23 | 88.45 | 89.27 | 0.01 | 0.01 | 10.76 | 0.00 |

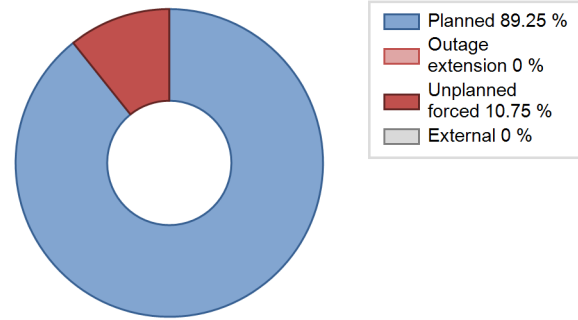
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 213 | |
| B. Refuelling without maintenance | | | | 31 | | |
| C. Inspection, maintenance or repair combined with refuelling | 939 | | | 780 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 37 | | |
| E. Testing of plant systems or components | | | | 2 | 3 | |
| H. Nuclear regulatory requirements | | | | | 4 | |
| L. Human factor related | | | | | 4 | |
| Z. Other | | | | 2 | 9 | |
| Subtotal | 939 | | | 852 | 233 | |
| Total | | 939 | | | 1085 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 4 |
| 12. Reactor I&C Systems | | 23 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 15 |
| 15. Reactor Cooling Systems | | 79 |
| 16. Steam generation systems | | 2 |
| 31. Turbine and auxiliaries | | 9 |
| 32. Feedwater and Main Steam System | | 38 |
| 33. Circulating Water System | | 8 |
| 34. Miscellaneous Systems | | 6 |
| 41. Main Generator Systems | | 11 |
| 42. Electrical Power Supply Systems | | 20 |
| Total | | 225 |

2023 Operating Experience

US-414

CATAWBA-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : DUKEENER (Duke Energy Corp.)
 Owner : NCPMA1 (North Carolina Municipal Power Agency No.1)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (ICECND)
 Thermal power : 3411 MWth
 Gross electrical power : 1188 MWe
 Reference unit power (net) : 1150 MWe

Key Dates

Construction Date : 1974-05-01
 Grid Date : 1986-05-18
 Commercial Date : 1986-08-19
 Age at end of year : 37 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 46
 Average discharge burnup [MWd/t] : 40200
 Active core diameter [m] : 3.4
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 18.3
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 326
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 0.204

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.83
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

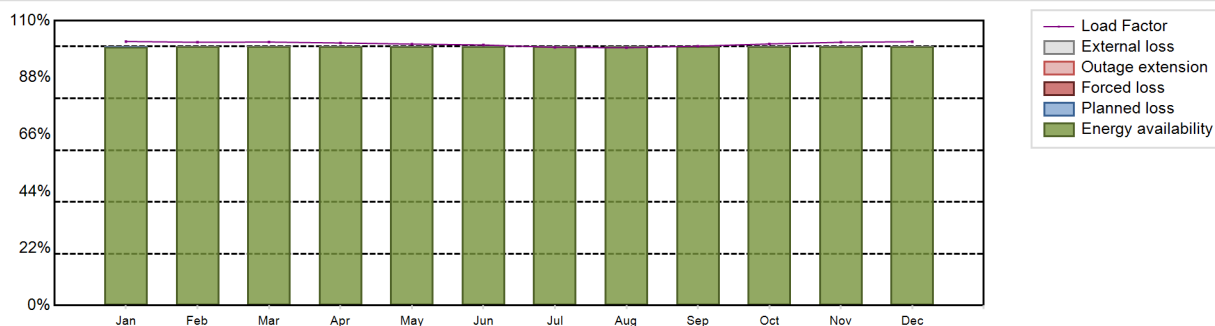
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 10177.43 GW(e).h
 Energy Availability Factor (EAF) : 99.99 %
 Unit Capability Factor (UCF) : 99.99 %
 Load Factor (LF) : 101.03 %
 Operating Factor (OF) : 100 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.01 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

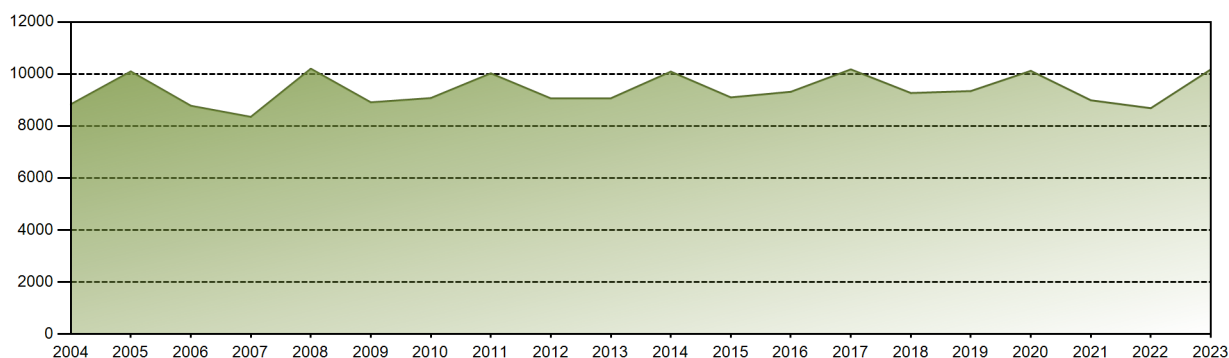


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 872.40 | 785.69 | 869.49 | 839.54 | 863.86 | 833.15 | 853.15 | 851.88 | 829.30 | 864.39 | 842.97 | 871.61 | 10177.43 |
| EAF [%] | 99.84 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| UCF [%] | 99.84 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| LF [%] | 101.96 | 101.67 | 101.76 | 101.39 | 100.97 | 100.62 | 99.71 | 99.56 | 100.16 | 101.03 | 101.67 | 101.87 | 101.03 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 327977.82 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.42 % |
| Cumulative Energy Availability Factor (EAF) | : 88.42 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.13 % |
| Cumulative Unit Capability Factor (UCF) | : 88.42 % | Cumulative Planned Unavailability Factor (PUF) | : 8.46 % |
| Cumulative Load Factor (LF) | : 88 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 88.12 % | | |

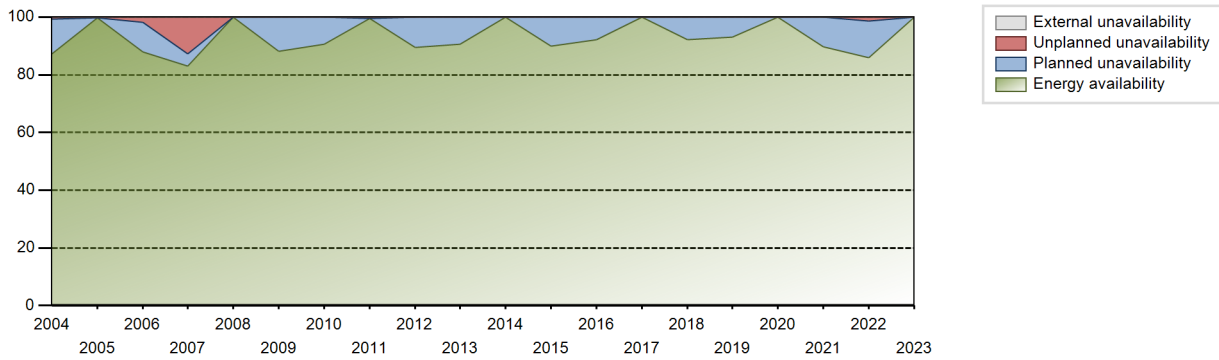
Electricity Production (net) [GWh]



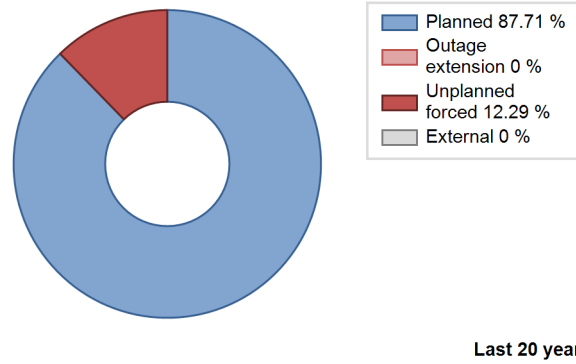
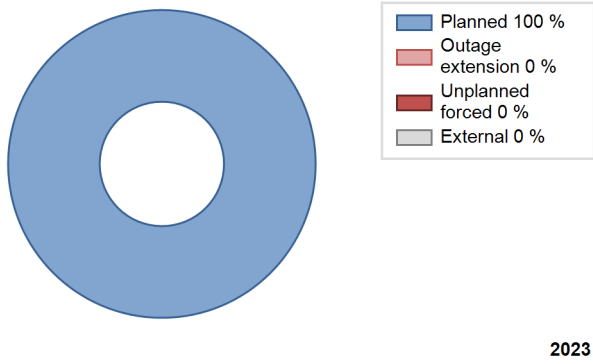
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 1324.22 | 1325 | 1135 | 35.55 | 35.55 | 29.10 | 34.59 | 64.45 | 64.45 | 0.00 | 0.00 |
| 1987 | 7169.49 | 7014 | 1145 | 80.16 | 80.16 | 71.48 | 80.07 | 18.04 | 17.64 | 2.19 | 0.00 |
| 1988 | 5434.95 | 5571 | 1129 | 71.80 | 71.80 | 54.80 | 63.42 | 11.82 | 9.62 | 18.58 | 0.00 |
| 1989 | 6527.10 | 6302 | 1129 | 71.97 | 71.97 | 66.00 | 71.94 | 4.01 | 3.00 | 25.03 | 0.00 |
| 1990 | 6502.99 | 5984 | 1129 | 69.00 | 69.00 | 65.75 | 68.31 | 0.59 | 0.41 | 30.59 | 0.00 |
| 1991 | 7274.89 | 6621 | 1129 | 75.59 | 75.59 | 73.56 | 75.58 | 6.64 | 5.38 | 19.03 | 0.00 |
| 1992 | 9273.46 | 8281 | 1129 | 94.29 | 94.29 | 93.51 | 94.27 | 1.62 | 1.55 | 4.17 | 0.00 |
| 1993 | 8177.41 | 7233 | 1129 | 82.57 | 82.57 | 82.68 | 82.57 | 0.60 | 0.50 | 16.93 | 0.00 |
| 1994 | 7691.73 | 6978 | 1129 | 79.75 | 79.75 | 77.77 | 79.66 | 2.70 | 2.21 | 18.04 | 0.00 |
| 1995 | 7960.18 | 7074 | 1129 | 80.83 | 80.83 | 80.49 | 80.75 | 9.08 | 8.07 | 11.10 | 0.00 |
| 1996 | 9233.63 | 8107 | 1129 | 92.33 | 92.33 | 93.11 | 92.29 | 7.67 | 7.67 | 0.00 | 0.00 |
| 1997 | 8593.36 | 7623 | 1129 | 87.09 | 87.09 | 86.89 | 87.02 | 1.47 | 1.30 | 11.61 | 0.00 |
| 1998 | 8672.30 | 7580 | 1129 | 86.55 | 86.55 | 87.69 | 86.53 | 2.16 | 1.91 | 11.54 | 0.00 |
| 1999 | 8855.38 | 7727 | 1129 | 88.23 | 88.23 | 89.54 | 88.21 | 11.77 | 11.77 | 0.00 | 0.00 |
| 2000 | 8981.37 | 7928 | 1129 | 90.29 | 90.29 | 90.56 | 90.26 | 2.00 | 1.85 | 7.86 | 0.00 |
| 2001 | 8574.14 | 7507 | 1129 | 85.72 | 85.72 | 86.69 | 85.70 | 5.44 | 4.93 | 9.35 | 0.00 |
| 2002 | 10172.30 | 8760 | 1129 | 100.00 | 100.00 | 102.85 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 9318.16 | 8117 | 1129 | 92.66 | 92.66 | 94.22 | 92.66 | 0.14 | 0.13 | 7.21 | 0.00 |
| 2004 | 8835.74 | 7672 | 1129 | 87.36 | 87.36 | 89.10 | 87.34 | 0.81 | 0.71 | 11.93 | 0.00 |
| 2005 | 10099.11 | 8737 | 1129 | 99.74 | 99.74 | 102.10 | 99.73 | 0.26 | 0.26 | 0.00 | 0.00 |
| 2006 | 8779.22 | 7696 | 1129 | 87.88 | 87.88 | 88.77 | 87.85 | 2.00 | 1.80 | 10.32 | 0.00 |
| 2007 | 8351.56 | 7262 | 1129 | 82.92 | 82.92 | 84.44 | 82.90 | 13.33 | 12.75 | 4.33 | 0.00 |
| 2008 | 10203.16 | 8784 | 1129 | 100.00 | 100.00 | 102.88 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 8910.22 | 7727 | 1129 | 88.22 | 88.22 | 90.09 | 88.21 | 0.00 | 0.00 | 11.78 | 0.00 |
| 2010 | 9075.00 | 7934 | 1129 | 90.58 | 90.58 | 91.76 | 90.57 | 0.00 | 0.00 | 9.42 | 0.00 |
| 2011 | 10025.54 | 8716 | 1129 | 99.50 | 99.50 | 101.37 | 99.50 | 0.50 | 0.50 | 0.00 | 0.00 |
| 2012 | 9061.97 | 7849 | 1146 | 89.49 | 89.49 | 90.35 | 89.36 | 0.00 | 0.00 | 10.51 | 0.00 |
| 2013 | 9065.55 | 7942 | 1146 | 90.67 | 90.67 | 90.29 | 90.65 | 0.00 | 0.00 | 9.33 | 0.00 |
| 2014 | 10091.90 | 8760 | 1146 | 100.00 | 100.00 | 100.53 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 9100.43 | 7886 | 1146 | 90.01 | 90.01 | 90.65 | 90.02 | 0.00 | 0.00 | 9.99 | 0.00 |
| 2016 | 9315.90 | 8090 | 1146 | 92.10 | 92.10 | 92.54 | 92.10 | 0.00 | 0.00 | 7.90 | 0.00 |
| 2017 | 10177.38 | 8760 | 1150 | 100.00 | 100.00 | 101.03 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 9269.23 | 8080 | 1150 | 92.23 | 92.23 | 92.01 | 92.24 | 0.00 | 0.00 | 7.77 | 0.00 |
| 2019 | 9343.86 | 8155 | 1150 | 93.10 | 93.10 | 92.75 | 93.09 | 0.00 | 0.00 | 6.90 | 0.00 |
| 2020 | 10121.15 | 8783 | 1150 | 100.00 | 100.00 | 100.19 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 8989.38 | 7864 | 1150 | 89.77 | 89.77 | 89.23 | 89.77 | 0.00 | 0.00 | 10.23 | 0.00 |
| 2022 | 8685.27 | 7526 | 1150 | 85.92 | 85.92 | 86.21 | 85.91 | 1.59 | 1.39 | 12.69 | 0.00 |

2023 10177.43 8760 1150 99.99 99.99 101.03 100.00 0.00 0.00 0.01 0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 260 | |
| B. Refuelling without maintenance | | | | 54 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 639 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 47 | | |
| E. Testing of plant systems or components | | | | 2 | 3 | |
| H. Nuclear regulatory requirements | | | | | 4 | |
| L. Human factor related | | | | | 1 | |
| Z. Other | | | | 0 | 6 | |
| Subtotal | | | | 742 | 274 | |
| Total | | 0 | | | 1016 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 5 |
| 12. Reactor I&C Systems | | 2 |
| 13. Reactor Auxiliary Systems | | 22 |
| 14. Safety Systems | | 5 |
| 15. Reactor Cooling Systems | | 22 |
| 16. Steam generation systems | | 3 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 9 |
| 31. Turbine and auxiliaries | | 40 |
| 32. Feedwater and Main Steam System | | 60 |
| 33. Circulating Water System | | 0 |
| 34. Miscellaneous Systems | | 1 |
| 41. Main Generator Systems | | 77 |
| 42. Electrical Power Supply Systems | | 24 |
| Total | | 270 |

2023 Operating Experience

US-461

CLINTON-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : BWR / BWR-6 (Mark 3)
 Thermal power : 3473 MWth
 Gross electrical power : 1098 MWe
 Reference unit power (net) : 1062 MWe

Key Dates

Construction Date : 1975-10-01
 Grid Date : 1987-04-24
 Commercial Date : 1987-11-24
 Age at end of year : 36 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 45
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 4.3
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 624
 Fuel linear heat generation rate [kW/m] : 18.85
 Number of control rod assemblies : 145
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.3
 Reactor outlet temperature [°C] : 288.3
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : 0.10

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.66
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Pond (closed-cycle)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

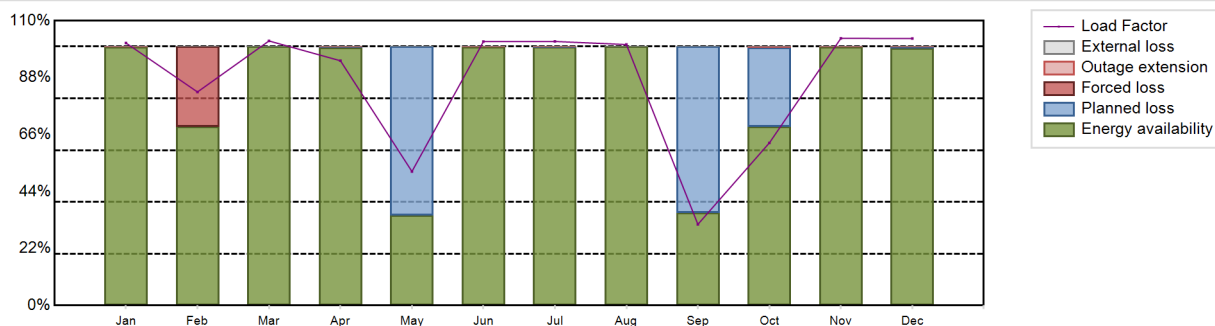
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8050.49 GW(e).h
 Energy Availability Factor (EAF) : 84.04 %
 Unit Capability Factor (UCF) : 84.04 %
 Load Factor (LF) : 86.54 %
 Operating Factor (OF) : 87.27 %

Forced Loss Rate (FLR) : 2.75 %
 Unplanned Capability Loss Factor (UCL) : 2.47 %
 Planned Unavailability Factor (PUF) : 13.49 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1115 hours

Annual Summary

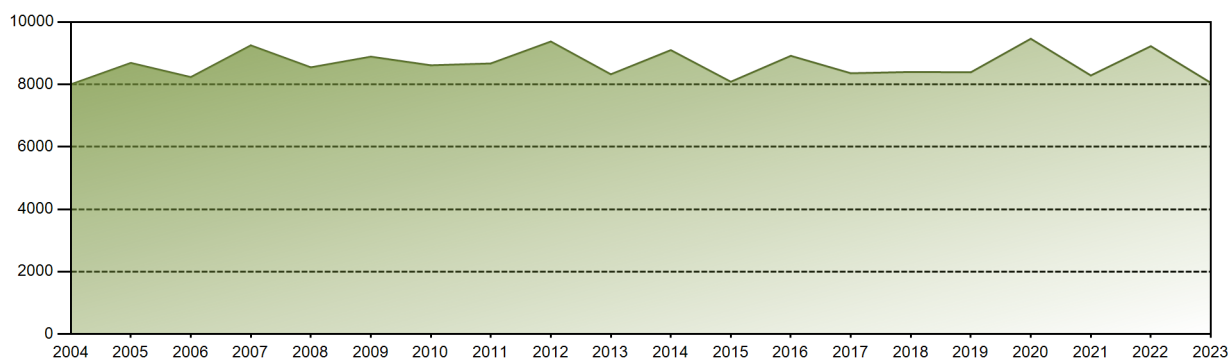


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 801.10 | 588.64 | 806.28 | 722.82 | 409.08 | 779.49 | 805.75 | 796.50 | 239.73 | 496.24 | 790.15 | 814.71 | 8050.49 |
| EAF [%] | 99.81 | 69.07 | 100.00 | 99.55 | 34.81 | 99.74 | 99.88 | 100.00 | 35.85 | 69.04 | 99.78 | 99.41 | 84.04 |
| UCF [%] | 99.81 | 69.07 | 100.00 | 99.55 | 34.81 | 99.74 | 99.88 | 100.00 | 35.85 | 69.04 | 99.78 | 99.41 | 84.04 |
| LF [%] | 101.39 | 82.48 | 102.18 | 94.53 | 51.77 | 101.94 | 101.98 | 100.81 | 31.35 | 62.80 | 103.19 | 103.11 | 86.54 |
| OF [%] | 100.00 | 86.90 | 100.00 | 100.00 | 58.33 | 100.00 | 100.00 | 100.00 | 33.33 | 68.15 | 100.00 | 100.00 | 87.27 |
| FLR [%] | 0.00 | 30.93 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.75 |
| UCL [%] | 0.19 | 30.93 | 0.00 | 0.03 | 0.00 | 0.26 | 0.03 | 0.00 | 0.00 | 0.31 | 0.22 | 0.12 | 2.47 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.42 | 65.19 | 0.00 | 0.09 | 0.00 | 64.15 | 30.65 | 0.00 | 0.47 | 13.49 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

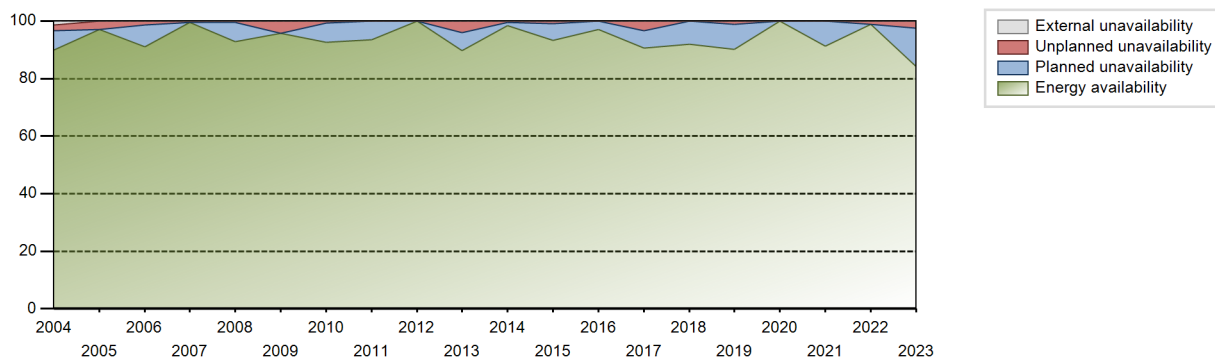
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 257321.56 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.7 % |
| Cumulative Energy Availability Factor (EAF) | : 82.98 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.19 % |
| Cumulative Unit Capability Factor (UCF) | : 83.02 % | Cumulative Planned Unavailability Factor (PUF) | : 13.79 % |
| Cumulative Load Factor (LF) | : 81.01 % | Cumulative Externally cause unavailability (XUF) | : 0.04 % |
| Cumulative Operating Factor (OF) | : 82.15 % | | |

Electricity Production (net) [GWh]

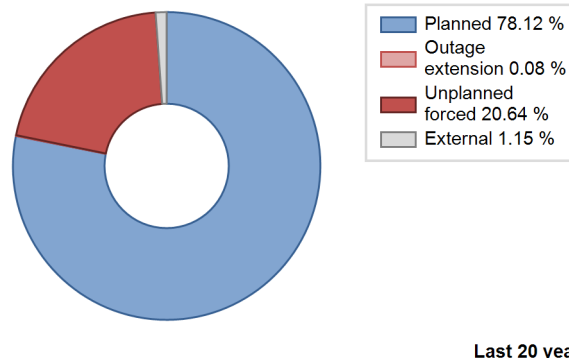
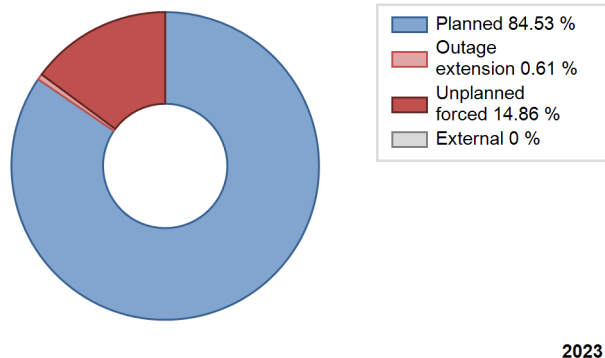


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | 1628.83 | 3264 | 932 | 100.00 | 100.00 | 80.98 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1988 | 5860.74 | 7244 | 930 | 82.50 | 82.50 | 71.73 | 82.46 | 6.52 | 5.75 | 11.75 | 0.00 |
| 1989 | 2861.90 | 3947 | 931 | 45.13 | 45.13 | 35.08 | 45.06 | 31.57 | 20.83 | 34.04 | 0.00 |
| 1990 | 3596.62 | 4604 | 930 | 52.57 | 52.57 | 44.15 | 52.56 | 19.21 | 12.50 | 34.93 | 0.00 |
| 1991 | 6048.01 | 6927 | 930 | 79.10 | 79.10 | 74.24 | 79.08 | 3.02 | 2.47 | 18.44 | 0.00 |
| 1992 | 4935.26 | 5824 | 930 | 66.31 | 66.31 | 60.41 | 66.30 | 31.03 | 29.84 | 3.85 | 0.00 |
| 1993 | 5879.18 | 6750 | 930 | 77.05 | 77.10 | 72.17 | 77.05 | 3.64 | 2.91 | 19.99 | 0.05 |
| 1994 | 7410.34 | 8217 | 930 | 93.85 | 93.85 | 90.96 | 93.80 | 0.18 | 0.17 | 5.98 | 0.00 |
| 1995 | 6109.18 | 7140 | 930 | 81.60 | 81.60 | 74.99 | 81.51 | 3.05 | 2.57 | 15.83 | 0.00 |
| 1996 | 5312.93 | 5833 | 930 | 66.46 | 66.46 | 65.02 | 66.40 | 14.96 | 11.69 | 21.85 | 0.00 |
| 1997 | 0.00 | 0 | 930 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1998 | 0.00 | 0 | 930 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1999 | 4704.21 | 5270 | 930 | 60.17 | 60.17 | 57.74 | 60.16 | 0.00 | 0.00 | 39.83 | 0.00 |
| 2000 | 6888.84 | 7542 | 930 | 85.89 | 85.89 | 84.33 | 85.86 | 3.31 | 2.94 | 11.16 | 0.00 |
| 2001 | 7877.25 | 8565 | 930 | 97.80 | 97.80 | 96.69 | 97.77 | 1.53 | 1.52 | 0.69 | 0.00 |
| 2002 | 7657.46 | 7805 | 1022 | 89.77 | 89.77 | 88.84 | 89.10 | 1.35 | 1.22 | 9.00 | 0.00 |
| 2003 | 8700.78 | 8634 | 1022 | 98.62 | 98.62 | 97.19 | 98.56 | 0.76 | 0.75 | 0.63 | 0.00 |
| 2004 | 8000.42 | 7911 | 1022 | 90.04 | 91.50 | 89.12 | 90.06 | 1.94 | 1.81 | 6.69 | 1.46 |
| 2005 | 8688.67 | 8497 | 1026 | 97.01 | 97.01 | 96.66 | 96.99 | 2.99 | 2.99 | 0.00 | 0.00 |
| 2006 | 8233.30 | 7974 | 1052 | 91.06 | 91.06 | 89.34 | 91.03 | 1.44 | 1.33 | 7.60 | 0.00 |
| 2007 | 9250.44 | 8714 | 1043 | 99.48 | 99.48 | 101.25 | 99.47 | 0.52 | 0.52 | 0.00 | 0.00 |
| 2008 | 8546.55 | 8160 | 1043 | 92.90 | 92.90 | 93.29 | 92.90 | 0.40 | 0.37 | 6.72 | 0.00 |
| 2009 | 8887.91 | 8390 | 1043 | 95.80 | 95.80 | 97.28 | 95.78 | 4.20 | 4.20 | 0.00 | 0.00 |
| 2010 | 8612.00 | 8089 | 1065 | 92.51 | 92.51 | 92.31 | 92.34 | 0.77 | 0.72 | 6.76 | 0.00 |
| 2011 | 8671.47 | 8184 | 1065 | 93.45 | 93.45 | 92.95 | 93.42 | 0.00 | 0.00 | 6.55 | 0.00 |
| 2012 | 9373.73 | 8784 | 1065 | 100.00 | 100.00 | 100.20 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 8323.86 | 7861 | 1065 | 89.74 | 89.74 | 89.21 | 89.73 | 4.21 | 3.95 | 6.32 | 0.00 |
| 2014 | 9098.05 | 8615 | 1065 | 98.34 | 98.34 | 97.52 | 98.34 | 0.47 | 0.47 | 1.19 | 0.00 |
| 2015 | 8084.74 | 8167 | 1065 | 93.24 | 93.24 | 86.66 | 93.23 | 1.04 | 0.98 | 5.78 | 0.00 |
| 2016 | 8915.50 | 8520 | 1065 | 96.99 | 96.99 | 95.30 | 96.99 | 0.00 | 0.00 | 3.01 | 0.00 |
| 2017 | 8357.89 | 7934 | 1062 | 90.55 | 90.55 | 89.84 | 90.57 | 3.62 | 3.40 | 6.05 | 0.00 |
| 2018 | 8398.48 | 8027 | 1062 | 91.95 | 91.95 | 90.28 | 91.63 | 0.00 | 0.00 | 8.05 | 0.00 |
| 2019 | 8388.42 | 7899 | 1062 | 90.19 | 90.19 | 90.17 | 90.17 | 1.32 | 1.21 | 8.61 | 0.00 |
| 2020 | 9462.48 | 8783 | 1062 | 100.00 | 100.00 | 101.44 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 8286.14 | 7998 | 1062 | 91.30 | 91.30 | 89.07 | 91.30 | 0.00 | 0.00 | 8.70 | 0.00 |
| 2022 | 9224.08 | 8665 | 1062 | 98.92 | 98.92 | 99.15 | 98.92 | 1.08 | 1.08 | 0.00 | 0.00 |
| 2023 | 8050.49 | 7645 | 1062 | 84.04 | 84.04 | 86.54 | 87.27 | 2.75 | 2.47 | 13.49 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 216 | | | 240 | |
| B. Refuelling without maintenance | | | | 21 | | |
| C. Inspection, maintenance or repair combined with refuelling | 716 | | | 1121 | | |
| D. Inspection, maintenance or repair without refuelling | 504 | | | 133 | | |
| E. Testing of plant systems or components | | | | 2 | | |
| H. Nuclear regulatory requirements | | | | | 8 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 11 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| Z. Other | | | | | 33 | |
| Subtotal | 1220 | 216 | | 1277 | 292 | 4 |
| Total | | 1436 | | | 1573 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1987 to 2023 | |
|--|------------|-----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 216 | | 9 |
| 12. Reactor I&C Systems | | | | 16 |
| 14. Safety Systems | | | | 8 |
| 15. Reactor Cooling Systems | | | | 56 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 1 |
| 31. Turbine and auxiliaries | | | | 30 |
| 32. Feedwater and Main Steam System | | | | 86 |
| 34. Miscellaneous Systems | | | | 3 |
| 41. Main Generator Systems | | | | 11 |
| 42. Electrical Power Supply Systems | | | | 27 |
| Total | | 216 | | 247 |

2023 Operating Experience

US-397 **COLUMBIA** **UNITED STATES OF AMERICA**

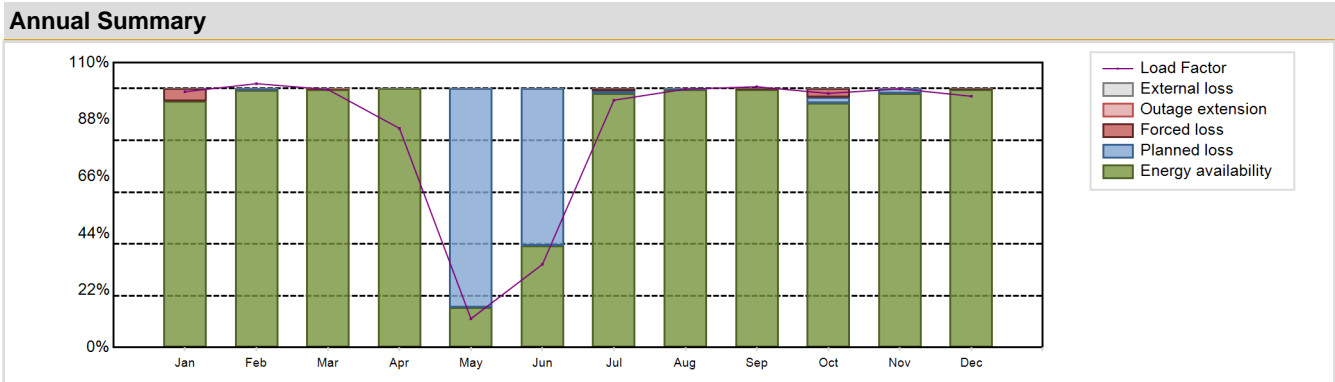
Status at end of year : **Operational**
 Operator : ENERGINW (Energy Northwest)
 Owner : ENERGINW (Energy Northwest)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-5 (Mark 2) | Construction Date | : 1972-08-01 |
| Thermal power | : 3486 MWth | Grid Date | : 1984-05-27 |
| Gross electrical power | : 1190 MWe | Commercial Date | : 1984-12-13 |
| Reference unit power (net) | : 1131 MWe | Age at end of year | : 39 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.17 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 287 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.316 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 20 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 42000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.75 | HP cylinder inlet steam pressure [MPa] | : 6.82 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 764 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 43 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 8408.02 GW(e).h | Forced Loss Rate (FLR) | : 1 % |
| Energy Availability Factor (EAF) | : 86.49 % | Unplanned Capability Loss Factor (UCL) | : 0.88 % |
| Unit Capability Factor (UCF) | : 86.49 % | Planned Unavailability Factor (PUF) | : 12.63 % |
| Load Factor (LF) | : 84.86 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 87.85 % | Total off-line time | : 1064 hours |

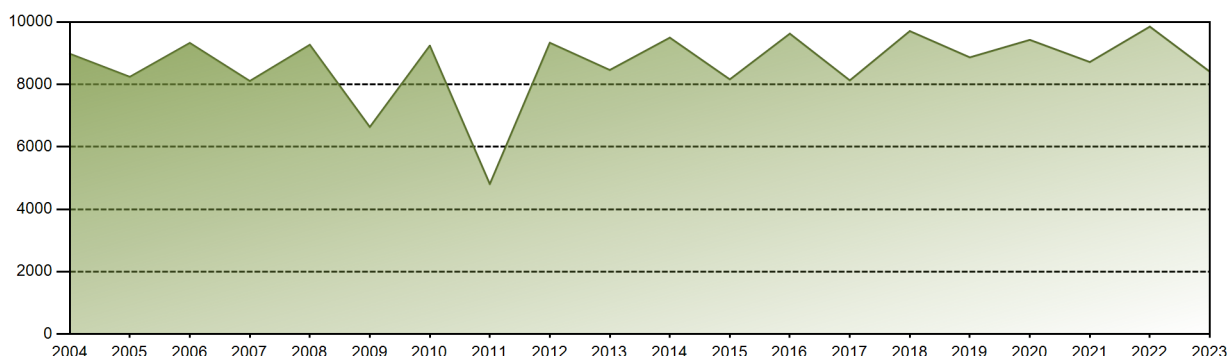


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 831.23 | 774.54 | 837.25 | 689.24 | 93.61 | 261.56 | 803.72 | 839.84 | 820.06 | 825.76 | 814.79 | 816.43 | 8408.02 |
| EAF [%] | 95.16 | 99.36 | 99.58 | 100.00 | 15.60 | 39.38 | 98.23 | 99.52 | 99.73 | 94.52 | 98.20 | 99.55 | 86.49 |
| UCF [%] | 95.16 | 99.36 | 99.58 | 100.00 | 15.60 | 39.38 | 98.23 | 99.52 | 99.73 | 94.52 | 98.20 | 99.55 | 86.49 |
| LF [%] | 98.78 | 101.91 | 99.63 | 84.64 | 11.12 | 32.12 | 95.51 | 99.81 | 100.71 | 98.13 | 99.92 | 97.03 | 84.86 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 15.59 | 39.44 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.85 |
| FLR [%] | 4.84 | 0.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.98 | 0.00 | 0.27 | 3.49 | 0.00 | 0.45 | 1.00 |
| UCL [%] | 4.84 | 0.00 | 0.42 | 0.00 | 0.00 | 0.00 | 0.97 | 0.00 | 0.27 | 3.42 | 0.00 | 0.45 | 0.88 |
| PUF [%] | 0.00 | 0.64 | 0.00 | 0.00 | 84.40 | 60.63 | 0.81 | 0.48 | 0.00 | 2.06 | 1.80 | 0.00 | 12.63 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 295663.5 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.7 % |
| Cumulative Energy Availability Factor (EAF) | : 82.25 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.08 % |
| Cumulative Unit Capability Factor (UCF) | : 82.76 % | Cumulative Planned Unavailability Factor (PUF) | : 13.16 % |
| Cumulative Load Factor (LF) | : 77.81 % | Cumulative Externally cause unavailability (XUF) | : 0.51 % |
| Cumulative Operating Factor (OF) | : 82.14 % | | |

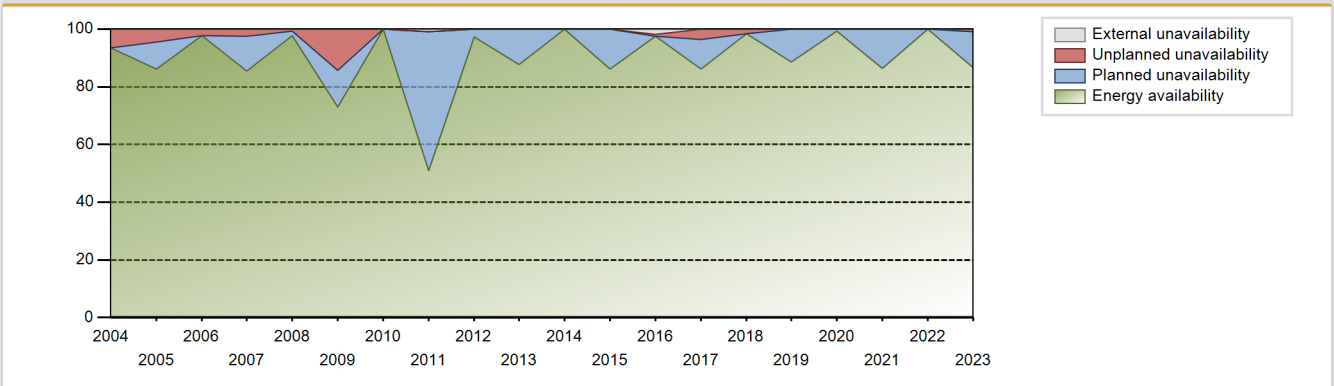
Electricity Production (net) [GWh]



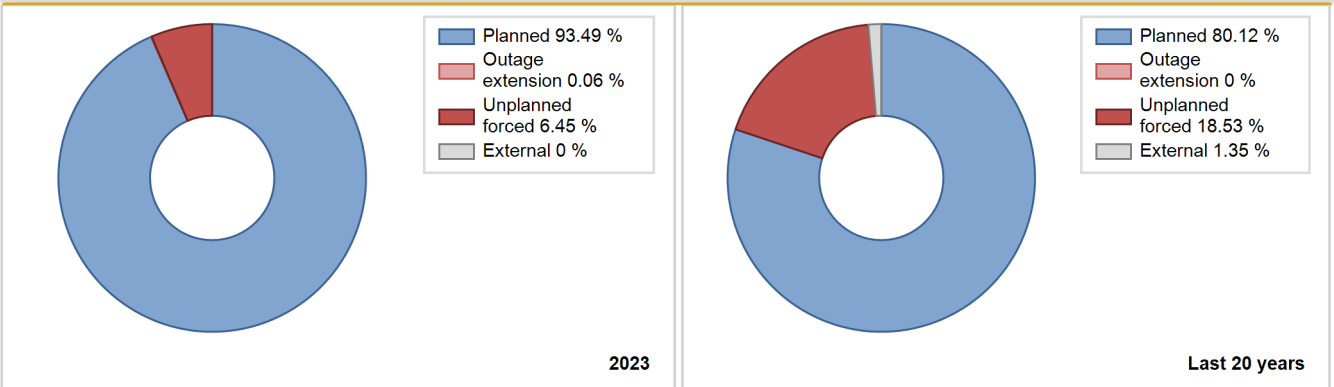
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 1458.42 | 2393 | 1104 | 90.49 | 90.49 | 84.56 | 90.68 | 9.51 | 9.51 | 0.00 | 0.00 |
| 1985 | 5176.39 | 6624 | 1100 | 77.10 | 77.10 | 53.70 | 75.62 | 8.28 | 6.96 | 15.94 | 0.00 |
| 1986 | 5183.20 | 6133 | 1095 | 74.11 | 74.11 | 54.04 | 70.01 | 4.33 | 3.35 | 22.54 | 0.00 |
| 1987 | 5397.98 | 5979 | 1095 | 67.93 | 67.93 | 56.27 | 68.25 | 8.83 | 6.58 | 25.49 | 0.00 |
| 1988 | 6000.36 | 6020 | 1095 | 68.24 | 68.24 | 62.38 | 68.53 | 15.00 | 12.04 | 19.72 | 0.00 |
| 1989 | 6127.94 | 6680 | 1095 | 76.05 | 76.05 | 63.88 | 76.26 | 4.41 | 3.51 | 20.43 | 0.00 |
| 1990 | 5791.26 | 5752 | 1095 | 65.31 | 65.31 | 60.37 | 65.66 | 6.68 | 4.67 | 30.02 | 0.00 |
| 1991 | 4272.55 | 4194 | 1090 | 47.10 | 47.10 | 44.75 | 47.88 | 42.75 | 35.16 | 17.74 | 0.00 |
| 1992 | 5705.42 | 5505 | 1085 | 61.96 | 61.96 | 59.86 | 62.67 | 15.37 | 11.26 | 26.78 | 0.00 |
| 1993 | 7141.96 | 6757 | 1107 | 77.16 | 77.16 | 73.61 | 77.13 | 8.30 | 6.98 | 15.86 | 0.00 |
| 1994 | 6753.81 | 6500 | 1086 | 73.73 | 73.73 | 70.99 | 74.20 | 1.32 | 0.99 | 25.29 | 0.00 |
| 1995 | 6947.98 | 6680 | 1091 | 75.98 | 75.98 | 72.67 | 76.26 | 5.02 | 4.02 | 20.01 | 0.00 |
| 1996 | 5562.63 | 5999 | 1106 | 68.30 | 79.66 | 57.24 | 68.29 | 1.73 | 1.40 | 18.94 | 11.36 |
| 1997 | 6129.89 | 6248 | 1107 | 71.35 | 77.36 | 63.21 | 71.32 | 0.21 | 0.16 | 22.48 | 6.02 |
| 1998 | 6922.83 | 6373 | 1107 | 72.78 | 72.78 | 71.39 | 72.75 | 13.97 | 11.82 | 15.40 | 0.00 |
| 1999 | 6099.69 | 6018 | 1107 | 68.51 | 68.51 | 62.90 | 68.70 | 0.00 | 0.00 | 31.49 | 0.00 |
| 2000 | 8605.23 | 8385 | 1107 | 95.41 | 95.41 | 88.50 | 95.46 | 3.21 | 3.16 | 1.43 | 0.00 |
| 2001 | 8257.71 | 7553 | 1107 | 86.14 | 86.14 | 85.15 | 86.22 | 2.28 | 2.01 | 11.85 | 0.00 |
| 2002 | 8981.29 | 8528 | 1107 | 97.35 | 97.35 | 92.62 | 97.35 | 2.65 | 2.65 | 0.00 | 0.00 |
| 2003 | 7614.87 | 7039 | 1107 | 80.39 | 80.39 | 78.53 | 80.35 | 6.92 | 5.98 | 13.63 | 0.00 |
| 2004 | 8981.58 | 8222 | 1107 | 93.61 | 93.61 | 92.37 | 93.60 | 6.39 | 6.39 | 0.00 | 0.00 |
| 2005 | 8242.27 | 7537 | 1108 | 86.05 | 86.05 | 84.91 | 86.03 | 4.92 | 4.45 | 9.50 | 0.00 |
| 2006 | 9328.28 | 8568 | 1131 | 97.82 | 97.82 | 94.15 | 97.81 | 2.18 | 2.18 | 0.00 | 0.00 |
| 2007 | 8108.56 | 7481 | 1131 | 85.43 | 85.43 | 81.84 | 85.40 | 2.86 | 2.52 | 12.05 | 0.00 |
| 2008 | 9269.64 | 8592 | 1131 | 97.83 | 97.83 | 93.31 | 97.81 | 0.71 | 0.70 | 1.47 | 0.00 |
| 2009 | 6634.01 | 6382 | 1131 | 72.93 | 72.93 | 66.96 | 72.85 | 16.39 | 14.30 | 12.77 | 0.00 |
| 2010 | 9241.13 | 8760 | 1131 | 100.00 | 100.00 | 93.27 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 4806.28 | 4466 | 1131 | 51.01 | 51.96 | 48.51 | 50.98 | 0.00 | 0.00 | 48.04 | 0.95 |
| 2012 | 9333.71 | 8545 | 1107 | 97.28 | 97.28 | 95.99 | 97.28 | 0.00 | 0.00 | 2.72 | 0.00 |
| 2013 | 8460.89 | 7678 | 1107 | 87.65 | 87.65 | 87.24 | 87.64 | 0.00 | 0.00 | 12.35 | 0.00 |
| 2014 | 9497.32 | 8760 | 1107 | 100.00 | 100.00 | 97.94 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 8160.91 | 7550 | 1107 | 86.19 | 86.19 | 84.16 | 86.19 | 0.00 | 0.00 | 13.81 | 0.00 |
| 2016 | 9625.62 | 8565 | 1107 | 97.51 | 99.28 | 98.99 | 97.51 | 0.72 | 0.72 | 0.00 | 1.78 |
| 2017 | 8128.26 | 7548 | 1116 | 86.22 | 86.22 | 83.48 | 86.16 | 3.93 | 3.53 | 10.25 | 0.00 |
| 2018 | 9708.44 | 8612 | 1131 | 98.31 | 98.31 | 97.99 | 98.31 | 1.69 | 1.69 | 0.00 | 0.00 |
| 2019 | 8866.50 | 7770 | 1131 | 88.70 | 88.70 | 89.49 | 88.70 | 0.00 | 0.00 | 11.30 | 0.00 |
| 2020 | 9427.05 | 8720 | 1131 | 99.28 | 99.28 | 94.89 | 99.27 | 0.00 | 0.00 | 0.72 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|------|--------|--------|-------|--------|------|------|-------|------|
| 2021 | 8716.73 | 7569 | 1131 | 86.40 | 86.40 | 87.98 | 86.40 | 0.00 | 0.00 | 13.60 | 0.00 |
| 2022 | 9851.53 | 8760 | 1131 | 100.00 | 100.00 | 99.43 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 8408.02 | 7696 | 1131 | 86.49 | 86.49 | 84.86 | 87.85 | 1.00 | 0.88 | 12.63 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 229 | |
| B. Refuelling without maintenance | | | | 30 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1136 | | | 968 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 87 | | |
| E. Testing of plant systems or components | | | | 16 | 1 | |
| H. Nuclear regulatory requirements | | | | | 92 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 39 |
| L. Human factor related | | | | | 15 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 48 | | 2 |
| Z. Other | | | | 2 | 19 | |
| Subtotal | 1136 | | | 1151 | 356 | 45 |
| Total | | 1136 | | | 1552 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 10 |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 25 |
| 15. Reactor Cooling Systems | | 27 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 19 |
| 31. Turbine and auxiliaries | | 72 |
| 32. Feedwater and Main Steam System | | 27 |
| 33. Circulating Water System | | 0 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 58 |
| Total | | 253 |

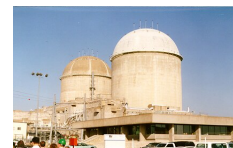
2023 Operating Experience

US-445

COMANCHE PEAK-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : LUMINANT (Luminant Generation Company, LLC)
 Owner : LUMINANT (Luminant Generation Company, LLC)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : AC (ALLIS CHALMERS)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3612 MWth
 Gross electrical power : 1259 MWe
 Reference unit power (net) : 1205 MWe

Key Dates

Construction Date : 1974-12-19
 Grid Date : 1990-04-24
 Commercial Date : 1990-08-13
 Age at end of year : 33 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 40000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.81
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 325
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.103

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.75
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

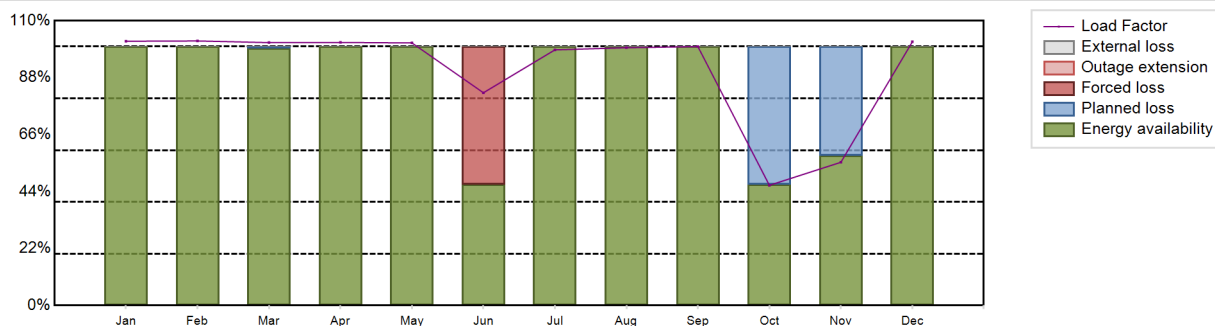
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9610.95 GW(e).h
 Energy Availability Factor (EAF) : 87.59 %
 Unit Capability Factor (UCF) : 87.59 %
 Load Factor (LF) : 91.05 %
 Operating Factor (OF) : 91.55 %
 Forced Loss Rate (FLR) : 4.77 %
 Unplanned Capability Loss Factor (UCL) : 4.38 %
 Planned Unavailability Factor (PUF) : 8.02 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 740 hours

Annual Summary

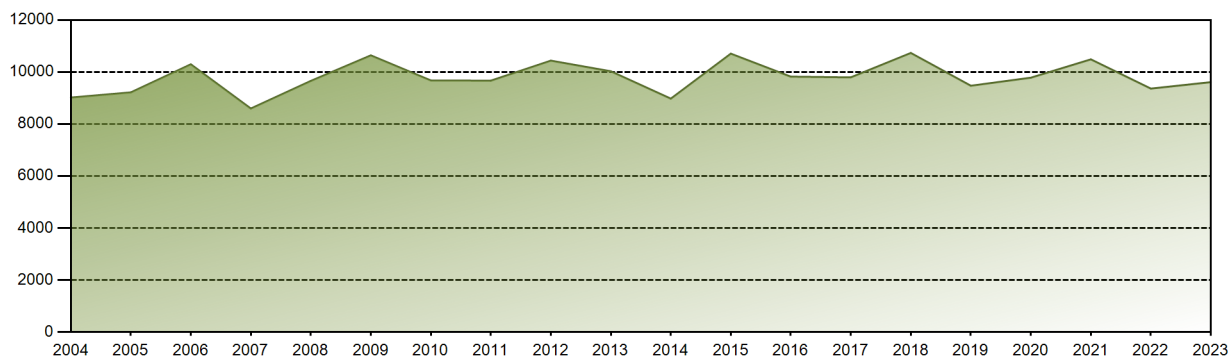


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 915.16 | 827.46 | 909.17 | 881.55 | 909.24 | 712.90 | 885.20 | 892.59 | 867.69 | 416.28 | 480.61 | 913.11 | 9610.95 |
| EAF [%] | 100.00 | 100.00 | 99.45 | 100.00 | 100.00 | 46.67 | 100.00 | 100.00 | 100.00 | 46.77 | 58.01 | 100.00 | 87.59 |
| UCF [%] | 100.00 | 100.00 | 99.45 | 100.00 | 100.00 | 46.67 | 100.00 | 100.00 | 100.00 | 46.77 | 58.01 | 100.00 | 87.59 |
| LF [%] | 102.08 | 102.19 | 101.55 | 101.61 | 101.42 | 82.17 | 98.74 | 99.56 | 100.01 | 46.43 | 55.32 | 101.85 | 91.05 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.31 | 100.00 | 100.00 | 100.00 | 46.77 | 57.98 | 100.00 | 91.55 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 53.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.77 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 53.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.38 |
| PUF [%] | 0.00 | 0.00 | 0.55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 53.23 | 41.99 | 0.00 | 8.02 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

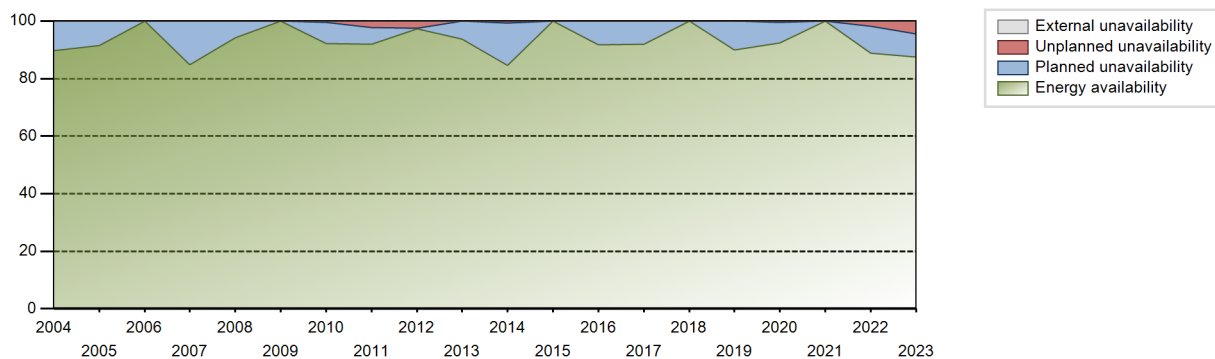
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 305010.48 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.58 % |
| Cumulative Energy Availability Factor (EAF) | : 90.75 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.46 % |
| Cumulative Unit Capability Factor (UCF) | : 90.76 % | Cumulative Planned Unavailability Factor (PUF) | : 7.78 % |
| Cumulative Load Factor (LF) | : 88.59 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 90.77 % | | |

Electricity Production (net) [GWh]

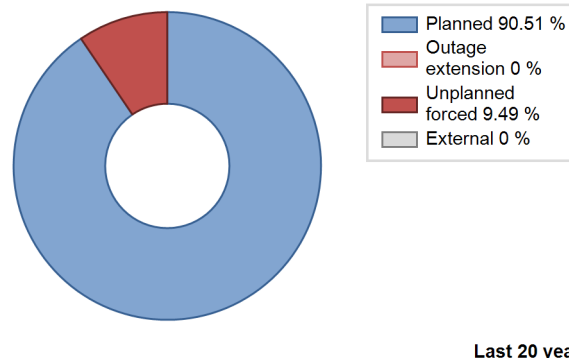
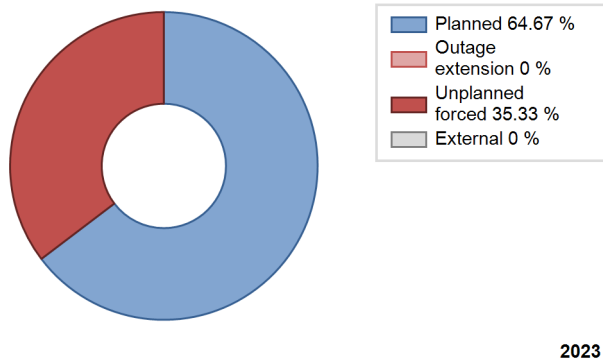


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1990 | 3335.18 | 4399 | 1140 | 80.61 | 80.61 | 60.19 | 78.00 | 8.53 | 7.52 | 11.87 | 0.00 |
| 1991 | 5360.52 | 5341 | 1150 | 60.51 | 60.51 | 53.21 | 60.97 | 12.05 | 8.29 | 31.20 | 0.00 |
| 1992 | 6937.48 | 6947 | 1150 | 79.11 | 79.11 | 68.68 | 79.09 | 3.93 | 3.23 | 17.66 | 0.00 |
| 1993 | 7150.44 | 6932 | 1150 | 79.14 | 79.14 | 70.98 | 79.13 | 1.92 | 1.55 | 19.30 | 0.00 |
| 1994 | 9367.60 | 8653 | 1150 | 98.78 | 98.78 | 92.99 | 98.78 | 1.22 | 1.22 | 0.00 | 0.00 |
| 1995 | 7803.75 | 7444 | 1150 | 84.98 | 84.98 | 77.46 | 84.98 | 3.11 | 2.73 | 12.29 | 0.00 |
| 1996 | 7756.24 | 7265 | 1150 | 82.73 | 83.00 | 76.78 | 82.71 | 6.01 | 5.31 | 11.69 | 0.27 |
| 1997 | 9478.88 | 8656 | 1150 | 98.81 | 98.81 | 94.09 | 98.81 | 1.19 | 1.19 | 0.00 | 0.00 |
| 1998 | 8505.96 | 7848 | 1150 | 89.59 | 89.59 | 84.43 | 89.59 | 0.00 | 0.00 | 10.41 | 0.00 |
| 1999 | 8601.51 | 7922 | 1150 | 90.44 | 90.44 | 85.38 | 90.43 | 0.01 | 0.01 | 9.54 | 0.00 |
| 2000 | 9619.80 | 8784 | 1150 | 100.00 | 100.00 | 95.23 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 8444.32 | 7781 | 1150 | 88.86 | 88.86 | 83.82 | 88.82 | 3.47 | 3.20 | 7.95 | 0.00 |
| 2002 | 7785.26 | 7213 | 1150 | 82.97 | 82.97 | 77.28 | 82.34 | 5.99 | 5.29 | 11.74 | 0.00 |
| 2003 | 9625.95 | 8653 | 1150 | 98.85 | 98.85 | 95.55 | 98.78 | 1.15 | 1.15 | 0.00 | 0.00 |
| 2004 | 9018.13 | 7877 | 1150 | 89.82 | 89.82 | 89.27 | 89.67 | 0.00 | 0.00 | 10.18 | 0.00 |
| 2005 | 9217.83 | 8004 | 1084 | 91.39 | 91.39 | 97.07 | 91.37 | 0.00 | 0.00 | 8.61 | 0.00 |
| 2006 | 10297.95 | 8760 | 1150 | 100.00 | 100.00 | 102.22 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 8596.75 | 7437 | 1150 | 84.91 | 84.91 | 85.34 | 84.90 | 0.00 | 0.00 | 15.09 | 0.00 |
| 2008 | 9658.71 | 8262 | 1209 | 94.11 | 94.11 | 94.80 | 94.06 | 0.00 | 0.00 | 5.89 | 0.00 |
| 2009 | 10640.87 | 8760 | 1209 | 100.00 | 100.00 | 100.47 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 9676.72 | 8074 | 1209 | 92.19 | 92.19 | 91.37 | 92.17 | 0.46 | 0.43 | 7.38 | 0.00 |
| 2011 | 9667.76 | 8056 | 1209 | 91.99 | 91.99 | 91.28 | 91.96 | 2.51 | 2.37 | 5.64 | 0.00 |
| 2012 | 10438.08 | 8537 | 1209 | 97.20 | 97.20 | 98.29 | 97.19 | 2.60 | 2.59 | 0.21 | 0.00 |
| 2013 | 10028.69 | 8211 | 1205 | 93.71 | 93.71 | 95.00 | 93.72 | 0.00 | 0.00 | 6.29 | 0.00 |
| 2014 | 8976.75 | 7401 | 1209 | 84.48 | 84.48 | 84.76 | 84.49 | 0.90 | 0.77 | 14.75 | 0.00 |
| 2015 | 10706.90 | 8760 | 1218 | 100.00 | 100.00 | 100.35 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 9821.67 | 8061 | 1218 | 91.77 | 91.77 | 91.80 | 91.77 | 0.00 | 0.00 | 8.23 | 0.00 |
| 2017 | 9795.19 | 8053 | 1218 | 91.93 | 91.93 | 91.80 | 91.93 | 0.00 | 0.00 | 8.07 | 0.00 |
| 2018 | 10733.89 | 8760 | 1218 | 100.00 | 100.00 | 100.60 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 9472.80 | 7895 | 1205 | 90.03 | 90.03 | 89.74 | 90.13 | 0.00 | 0.00 | 9.97 | 0.00 |
| 2020 | 9781.85 | 8131 | 1205 | 92.31 | 92.31 | 92.41 | 92.57 | 0.55 | 0.51 | 7.18 | 0.00 |
| 2021 | 10487.56 | 8760 | 1205 | 100.00 | 100.00 | 99.35 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 9363.00 | 7771 | 1205 | 88.71 | 88.71 | 88.70 | 88.71 | 2.00 | 1.81 | 9.48 | 0.00 |
| 2023 | 9610.95 | 8020 | 1205 | 87.59 | 87.59 | 91.05 | 91.55 | 4.77 | 4.38 | 8.02 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1990 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 384 | | | 119 | |
| B. Refuelling without maintenance | | | | 44 | | |
| C. Inspection, maintenance or repair combined with refuelling | 698 | | | 594 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 71 | | |
| L. Human factor related | | | | | 10 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 5 |
| Z. Other | | | | | 1 | |
| Subtotal | 698 | 384 | | 709 | 130 | 5 |
| Total | | 1082 | | | 844 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1990 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 384 | 16 |
| 12. Reactor I&C Systems | | 12 |
| 13. Reactor Auxiliary Systems | | 0 |
| 15. Reactor Cooling Systems | | 11 |
| 16. Steam generation systems | | 6 |
| 31. Turbine and auxiliaries | | 24 |
| 32. Feedwater and Main Steam System | | 21 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 11 |
| 42. Electrical Power Supply Systems | | 15 |
| Total | 384 | 121 |

2023 Operating Experience

US-446

COMANCHE PEAK-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : LUMINANT (Luminant Generation Company, LLC)
 Owner : LUMINANT (Luminant Generation Company, LLC)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : AC (ALLIS CHALMERS)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3612 MWth
 Gross electrical power : 1250 MWe
 Reference unit power (net) : 1195 MWe

Key Dates

Construction Date : 1974-12-19
 Grid Date : 1993-04-09
 Commercial Date : 1993-08-03
 Age at end of year : 30 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 36000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.81
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 325
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.103

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.75
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

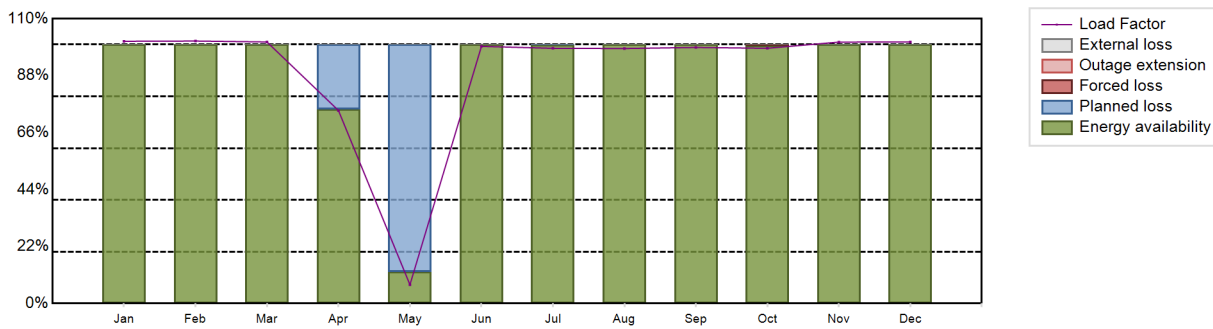
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9419.27 GW(e).h
 Energy Availability Factor (EAF) : 90.46 %
 Unit Capability Factor (UCF) : 90.46 %
 Load Factor (LF) : 89.98 %
 Operating Factor (OF) : 90.49 %

Forced Loss Rate (FLR) : 0.03 %
 Unplanned Capability Loss Factor (UCL) : 0.03 %
 Planned Unavailability Factor (PUF) : 9.51 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 833 hours

Annual Summary

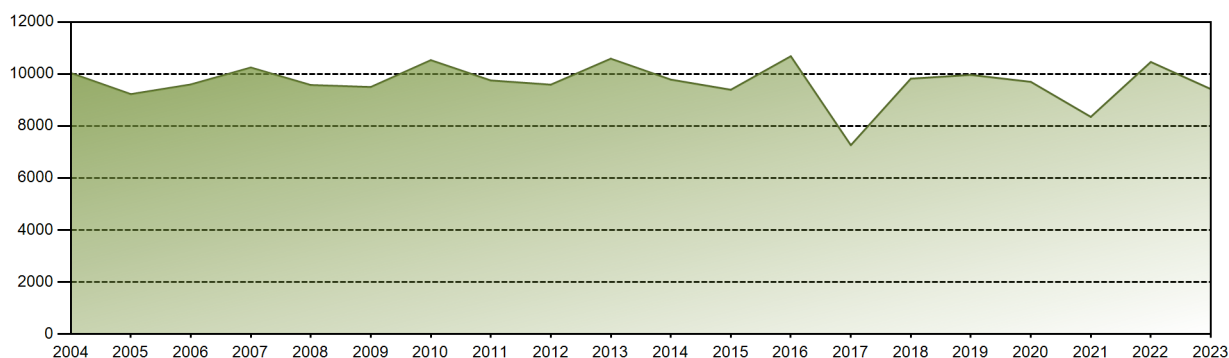


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 900.46 | 814.07 | 896.85 | 641.38 | 64.60 | 854.46 | 876.38 | 875.47 | 850.94 | 876.40 | 870.01 | 898.25 | 9419.27 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 75.00 | 12.23 | 100.00 | 99.97 | 100.00 | 100.00 | 99.68 | 100.00 | 100.00 | 90.46 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 75.00 | 12.23 | 100.00 | 99.97 | 100.00 | 100.00 | 99.68 | 100.00 | 100.00 | 90.46 |
| LF [%] | 101.28 | 101.37 | 101.01 | 74.54 | 7.27 | 99.31 | 98.57 | 98.47 | 98.90 | 98.57 | 100.98 | 101.03 | 89.98 |
| OF [%] | 100.00 | 100.00 | 100.00 | 75.00 | 12.23 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.49 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.03 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.03 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 25.00 | 87.77 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.51 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

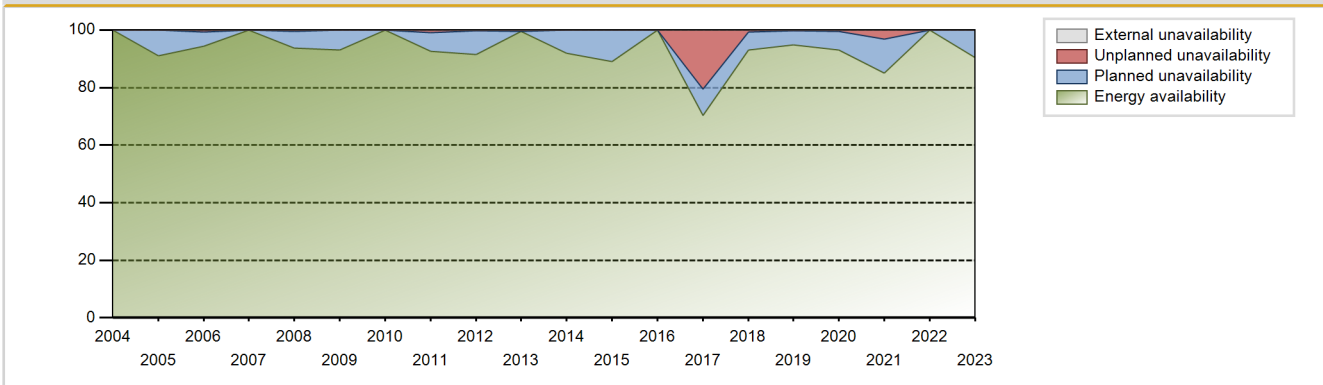
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 280596.19 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.25 % |
| Cumulative Energy Availability Factor (EAF) | : 91.42 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.11 % |
| Cumulative Unit Capability Factor (UCF) | : 91.45 % | Cumulative Planned Unavailability Factor (PUF) | : 6.45 % |
| Cumulative Load Factor (LF) | : 89.9 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 91.39 % | | |

Electricity Production (net) [GWh]

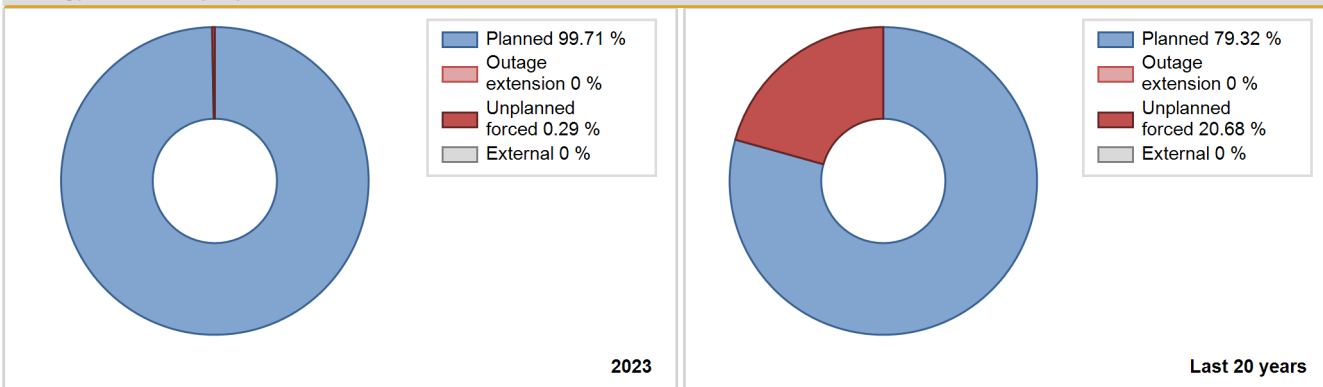


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1993 | 4131.71 | 4600 | 1150 | 89.74 | 89.74 | 82.77 | 89.74 | 10.26 | 10.26 | 0.00 | 0.00 |
| 1994 | 5263.15 | 5697 | 1150 | 65.07 | 65.07 | 52.24 | 65.03 | 17.02 | 13.34 | 21.59 | 0.00 |
| 1995 | 9166.58 | 8382 | 1150 | 95.68 | 95.68 | 90.99 | 95.68 | 1.60 | 1.55 | 2.76 | 0.00 |
| 1996 | 7370.37 | 6911 | 1150 | 78.68 | 79.42 | 72.96 | 78.68 | 7.06 | 6.03 | 14.55 | 0.74 |
| 1997 | 8062.05 | 7554 | 1150 | 86.23 | 86.23 | 80.03 | 86.23 | 0.00 | 0.00 | 13.77 | 0.00 |
| 1998 | 9345.30 | 8741 | 1150 | 99.78 | 99.78 | 92.77 | 99.78 | 0.22 | 0.22 | 0.00 | 0.00 |
| 1999 | 8756.02 | 7901 | 1150 | 90.19 | 90.19 | 86.92 | 90.19 | 0.65 | 0.59 | 9.21 | 0.00 |
| 2000 | 8868.05 | 7927 | 1150 | 90.24 | 90.24 | 87.79 | 90.24 | 0.00 | 0.00 | 9.76 | 0.00 |
| 2001 | 9877.95 | 8731 | 1150 | 99.67 | 99.67 | 98.05 | 99.67 | 0.33 | 0.33 | 0.00 | 0.00 |
| 2002 | 8793.82 | 7888 | 1150 | 90.11 | 90.11 | 87.29 | 90.05 | 0.36 | 0.33 | 9.56 | 0.00 |
| 2003 | 8123.39 | 7307 | 1150 | 83.80 | 83.80 | 80.64 | 83.41 | 10.11 | 9.43 | 6.77 | 0.00 |
| 2004 | 10038.85 | 8784 | 1150 | 100.00 | 100.00 | 99.38 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 9225.37 | 7979 | 1124 | 91.10 | 91.10 | 93.68 | 91.07 | 0.00 | 0.00 | 8.90 | 0.00 |
| 2006 | 9598.20 | 8260 | 1150 | 94.30 | 94.30 | 95.28 | 94.29 | 0.63 | 0.60 | 5.10 | 0.00 |
| 2007 | 10249.00 | 8760 | 1150 | 100.00 | 100.00 | 101.74 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 9575.91 | 8241 | 1150 | 93.83 | 93.83 | 94.80 | 93.82 | 0.41 | 0.39 | 5.78 | 0.00 |
| 2009 | 9500.60 | 8155 | 1158 | 93.15 | 93.15 | 93.66 | 93.09 | 0.00 | 0.00 | 6.85 | 0.00 |
| 2010 | 10531.75 | 8760 | 1158 | 100.00 | 100.00 | 103.82 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 9751.59 | 8099 | 1197 | 92.71 | 92.71 | 93.00 | 92.45 | 1.00 | 0.94 | 6.36 | 0.00 |
| 2012 | 9588.68 | 8027 | 1197 | 91.41 | 91.41 | 91.20 | 91.38 | 0.33 | 0.30 | 8.29 | 0.00 |
| 2013 | 10588.12 | 8721 | 1195 | 99.55 | 99.55 | 101.13 | 99.54 | 0.45 | 0.45 | 0.00 | 0.00 |
| 2014 | 9784.63 | 8063 | 1197 | 92.04 | 92.04 | 93.31 | 92.04 | 0.00 | 0.00 | 7.96 | 0.00 |
| 2015 | 9393.65 | 7789 | 1207 | 89.01 | 89.01 | 88.84 | 88.92 | 0.03 | 0.02 | 10.97 | 0.00 |
| 2016 | 10682.62 | 8784 | 1207 | 100.00 | 100.00 | 100.76 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 7262.76 | 6152 | 1207 | 70.23 | 70.23 | 68.69 | 70.23 | 22.57 | 20.48 | 9.29 | 0.00 |
| 2018 | 9820.04 | 8141 | 1207 | 93.01 | 93.01 | 92.88 | 92.93 | 0.66 | 0.62 | 6.37 | 0.00 |
| 2019 | 9965.35 | 8305 | 1195 | 94.76 | 94.76 | 95.20 | 94.81 | 0.30 | 0.29 | 4.95 | 0.00 |
| 2020 | 9698.10 | 8182 | 1195 | 93.15 | 93.15 | 92.39 | 93.15 | 0.58 | 0.54 | 6.31 | 0.00 |
| 2021 | 8351.29 | 7453 | 1195 | 85.09 | 85.09 | 79.78 | 85.08 | 3.64 | 3.22 | 11.70 | 0.00 |
| 2022 | 10462.06 | 8760 | 1195 | 100.00 | 100.00 | 99.94 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 9419.27 | 7927 | 1195 | 90.46 | 90.46 | 89.98 | 90.49 | 0.03 | 0.03 | 9.51 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1993 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 164 | |
| B. Refuelling without maintenance | | | | 52 | | |
| C. Inspection, maintenance or repair combined with refuelling | 813 | | | 476 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 45 | | |
| E. Testing of plant systems or components | | | | 34 | | |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 14 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 7 | | |
| Z. Other | | | | | 12 | |
| Subtotal | 813 | | | 614 | 177 | 14 |
| Total | | 813 | | | 805 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1993 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 5 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 22 |
| 15. Reactor Cooling Systems | | 30 |
| 16. Steam generation systems | | 5 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 31. Turbine and auxiliaries | | 10 |
| 32. Feedwater and Main Steam System | | 29 |
| 34. Miscellaneous Systems | | 2 |
| 41. Main Generator Systems | | 57 |
| 42. Electrical Power Supply Systems | | 13 |
| Total | | 174 |

2023 Operating Experience

US-315

COOK-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : AEP (American Electric Power Company, Inc.)
 Owner : AEP (American Electric Power Company, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (ICECDN)
 Thermal power : 3304 MWth
 Gross electrical power : 1131 MWe
 Reference unit power (net) : 1030 MWe

Key Dates

Construction Date : 1969-03-25
 Grid Date : 1975-02-10
 Commercial Date : 1975-08-28
 Age at end of year : 48 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 38000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 21.98
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 14.76
 Reactor outlet temperature [°C] : 306
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.19

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.12
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

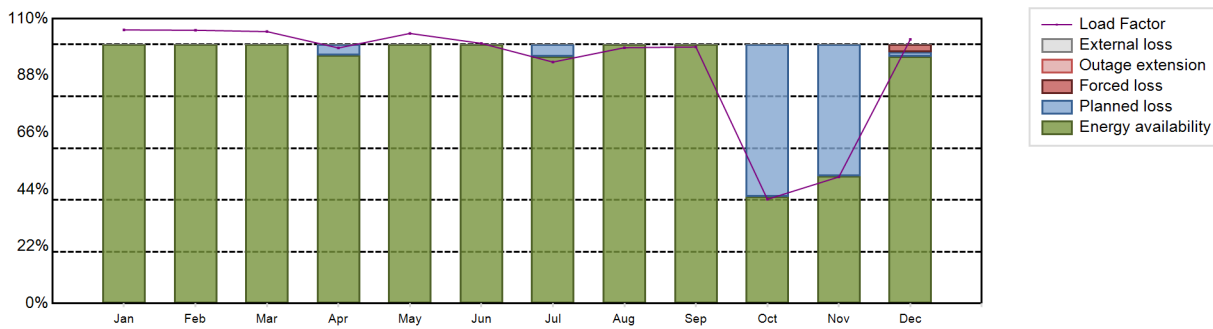
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8279.91 GW(e).h
 Energy Availability Factor (EAF) : 89.71 %
 Unit Capability Factor (UCF) : 89.71 %
 Load Factor (LF) : 91.77 %
 Operating Factor (OF) : 90.99 %
 Forced Loss Rate (FLR) : 0.27 %
 Unplanned Capability Loss Factor (UCL) : 0.25 %
 Planned Unavailability Factor (PUF) : 10.04 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 789 hours

Annual Summary

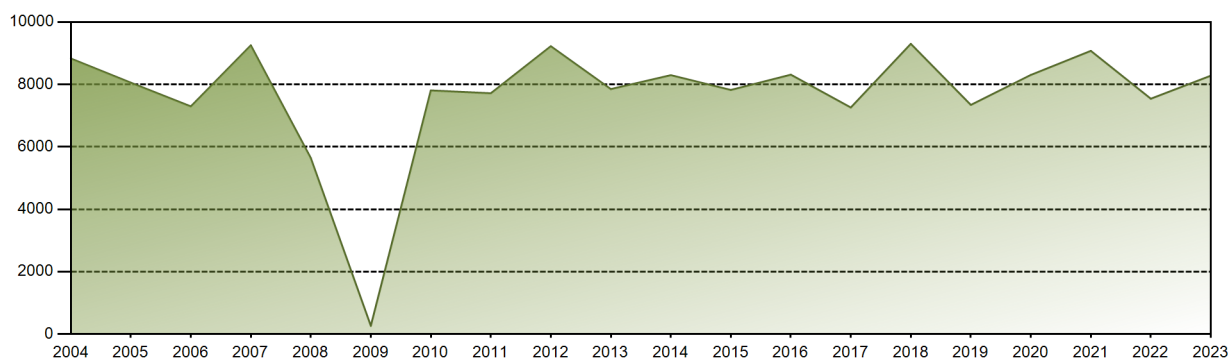


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 809.81 | 730.41 | 803.71 | 731.94 | 799.35 | 745.07 | 714.53 | 757.11 | 734.75 | 308.41 | 363.07 | 781.76 | 8279.91 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 95.93 | 100.00 | 100.00 | 95.27 | 100.00 | 100.00 | 41.33 | 49.19 | 95.47 | 89.71 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 95.93 | 100.00 | 100.00 | 95.27 | 100.00 | 100.00 | 41.33 | 49.19 | 95.47 | 89.71 |
| LF [%] | 105.68 | 105.53 | 105.02 | 98.70 | 104.31 | 100.47 | 93.24 | 98.80 | 99.08 | 40.25 | 48.89 | 102.02 | 91.77 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 42.34 | 50.07 | 100.00 | 90.99 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.94 | 0.27 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.89 | 0.25 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 4.07 | 0.00 | 0.00 | 4.73 | 0.00 | 0.00 | 58.67 | 50.81 | 1.64 | 10.04 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 313317.06 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 14.25 % |
| Cumulative Energy Availability Factor (EAF) | : 73.96 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 12.32 % |
| Cumulative Unit Capability Factor (UCF) | : 74.08 % | Cumulative Planned Unavailability Factor (PUF) | : 13.6 % |
| Cumulative Load Factor (LF) | : 71.99 % | Cumulative Externally cause unavailability (XUF) | : 0.12 % |
| Cumulative Operating Factor (OF) | : 74.48 % | | |

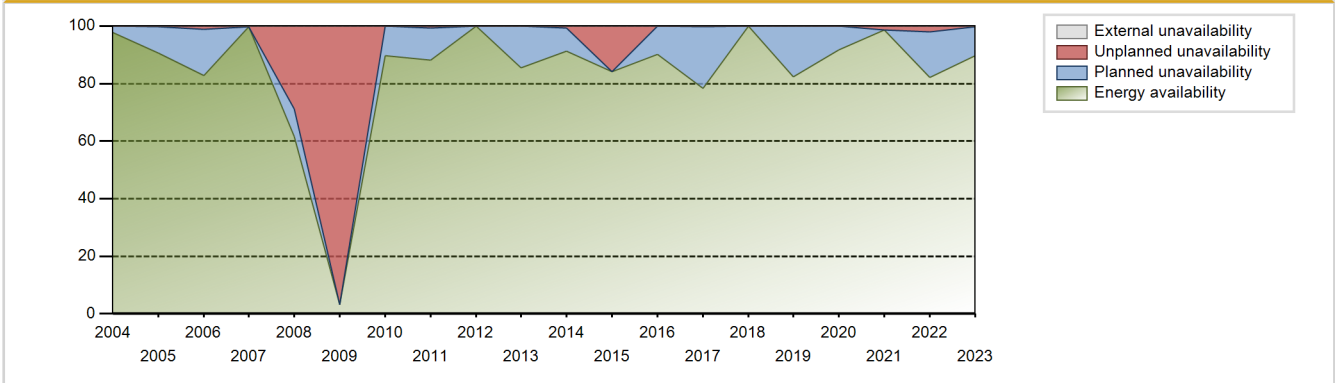
Electricity Production (net) [GWh]



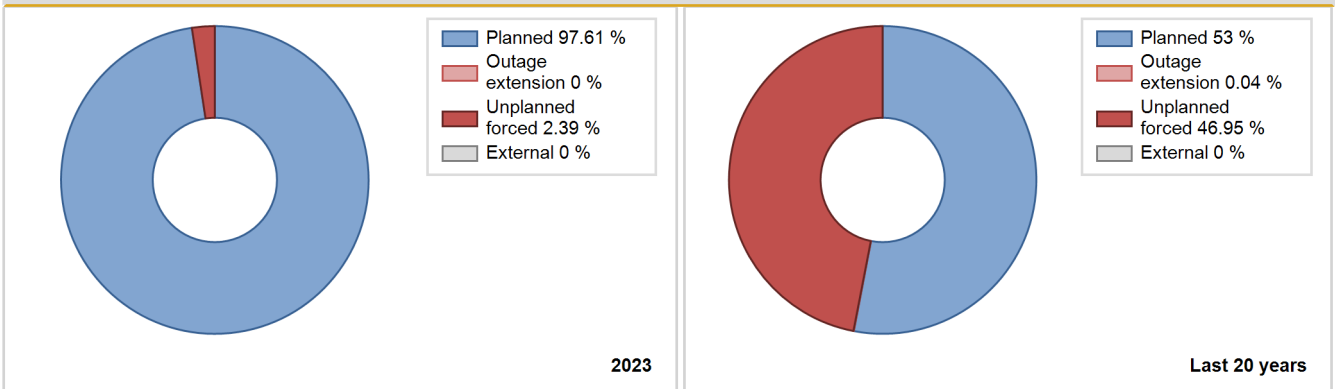
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|------------------------|------------------------------|---|--------|--------|--------|--------|--------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 4450.80 | 5955 | 848 | 80.79 | 80.79 | 80.81 | 82.48 | 5.03 | 4.28 | 14.94 | 0.00 |
| 1976 | 6804.90 | 7298 | 983 | 79.21 | 79.21 | 78.81 | 83.08 | 3.86 | 3.18 | 17.61 | 0.00 |
| 1977 | 4785.80 | 6658 | 1044 | 52.38 | 52.38 | 52.33 | 76.00 | 29.20 | 21.61 | 26.02 | 0.00 |
| 1978 | 6286.90 | 6438 | 1044 | 68.75 | 68.75 | 68.74 | 73.49 | 6.67 | 4.91 | 26.34 | 0.00 |
| 1979 | 5660.20 | 5666 | 1044 | 61.89 | 61.89 | 61.89 | 64.68 | 11.37 | 7.94 | 30.17 | 0.00 |
| 1980 | 6461.30 | 6470 | 1044 | 74.77 | 79.48 | 70.46 | 73.66 | 0.99 | 0.79 | 19.73 | 4.71 |
| 1981 | 6781.50 | 6663 | 1044 | 77.13 | 77.13 | 74.15 | 76.06 | 5.09 | 4.14 | 18.73 | 0.00 |
| 1982 | 5352.70 | 5487 | 1044 | 64.17 | 64.17 | 58.53 | 62.64 | 15.78 | 12.02 | 23.80 | 0.00 |
| 1983 | 5286.70 | 5628 | 1030 | 64.33 | 64.33 | 58.59 | 64.25 | 0.87 | 0.57 | 35.11 | 0.00 |
| 1984 | 7550.76 | 8016 | 1020 | 91.33 | 91.33 | 84.27 | 91.26 | 4.92 | 4.72 | 3.95 | 0.00 |
| 1985 | 2116.06 | 2489 | 1020 | 29.85 | 29.85 | 23.68 | 28.41 | 14.24 | 4.96 | 65.19 | 0.00 |
| 1986 | 6650.07 | 7464 | 1020 | 85.53 | 85.53 | 74.43 | 85.21 | 14.46 | 14.46 | 0.01 | 0.00 |
| 1987 | 5033.77 | 5917 | 1020 | 68.21 | 68.21 | 56.34 | 67.55 | 5.90 | 4.28 | 27.52 | 0.00 |
| 1988 | 7467.79 | 8379 | 1020 | 95.51 | 95.51 | 83.35 | 95.39 | 1.79 | 1.74 | 2.75 | 0.00 |
| 1989 | 5433.04 | 6069 | 1020 | 69.90 | 69.90 | 60.80 | 69.28 | 0.41 | 0.29 | 29.81 | 0.00 |
| 1990 | 6301.64 | 6939 | 1020 | 79.24 | 79.24 | 70.53 | 79.21 | 0.00 | 0.00 | 20.76 | 0.00 |
| 1991 | 7338.24 | 7524 | 1013 | 85.96 | 85.96 | 82.67 | 85.89 | 2.91 | 2.58 | 11.46 | 0.00 |
| 1992 | 4990.66 | 5690 | 1008 | 65.09 | 65.09 | 56.35 | 64.78 | 0.36 | 0.24 | 34.67 | 0.00 |
| 1993 | 8759.43 | 8760 | 1006 | 100.00 | 100.00 | 99.34 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1994 | 5759.52 | 6214 | 1000 | 70.96 | 70.96 | 65.75 | 70.94 | 0.00 | 0.00 | 29.04 | 0.00 |
| 1995 | 5396.79 | 5809 | 1000 | 66.37 | 66.37 | 61.61 | 66.31 | 14.56 | 11.31 | 22.32 | 0.00 |
| 1996 | 8373.26 | 8574 | 1000 | 97.62 | 97.62 | 95.32 | 97.61 | 2.38 | 2.38 | 0.00 | 0.00 |
| 1997 | 4545.86 | 4608 | 1000 | 52.41 | 52.41 | 51.89 | 52.60 | 37.55 | 31.51 | 16.07 | 0.00 |
| 1998 | 0.00 | 0 | 1000 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1999 | 0.00 | 0 | 1000 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 2000 | 129.80 | 242 | 1000 | 2.77 | 2.77 | 1.48 | 2.76 | 97.23 | 97.23 | 0.00 | 0.00 |
| 2001 | 7797.85 | 7840 | 1000 | 89.53 | 90.55 | 89.02 | 89.50 | 5.69 | 5.46 | 3.98 | 1.03 |
| 2002 | 7740.90 | 7782 | 1000 | 88.86 | 88.86 | 88.37 | 88.84 | 1.23 | 1.11 | 10.03 | 0.00 |
| 2003 | 6570.09 | 6489 | 1000 | 74.10 | 74.10 | 74.99 | 74.07 | 16.81 | 14.98 | 10.92 | 0.00 |
| 2004 | 8831.48 | 8588 | 1000 | 97.74 | 97.74 | 100.54 | 97.77 | 0.00 | 0.00 | 2.26 | 0.00 |
| 2005 | 8055.85 | 7940 | 1016 | 90.67 | 90.67 | 90.50 | 90.63 | 0.28 | 0.25 | 9.08 | 0.00 |
| 2006 | 7296.16 | 7256 | 1016 | 82.85 | 82.85 | 81.98 | 82.83 | 1.24 | 1.04 | 16.11 | 0.00 |
| 2007 | 9252.68 | 8728 | 1009 | 99.63 | 99.63 | 104.68 | 99.63 | 0.37 | 0.37 | 0.00 | 0.00 |
| 2008 | 5639.68 | 5407 | 1009 | 61.57 | 61.57 | 63.63 | 61.56 | 31.94 | 28.89 | 9.54 | 0.00 |
| 2009 | 263.43 | 289 | 1009 | 3.30 | 3.30 | 2.98 | 3.30 | 96.70 | 96.70 | 0.00 | 0.00 |
| 2010 | 7806.86 | 7859 | 1009 | 89.73 | 89.73 | 88.32 | 89.71 | 0.00 | 0.00 | 10.27 | 0.00 |
| 2011 | 7716.35 | 7716 | 1009 | 88.11 | 88.11 | 87.30 | 88.08 | 0.75 | 0.66 | 11.23 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|------|--------|--------|--------|--------|-------|-------|-------|------|
| 2012 | 9224.63 | 8784 | 1045 | 100.00 | 100.00 | 100.49 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 7850.11 | 7470 | 1045 | 85.49 | 85.49 | 85.74 | 85.26 | 0.00 | 0.00 | 14.51 | 0.00 |
| 2014 | 8296.79 | 7974 | 1045 | 91.16 | 91.16 | 90.63 | 91.03 | 0.71 | 0.65 | 8.19 | 0.00 |
| 2015 | 7822.53 | 7352 | 1045 | 84.15 | 84.15 | 85.45 | 83.93 | 15.85 | 15.85 | 0.00 | 0.00 |
| 2016 | 8311.75 | 7914 | 1045 | 90.09 | 90.09 | 90.55 | 90.10 | 0.00 | 0.00 | 9.91 | 0.00 |
| 2017 | 7260.08 | 6932 | 1045 | 78.29 | 78.29 | 79.31 | 79.13 | 0.03 | 0.16 | 21.55 | 0.00 |
| 2018 | 9299.54 | 8760 | 1030 | 100.00 | 100.00 | 103.07 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 7343.23 | 7207 | 1030 | 82.28 | 82.28 | 81.39 | 82.27 | 0.00 | 0.00 | 17.72 | 0.00 |
| 2020 | 8303.66 | 8050 | 1030 | 91.65 | 91.65 | 91.78 | 91.64 | 0.06 | 0.06 | 8.29 | 0.00 |
| 2021 | 9074.88 | 8648 | 1030 | 98.72 | 98.72 | 100.58 | 98.72 | 1.28 | 1.28 | 0.00 | 0.00 |
| 2022 | 7542.17 | 7196 | 1030 | 82.14 | 82.14 | 83.59 | 82.15 | 2.30 | 1.93 | 15.92 | 0.00 |
| 2023 | 8279.91 | 7971 | 1030 | 89.71 | 89.71 | 91.77 | 90.99 | 0.27 | 0.25 | 10.04 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | | 397 |
| B. Refuelling without maintenance | | | | 50 | | |
| C. Inspection, maintenance or repair combined with refuelling | 789 | | | 1010 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 95 | | |
| E. Testing of plant systems or components | | | | 7 | 5 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 2 | | |
| H. Nuclear regulatory requirements | | | | | 643 | |
| L. Human factor related | | | | | 9 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| P. Fire | | | | | 10 | |
| Z. Other | | | | | 3 | 2 |
| Subtotal | 789 | | | 1164 | 1067 | 6 |
| Total | | 789 | | | 2237 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 14 |
| 14. Safety Systems | | 6 |
| 15. Reactor Cooling Systems | | 27 |
| 16. Steam generation systems | | 5 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 31. Turbine and auxiliaries | | 271 |
| 32. Feedwater and Main Steam System | | 14 |
| 33. Circulating Water System | | 28 |
| 34. Miscellaneous Systems | | 590 |
| 35. All other I&C Systems | | 0 |
| 41. Main Generator Systems | | 20 |
| 42. Electrical Power Supply Systems | | 51 |
| Total | | 1032 |

2023 Operating Experience

US-316

COOK-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : AEP (American Electric Power Company, Inc.)
 Owner : AEP (American Electric Power Company, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : BB&C (BROWN BOVERI & CIE)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (ICECDN)
 Thermal power : 3468 MWth
 Gross electrical power : 1231 MWe
 Reference unit power (net) : 1168 MWe

Key Dates

Construction Date : 1969-03-25
 Grid Date : 1978-03-22
 Commercial Date : 1978-07-01
 Age at end of year : 45 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 48000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.81
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.82
 Reactor outlet temperature [°C] : 319
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.19

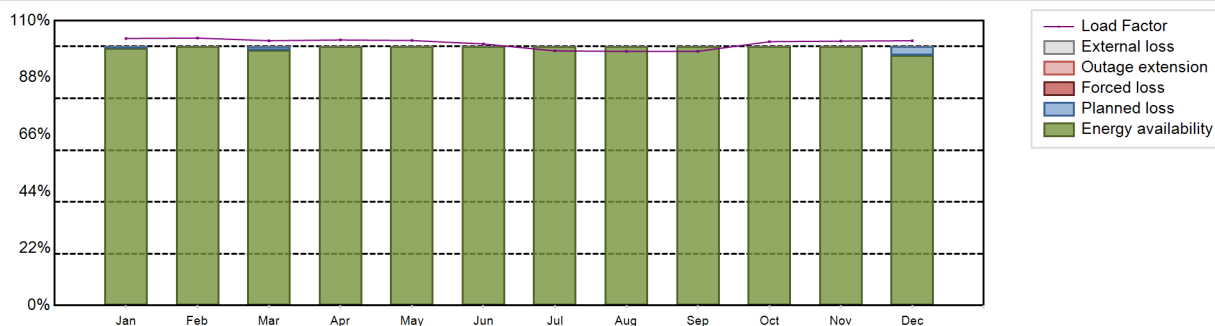
Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.43
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 10362.52 GW(e).h
 Energy Availability Factor (EAF) : 99.56 %
 Unit Capability Factor (UCF) : 99.56 %
 Load Factor (LF) : 101.28 %
 Operating Factor (OF) : 100 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.44 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

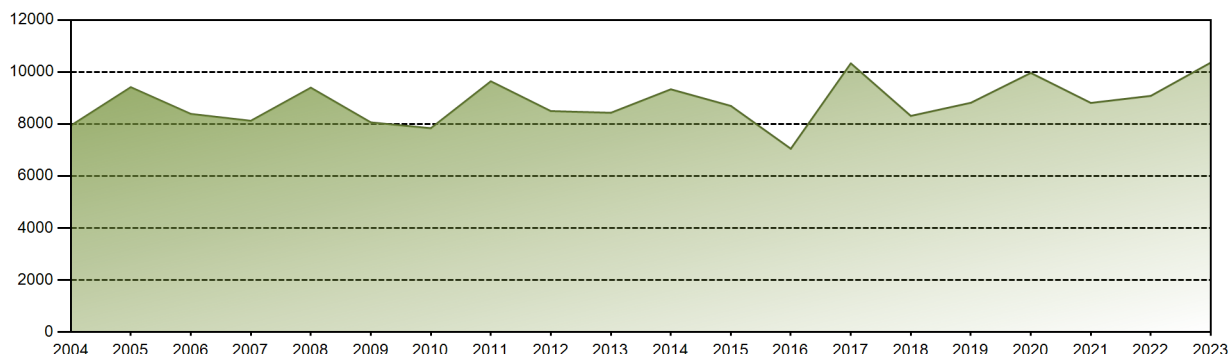


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 896.09 | 810.70 | 887.56 | 862.45 | 889.36 | 849.47 | 854.50 | 852.85 | 825.43 | 885.45 | 859.89 | 888.77 | 10362.52 |
| EAF [%] | 99.41 | 100.00 | 98.69 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.73 | 99.56 |
| UCF [%] | 99.41 | 100.00 | 98.69 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.73 | 99.56 |
| LF [%] | 103.12 | 103.29 | 102.27 | 102.56 | 102.34 | 101.01 | 98.33 | 98.14 | 98.15 | 101.89 | 102.11 | 102.28 | 101.28 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.59 | 0.00 | 1.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.27 | 0.44 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 318304.81 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 13.15 % |
| Cumulative Energy Availability Factor (EAF) | : 75.52 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 11.45 % |
| Cumulative Unit Capability Factor (UCF) | : 75.65 % | Cumulative Planned Unavailability Factor (PUF) | : 12.9 % |
| Cumulative Load Factor (LF) | : 73.46 % | Cumulative Externally cause unavailability (XUF) | : 0.13 % |
| Cumulative Operating Factor (OF) | : 75.38 % | | |

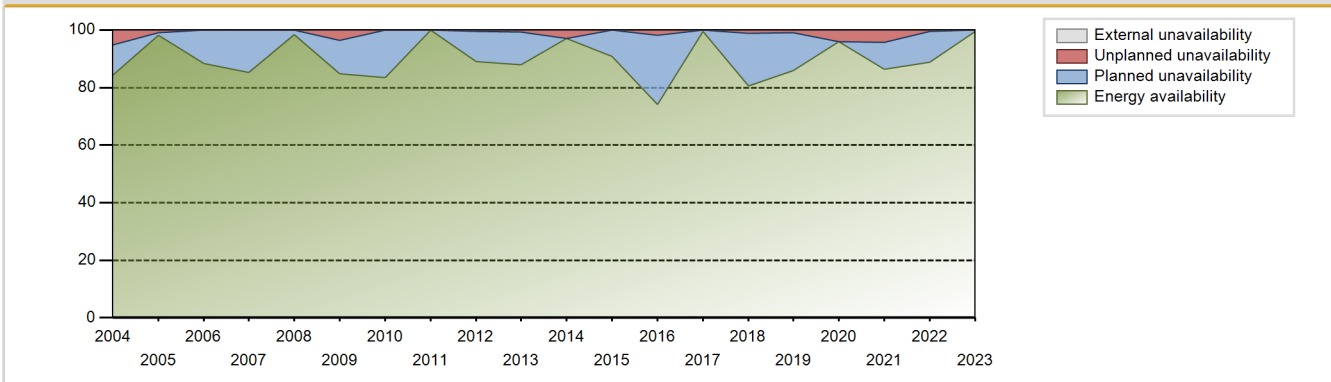
Electricity Production (net) [GWh]



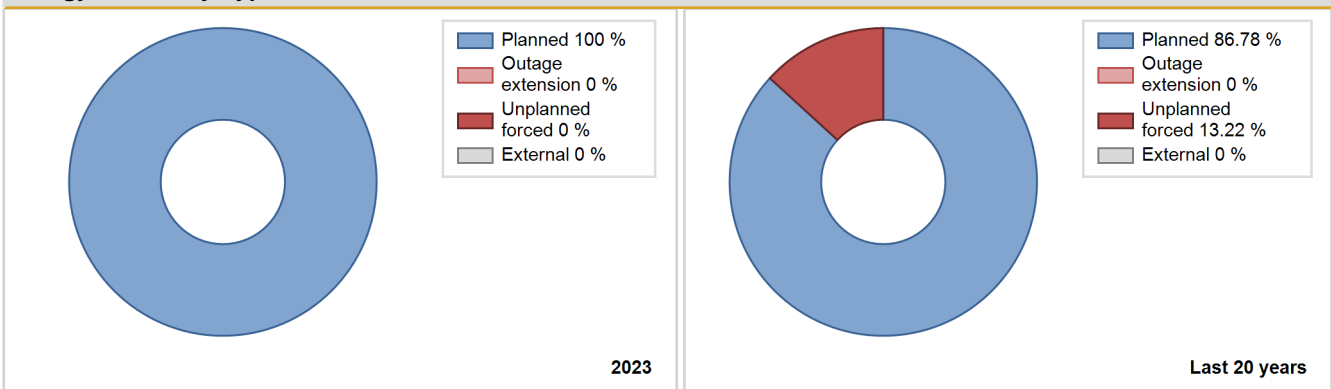
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|--------|--------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1978 | 3814.00 | 4729 | 1078 | 65.36 | 65.36 | 65.34 | 77.22 | 21.39 | 17.78 | 16.86 | 0.00 |
| 1979 | 5953.50 | 5773 | 1082 | 62.81 | 62.81 | 62.81 | 65.90 | 19.38 | 15.10 | 22.08 | 0.00 |
| 1980 | 6691.20 | 6535 | 1082 | 74.81 | 80.15 | 70.40 | 74.40 | 16.26 | 15.56 | 4.29 | 5.34 |
| 1981 | 6384.80 | 6178 | 1082 | 71.21 | 71.21 | 67.36 | 70.53 | 10.24 | 8.12 | 20.67 | 0.00 |
| 1982 | 6995.60 | 6738 | 1082 | 77.17 | 77.17 | 73.81 | 76.92 | 13.09 | 11.62 | 11.21 | 0.00 |
| 1983 | 7013.60 | 6835 | 1071 | 78.32 | 78.32 | 74.76 | 78.03 | 12.60 | 11.29 | 10.39 | 0.00 |
| 1984 | 5364.36 | 5196 | 1060 | 59.19 | 59.19 | 57.61 | 59.15 | 10.64 | 7.05 | 33.77 | 0.00 |
| 1985 | 5683.63 | 5852 | 1060 | 66.85 | 66.85 | 61.21 | 66.80 | 33.15 | 33.15 | 0.00 | 0.00 |
| 1986 | 4335.57 | 5389 | 1060 | 61.54 | 61.54 | 46.69 | 61.52 | 3.41 | 2.17 | 36.29 | 0.00 |
| 1987 | 5026.56 | 6248 | 1060 | 71.38 | 71.38 | 54.13 | 71.32 | 17.65 | 15.30 | 13.32 | 0.00 |
| 1988 | 2323.26 | 2715 | 1060 | 30.92 | 30.92 | 24.95 | 30.91 | 0.00 | 0.00 | 69.08 | 0.00 |
| 1989 | 6660.99 | 6518 | 1060 | 74.43 | 74.43 | 71.73 | 74.41 | 1.50 | 1.14 | 24.43 | 0.00 |
| 1990 | 4813.31 | 4854 | 1060 | 55.42 | 55.42 | 51.84 | 55.41 | 10.79 | 6.70 | 37.88 | 0.00 |
| 1991 | 8185.91 | 8013 | 1065 | 91.51 | 92.17 | 87.74 | 91.47 | 7.83 | 7.83 | 0.00 | 0.66 |
| 1992 | 1427.30 | 1714 | 1072 | 20.47 | 20.47 | 15.15 | 19.51 | 68.47 | 44.45 | 35.08 | 0.00 |
| 1993 | 7553.81 | 8459 | 1070 | 96.60 | 96.60 | 80.60 | 96.56 | 3.40 | 3.40 | 0.00 | 0.00 |
| 1994 | 3531.45 | 4757 | 1060 | 54.38 | 54.38 | 38.03 | 54.30 | 26.08 | 19.19 | 26.43 | 0.00 |
| 1995 | 8602.53 | 8268 | 1060 | 94.45 | 94.45 | 92.64 | 94.38 | 5.55 | 5.55 | 0.00 | 0.00 |
| 1996 | 8022.60 | 7641 | 1060 | 87.01 | 87.01 | 86.16 | 86.99 | 0.13 | 0.11 | 12.88 | 0.00 |
| 1997 | 5875.21 | 5705 | 1060 | 64.87 | 64.87 | 63.27 | 65.12 | 14.76 | 11.23 | 23.90 | 0.00 |
| 1998 | 0.00 | 0 | 1060 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 98.15 | 1.85 | 0.00 |
| 1999 | 0.00 | 0 | 1060 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 2000 | 4789.85 | 4557 | 1060 | 51.88 | 51.88 | 51.44 | 51.88 | 48.12 | 48.12 | 0.00 | 0.00 |
| 2001 | 7963.43 | 7690 | 1060 | 87.81 | 87.81 | 85.76 | 87.79 | 12.19 | 12.19 | 0.00 | 0.00 |
| 2002 | 7687.69 | 7335 | 1060 | 83.80 | 83.80 | 82.79 | 83.73 | 5.84 | 5.20 | 11.00 | 0.00 |
| 2003 | 7112.17 | 6610 | 1060 | 75.46 | 75.46 | 76.59 | 75.46 | 13.38 | 11.66 | 12.88 | 0.00 |
| 2004 | 7938.51 | 7407 | 1060 | 84.33 | 84.33 | 85.26 | 84.32 | 5.68 | 5.08 | 10.59 | 0.00 |
| 2005 | 9415.54 | 8603 | 1077 | 98.22 | 98.22 | 99.79 | 98.20 | 0.97 | 0.96 | 0.81 | 0.00 |
| 2006 | 8388.76 | 7732 | 1077 | 88.28 | 88.28 | 88.91 | 88.25 | 0.00 | 0.00 | 11.72 | 0.00 |
| 2007 | 8124.48 | 7492 | 1060 | 85.30 | 85.30 | 87.50 | 85.53 | 0.00 | 0.00 | 14.70 | 0.00 |
| 2008 | 9396.64 | 8650 | 1060 | 98.48 | 98.48 | 100.92 | 98.47 | 0.00 | 0.00 | 1.52 | 0.00 |
| 2009 | 8062.96 | 7434 | 1060 | 84.88 | 84.88 | 86.83 | 84.86 | 3.98 | 3.52 | 11.60 | 0.00 |
| 2010 | 7839.20 | 7302 | 1060 | 83.37 | 83.37 | 84.42 | 83.36 | 0.00 | 0.00 | 16.63 | 0.00 |
| 2011 | 9641.90 | 8760 | 1077 | 100.00 | 100.00 | 102.20 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 8497.17 | 7818 | 1077 | 89.03 | 89.03 | 89.82 | 89.00 | 0.46 | 0.41 | 10.56 | 0.00 |
| 2013 | 8430.45 | 7709 | 1077 | 88.00 | 88.00 | 89.35 | 87.99 | 0.75 | 0.66 | 11.34 | 0.00 |
| 2014 | 9334.04 | 8505 | 1077 | 97.09 | 97.09 | 98.93 | 97.09 | 2.91 | 2.91 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|-------|-------|--------|--------|------|------|-------|------|
| 2015 | 8696.59 | 7942 | 1107 | 90.91 | 90.91 | 89.68 | 90.66 | 0.00 | 0.00 | 9.09 | 0.00 |
| 2016 | 7048.50 | 6510 | 1107 | 74.12 | 74.12 | 72.49 | 74.11 | 2.42 | 1.84 | 24.04 | 0.00 |
| 2017 | 10332.09 | 8717 | 1168 | 99.53 | 99.53 | 100.98 | 99.51 | 0.00 | 0.00 | 0.47 | 0.00 |
| 2018 | 8311.42 | 7056 | 1168 | 80.55 | 80.55 | 81.23 | 80.55 | 1.34 | 1.10 | 18.35 | 0.00 |
| 2019 | 8816.66 | 7525 | 1168 | 85.92 | 85.92 | 86.17 | 85.90 | 1.16 | 1.01 | 13.07 | 0.00 |
| 2020 | 9962.99 | 8423 | 1168 | 95.89 | 95.89 | 97.11 | 95.89 | 4.11 | 4.11 | 0.00 | 0.00 |
| 2021 | 8811.30 | 7575 | 1168 | 86.47 | 86.47 | 86.12 | 86.47 | 4.81 | 4.37 | 9.16 | 0.00 |
| 2022 | 9082.20 | 7783 | 1168 | 88.85 | 88.85 | 88.77 | 88.85 | 0.54 | 0.49 | 10.66 | 0.00 |
| 2023 | 10362.52 | 8760 | 1168 | 99.56 | 99.56 | 101.28 | 100.00 | 0.00 | 0.00 | 0.44 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1978 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 471 | |
| B. Refuelling without maintenance | | | | 38 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 980 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 85 | | |
| E. Testing of plant systems or components | | | | 0 | | |
| H. Nuclear regulatory requirements | | | | | 510 | |
| L. Human factor related | | | | | 13 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 18 | 4 |
| Subtotal | | | | 1103 | 1012 | 5 |
| Total | | 0 | | | 2120 | |

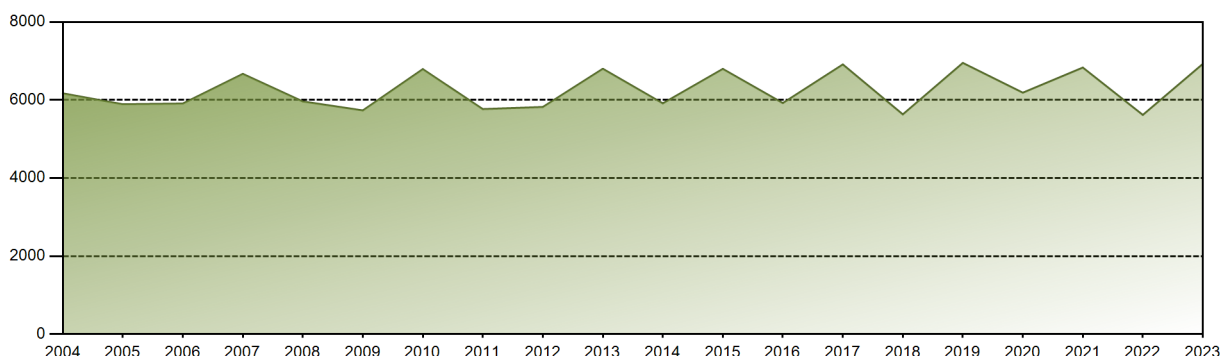
Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1978 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 1 |
| 12. Reactor I&C Systems | | 12 |
| 13. Reactor Auxiliary Systems | | 34 |
| 15. Reactor Cooling Systems | | 70 |
| 16. Steam generation systems | | 123 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 6 |
| 31. Turbine and auxiliaries | | 108 |
| 32. Feedwater and Main Steam System | | 16 |
| 33. Circulating Water System | | 36 |
| 34. Miscellaneous Systems | | 491 |
| 35. All other I&C Systems | | 10 |
| 41. Main Generator Systems | | 31 |
| 42. Electrical Power Supply Systems | | 31 |
| Total | | 969 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 258381.93 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.25 % |
| Cumulative Energy Availability Factor (EAF) | : 80.64 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.48 % |
| Cumulative Unit Capability Factor (UCF) | : 80.67 % | Cumulative Planned Unavailability Factor (PUF) | : 14.85 % |
| Cumulative Load Factor (LF) | : 77.64 % | Cumulative Externally cause unavailability (XUF) | : 0.03 % |
| Cumulative Operating Factor (OF) | : 82.6 % | | |

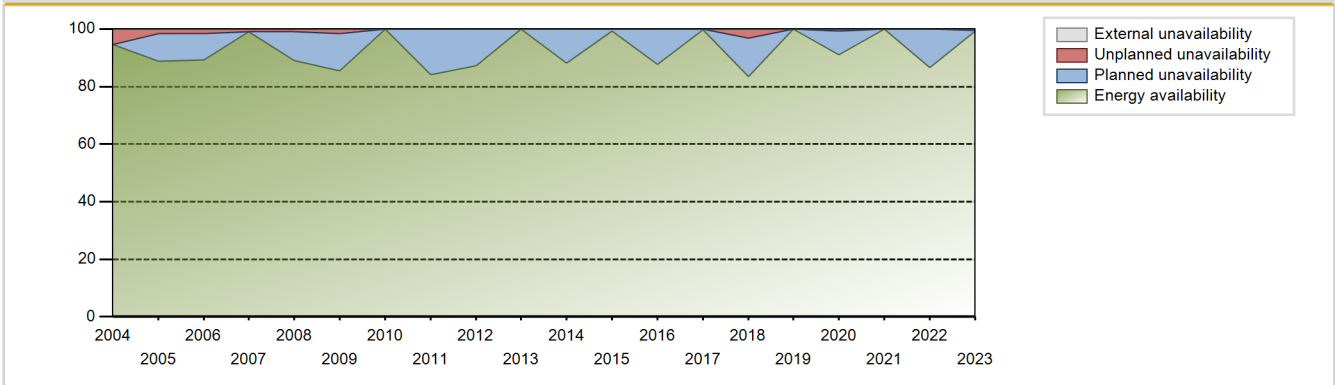
Electricity Production (net) [GWh]



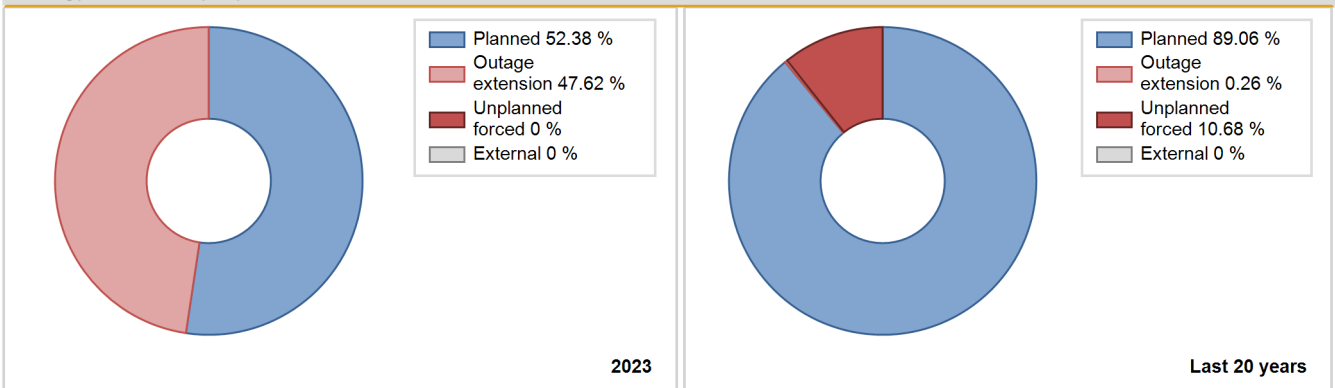
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1974 | 1885.60 | 3897 | 778 | 100.00 | 100.00 | 50.66 | 73.37 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1975 | 3363.20 | 7320 | 764 | 50.30 | 50.30 | 50.25 | 83.56 | 30.39 | 21.96 | 27.73 | 0.00 |
| 1976 | 3642.60 | 6626 | 764 | 54.32 | 54.32 | 54.28 | 75.43 | 10.82 | 6.59 | 39.08 | 0.00 |
| 1977 | 4540.10 | 7546 | 764 | 67.89 | 67.89 | 67.84 | 86.14 | 11.41 | 8.74 | 23.36 | 0.00 |
| 1978 | 4886.80 | 7966 | 764 | 73.01 | 73.01 | 73.02 | 90.94 | 2.19 | 1.64 | 25.35 | 0.00 |
| 1979 | 4995.00 | 7670 | 764 | 74.63 | 74.63 | 74.63 | 87.56 | 8.86 | 7.26 | 18.11 | 0.00 |
| 1980 | 3787.50 | 6240 | 764 | 70.59 | 71.64 | 56.44 | 71.04 | 1.41 | 1.03 | 27.33 | 1.05 |
| 1981 | 3851.10 | 6239 | 764 | 71.00 | 71.00 | 57.54 | 71.22 | 2.02 | 1.47 | 27.54 | 0.00 |
| 1982 | 5276.10 | 7412 | 764 | 84.39 | 84.39 | 78.83 | 84.61 | 2.74 | 2.38 | 13.23 | 0.00 |
| 1983 | 3343.30 | 5544 | 764 | 62.68 | 62.68 | 49.95 | 63.29 | 3.08 | 1.99 | 35.33 | 0.00 |
| 1984 | 3469.95 | 5901 | 764 | 67.14 | 67.64 | 51.71 | 67.18 | 1.52 | 1.04 | 31.31 | 0.50 |
| 1985 | 1067.75 | 1884 | 764 | 20.09 | 20.09 | 15.95 | 21.51 | 40.65 | 13.76 | 66.14 | 0.00 |
| 1986 | 4052.14 | 6546 | 764 | 74.71 | 74.71 | 60.55 | 74.73 | 1.27 | 0.96 | 24.33 | 0.00 |
| 1987 | 5522.13 | 8291 | 764 | 94.61 | 94.61 | 82.51 | 94.65 | 3.93 | 3.87 | 1.52 | 0.00 |
| 1988 | 4200.61 | 5887 | 764 | 66.47 | 66.47 | 62.59 | 67.02 | 5.92 | 4.18 | 29.35 | 0.00 |
| 1989 | 4790.90 | 6594 | 764 | 74.91 | 74.91 | 71.58 | 75.27 | 6.64 | 5.33 | 19.76 | 0.00 |
| 1990 | 5111.39 | 6908 | 764 | 78.49 | 78.49 | 76.37 | 78.86 | 4.42 | 3.63 | 17.88 | 0.00 |
| 1991 | 4803.81 | 6830 | 764 | 77.93 | 77.93 | 71.78 | 77.97 | 0.00 | 0.00 | 22.07 | 0.00 |
| 1992 | 6227.93 | 8436 | 764 | 95.97 | 95.97 | 92.80 | 96.04 | 1.56 | 1.52 | 2.52 | 0.00 |
| 1993 | 3712.86 | 5041 | 764 | 56.77 | 56.77 | 55.48 | 57.55 | 3.13 | 1.84 | 41.40 | 0.00 |
| 1994 | 2227.26 | 3033 | 764 | 33.44 | 33.44 | 33.28 | 34.62 | 66.56 | 66.56 | 0.00 | 0.00 |
| 1995 | 4127.76 | 5663 | 764 | 64.03 | 64.03 | 61.68 | 64.65 | 18.35 | 14.39 | 21.58 | 0.00 |
| 1996 | 6338.90 | 8540 | 764 | 97.19 | 97.19 | 94.46 | 97.22 | 0.00 | 0.00 | 2.81 | 0.00 |
| 1997 | 5455.70 | 7336 | 764 | 83.64 | 83.64 | 81.52 | 83.74 | 1.76 | 1.50 | 14.86 | 0.00 |
| 1998 | 4869.91 | 6544 | 764 | 74.41 | 74.41 | 72.77 | 74.70 | 0.00 | 0.00 | 25.59 | 0.00 |
| 1999 | 6510.41 | 8563 | 764 | 97.74 | 97.74 | 97.28 | 97.75 | 2.26 | 2.26 | 0.00 | 0.00 |
| 2000 | 4735.94 | 6414 | 764 | 73.11 | 73.11 | 70.57 | 73.02 | 16.33 | 14.27 | 12.62 | 0.00 |
| 2001 | 5206.54 | 7009 | 764 | 79.95 | 79.95 | 77.80 | 80.01 | 0.00 | 0.00 | 20.05 | 0.00 |
| 2002 | 6318.15 | 8478 | 764 | 96.83 | 96.83 | 94.40 | 96.78 | 2.89 | 2.88 | 0.30 | 0.00 |
| 2003 | 4492.33 | 6236 | 764 | 71.29 | 71.29 | 67.12 | 71.19 | 17.41 | 15.03 | 13.68 | 0.00 |
| 2004 | 6171.77 | 8299 | 764 | 94.55 | 94.55 | 91.97 | 94.48 | 5.45 | 5.45 | 0.00 | 0.00 |
| 2005 | 5891.92 | 7774 | 757 | 88.77 | 88.77 | 88.84 | 88.73 | 1.84 | 1.67 | 9.57 | 0.00 |
| 2006 | 5910.48 | 7823 | 760 | 89.34 | 89.34 | 88.78 | 89.30 | 1.69 | 1.53 | 9.13 | 0.00 |
| 2007 | 6671.25 | 8685 | 758 | 99.14 | 99.14 | 100.47 | 99.14 | 0.86 | 0.86 | 0.00 | 0.00 |
| 2008 | 5964.14 | 7825 | 770 | 89.06 | 89.06 | 88.52 | 89.08 | 0.92 | 0.83 | 10.11 | 0.00 |
| 2009 | 5734.58 | 7494 | 769 | 85.54 | 85.54 | 85.13 | 85.55 | 1.75 | 1.52 | 12.94 | 0.00 |
| 2010 | 6792.88 | 8760 | 774 | 100.00 | 100.00 | 100.19 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2011 | 5768.10 | 7376 | 774 | 84.21 | 84.21 | 85.07 | 84.20 | 0.00 | 0.00 | 15.79 | 0.00 |
| 2012 | 5822.50 | 7657 | 768 | 87.19 | 87.19 | 86.31 | 87.17 | 0.00 | 0.00 | 12.81 | 0.00 |
| 2013 | 6801.93 | 8760 | 766 | 100.00 | 100.00 | 101.36 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 5915.35 | 7726 | 768 | 88.20 | 88.20 | 87.93 | 88.20 | 0.00 | 0.00 | 11.80 | 0.00 |
| 2015 | 6798.49 | 8692 | 768 | 99.23 | 99.23 | 101.05 | 99.22 | 0.00 | 0.00 | 0.77 | 0.00 |
| 2016 | 5922.80 | 7701 | 768 | 87.67 | 87.67 | 87.80 | 87.67 | 0.00 | 0.00 | 12.33 | 0.00 |
| 2017 | 6912.38 | 8741 | 769 | 99.79 | 99.79 | 102.61 | 99.78 | 0.00 | 0.00 | 0.21 | 0.00 |
| 2018 | 5632.14 | 7306 | 769 | 83.39 | 83.39 | 83.61 | 83.40 | 3.74 | 3.24 | 13.37 | 0.00 |
| 2019 | 6951.60 | 8760 | 769 | 100.00 | 100.00 | 103.19 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 6188.55 | 7997 | 769 | 91.04 | 91.04 | 91.62 | 91.04 | 0.73 | 0.67 | 8.29 | 0.00 |
| 2021 | 6832.56 | 8760 | 769 | 100.00 | 100.00 | 101.43 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 5618.50 | 7585 | 769 | 86.59 | 86.59 | 83.40 | 86.59 | 0.00 | 0.00 | 13.41 | 0.00 |
| 2023 | 6926.05 | 8760 | 769 | 99.20 | 99.20 | 102.81 | 100.00 | 0.00 | 0.38 | 0.42 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1974 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 151 | |
| B. Refuelling without maintenance | | | | 36 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1022 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 113 | | |
| E. Testing of plant systems or components | | | | 1 | 133 | |
| H. Nuclear regulatory requirements | | | | | 8 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| P. Fire | | | | | 3 | |
| Z. Other | | | | | 31 | |
| Subtotal | | | | 1172 | 332 | 3 |
| Total | | 0 | | | 1507 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1974 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 5 |
| 13. Reactor Auxiliary Systems | | 19 |
| 14. Safety Systems | | 8 |
| 15. Reactor Cooling Systems | | 13 |
| 31. Turbine and auxiliaries | | 64 |
| 32. Feedwater and Main Steam System | | 10 |
| 34. Miscellaneous Systems | | 146 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 5 |
| 42. Electrical Power Supply Systems | | 12 |
| Total | | 290 |

2023 Operating Experience

US-346 DAVIS BESSE-1 UNITED STATES OF AMERICA

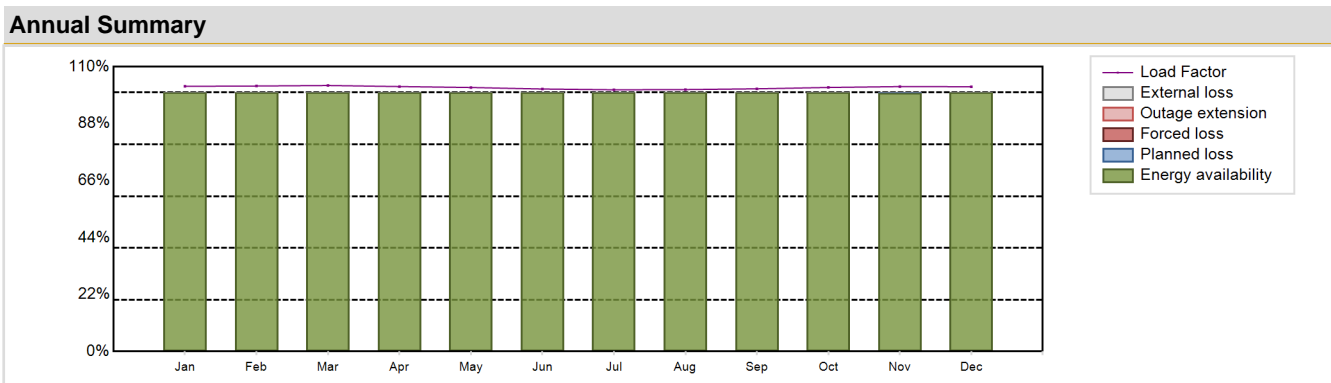
Status at end of year : **Operational**
 Operator : FENOC (FIRST ENERGY NUCLEAR OPERATING CO.)
 Owner : CEI (CLEVELAND ELECTRIC ILLUMINATING CO.)
 Reactor Supplier : B&W (BABCOCK & WILCOX CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------------|--------------------|--------------|
| Reactor type and model | : PWR / B&W RLP (DRYAMB) | Construction Date | : 1970-09-01 |
| Thermal power | : 2817 MWth | Grid Date | : 1977-08-28 |
| Gross electrical power | : 925 MWe | Commercial Date | : 1978-07-31 |
| Reference unit power (net) | : 894 MWe | Age at end of year | : 46 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 321 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.38 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 50000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 2.9 | HP cylinder inlet steam pressure [MPa] | : 6.22 |
| Active core height/length [m] | : 3.57 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 177 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 21.1 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 28 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 7985.73 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.99 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 99.99 % | Planned Unavailability Factor (PUF) | : 0.01 % |
| Load Factor (LF) | : 101.97 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

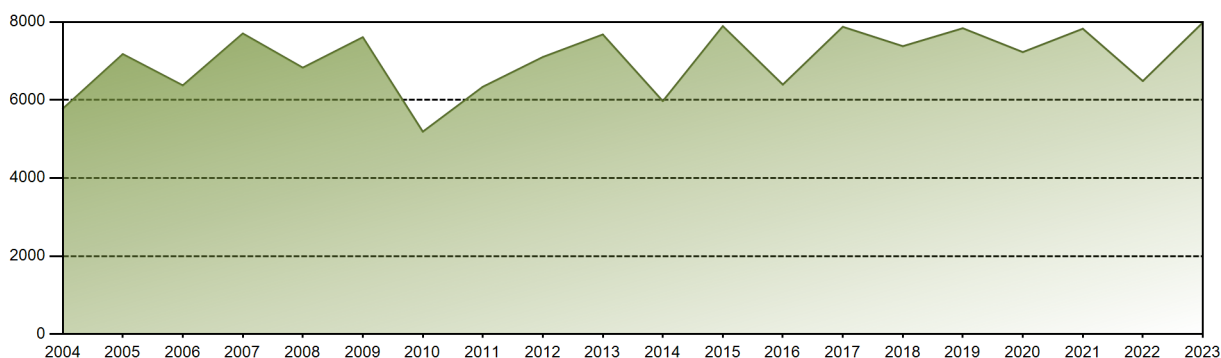


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 681.31 | 616.03 | 682.42 | 658.75 | 678.16 | 652.62 | 672.34 | 672.86 | 653.15 | 678.29 | 659.50 | 680.29 | 7985.73 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.90 | 100.00 | 99.99 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.90 | 100.00 | 99.99 |
| LF [%] | 102.43 | 102.54 | 102.74 | 102.34 | 101.96 | 101.39 | 101.08 | 101.16 | 101.47 | 101.98 | 102.31 | 102.28 | 101.97 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 259846.45 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.52 % |
| Cumulative Energy Availability Factor (EAF) | : 75.46 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.04 % |
| Cumulative Unit Capability Factor (UCF) | : 75.53 % | Cumulative Planned Unavailability Factor (PUF) | : 17.43 % |
| Cumulative Load Factor (LF) | : 73.99 % | Cumulative Externally cause unavailability (XUF) | : 0.07 % |
| Cumulative Operating Factor (OF) | : 75.8 % | | |

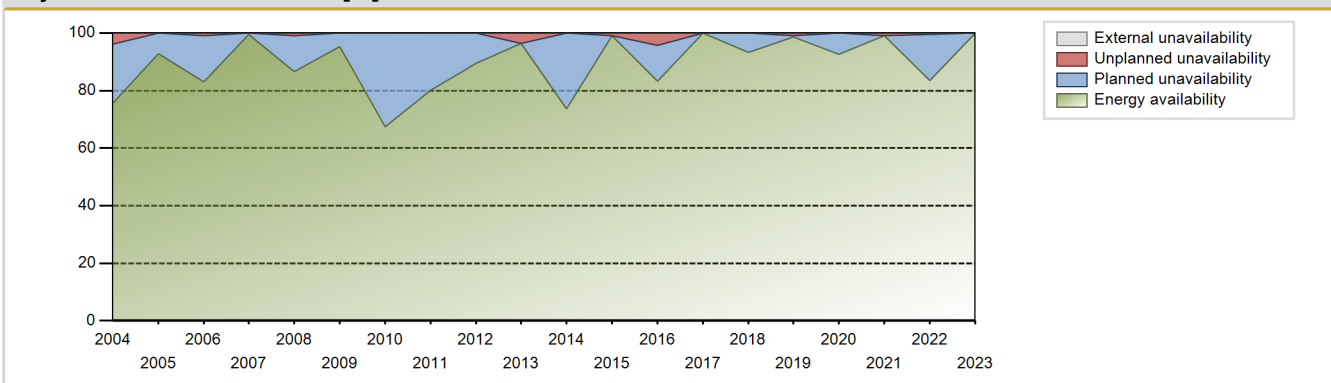
Electricity Production (net) [GWh]



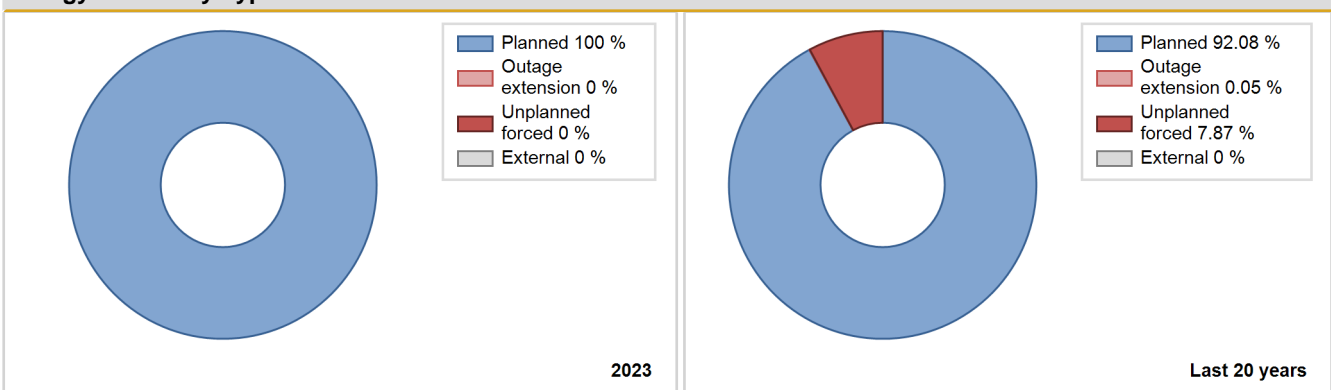
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1978 | 2614.50 | 4263 | 906 | 39.26 | 39.26 | 39.27 | 54.72 | 49.49 | 38.46 | 22.28 | 0.00 |
| 1979 | 3129.10 | 4139 | 906 | 39.43 | 39.43 | 39.43 | 47.25 | 36.36 | 22.52 | 38.05 | 0.00 |
| 1980 | 2093.60 | 3171 | 892 | 34.95 | 34.95 | 26.72 | 36.10 | 14.18 | 5.78 | 59.27 | 0.00 |
| 1981 | 4363.40 | 5902 | 888 | 67.39 | 67.39 | 56.09 | 67.37 | 28.77 | 27.22 | 5.39 | 0.00 |
| 1982 | 3218.10 | 4508 | 874 | 51.52 | 51.52 | 42.03 | 51.46 | 1.18 | 0.61 | 47.87 | 0.00 |
| 1983 | 4883.30 | 6389 | 874 | 72.26 | 72.26 | 63.78 | 72.93 | 10.53 | 8.51 | 19.23 | 0.00 |
| 1984 | 4291.56 | 5486 | 874 | 62.48 | 62.48 | 55.90 | 62.45 | 11.02 | 7.74 | 29.78 | 0.00 |
| 1985 | 1942.92 | 2729 | 862 | 30.92 | 30.92 | 25.72 | 31.15 | 64.96 | 57.33 | 11.75 | 0.00 |
| 1986 | 3.49 | 116 | 860 | 1.33 | 1.33 | 0.05 | 1.32 | 98.67 | 98.67 | 0.00 | 0.00 |
| 1987 | 5063.98 | 7308 | 860 | 82.82 | 82.82 | 67.22 | 83.42 | 6.91 | 6.14 | 11.04 | 0.00 |
| 1988 | 1164.40 | 1891 | 860 | 20.35 | 20.35 | 15.41 | 21.53 | 3.20 | 0.67 | 78.98 | 0.00 |
| 1989 | 7322.11 | 8506 | 870 | 97.08 | 97.08 | 96.02 | 97.10 | 1.84 | 1.82 | 1.10 | 0.00 |
| 1990 | 4161.47 | 4867 | 874 | 55.62 | 55.62 | 54.35 | 55.56 | 41.73 | 39.83 | 4.55 | 0.00 |
| 1991 | 5843.86 | 6962 | 874 | 78.62 | 78.62 | 76.33 | 79.47 | 2.16 | 1.74 | 19.64 | 0.00 |
| 1992 | 7650.49 | 8742 | 877 | 99.54 | 99.54 | 99.31 | 99.52 | 0.46 | 0.46 | 0.00 | 0.00 |
| 1993 | 6083.40 | 7246 | 871 | 82.70 | 82.70 | 79.66 | 82.72 | 0.83 | 0.69 | 16.61 | 0.00 |
| 1994 | 6385.00 | 7667 | 868 | 86.92 | 86.92 | 83.97 | 87.52 | 0.00 | 0.00 | 13.08 | 0.00 |
| 1995 | 7670.57 | 8760 | 869 | 100.00 | 100.00 | 100.76 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1996 | 6456.29 | 7452 | 872 | 84.83 | 84.83 | 84.29 | 84.84 | 0.00 | 0.00 | 15.17 | 0.00 |
| 1997 | 7183.36 | 8184 | 873 | 93.45 | 93.45 | 93.93 | 93.42 | 6.55 | 6.55 | 0.00 | 0.00 |
| 1998 | 6130.68 | 7181 | 873 | 82.01 | 85.38 | 80.17 | 81.97 | 3.88 | 3.45 | 11.18 | 3.37 |
| 1999 | 7369.99 | 8311 | 873 | 94.89 | 94.89 | 96.37 | 94.87 | 0.00 | 0.00 | 5.11 | 0.00 |
| 2000 | 6770.53 | 7633 | 882 | 86.96 | 86.96 | 87.91 | 86.90 | 0.00 | 0.00 | 13.04 | 0.00 |
| 2001 | 7690.85 | 8738 | 882 | 99.75 | 99.75 | 99.54 | 99.75 | 0.00 | 0.00 | 0.25 | 0.00 |
| 2002 | 929.02 | 1081 | 882 | 12.36 | 12.36 | 12.02 | 12.34 | 2.21 | 0.28 | 87.36 | 0.00 |
| 2003 | 0.00 | 0 | 882 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 2004 | 5778.43 | 6628 | 882 | 75.56 | 75.56 | 74.58 | 75.46 | 4.95 | 3.94 | 20.51 | 0.00 |
| 2005 | 7177.43 | 8125 | 873 | 92.77 | 92.77 | 93.85 | 92.75 | 0.00 | 0.00 | 7.23 | 0.00 |
| 2006 | 6375.42 | 7265 | 891 | 82.94 | 82.94 | 81.68 | 82.93 | 0.90 | 0.85 | 16.21 | 0.00 |
| 2007 | 7705.80 | 8712 | 879 | 99.45 | 99.45 | 100.07 | 99.45 | 0.00 | 0.00 | 0.55 | 0.00 |
| 2008 | 6829.44 | 7621 | 894 | 86.61 | 86.61 | 87.95 | 86.76 | 1.13 | 0.99 | 12.40 | 0.00 |
| 2009 | 7609.61 | 8361 | 879 | 95.38 | 95.38 | 98.83 | 95.45 | 0.00 | 0.00 | 4.62 | 0.00 |
| 2010 | 5188.16 | 5851 | 894 | 67.35 | 67.35 | 66.25 | 66.79 | 0.00 | 0.00 | 32.65 | 0.00 |
| 2011 | 6339.24 | 7012 | 894 | 80.07 | 80.07 | 80.95 | 80.05 | 0.00 | 0.00 | 19.93 | 0.00 |
| 2012 | 7101.70 | 7868 | 894 | 89.58 | 89.58 | 90.43 | 89.57 | 0.00 | 0.00 | 10.42 | 0.00 |
| 2013 | 7679.22 | 8451 | 894 | 96.48 | 96.48 | 98.05 | 96.46 | 3.52 | 3.52 | 0.00 | 0.00 |
| 2014 | 5972.42 | 6453 | 894 | 73.67 | 73.67 | 76.26 | 73.66 | 0.00 | 0.00 | 26.33 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2015 | 7893.92 | 8684 | 894 | 99.13 | 99.13 | 100.80 | 99.13 | 0.87 | 0.87 | 0.00 | 0.00 |
| 2016 | 6394.93 | 7321 | 894 | 83.35 | 83.35 | 81.43 | 83.34 | 4.97 | 4.36 | 12.28 | 0.00 |
| 2017 | 7876.43 | 8760 | 894 | 100.00 | 100.00 | 100.57 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 7380.27 | 8169 | 894 | 93.25 | 93.25 | 94.24 | 93.25 | 0.00 | 0.00 | 6.75 | 0.00 |
| 2019 | 7839.46 | 8632 | 894 | 98.55 | 98.55 | 100.10 | 98.54 | 0.84 | 0.84 | 0.61 | 0.00 |
| 2020 | 7228.06 | 8130 | 894 | 92.57 | 92.57 | 92.04 | 92.55 | 0.00 | 0.00 | 7.43 | 0.00 |
| 2021 | 7827.04 | 8682 | 894 | 99.10 | 99.10 | 99.94 | 99.11 | 0.90 | 0.90 | 0.00 | 0.00 |
| 2022 | 6486.64 | 7310 | 894 | 83.46 | 83.46 | 82.83 | 83.45 | 0.49 | 0.41 | 16.13 | 0.00 |
| 2023 | 7985.73 | 8760 | 894 | 99.99 | 99.99 | 101.97 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1978 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 591 | |
| B. Refuelling without maintenance | | | | 51 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 842 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 214 | | |
| E. Testing of plant systems or components | | | | 8 | 3 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 401 | | |
| H. Nuclear regulatory requirements | | | | | 38 | |
| L. Human factor related | | | | | 10 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 6 |
| Z. Other | | | | | 14 | |
| Subtotal | | | | 1516 | 656 | 6 |
| Total | | 0 | | | 2178 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1978 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 74 |
| 12. Reactor I&C Systems | | 48 |
| 13. Reactor Auxiliary Systems | | 5 |
| 14. Safety Systems | | 0 |
| 15. Reactor Cooling Systems | | 44 |
| 16. Steam generation systems | | 0 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 31. Turbine and auxiliaries | | 15 |
| 32. Feedwater and Main Steam System | | 330 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 7 |
| 42. Electrical Power Supply Systems | | 57 |
| Total | | 586 |

2023 Operating Experience

US-275 **DIABLO CANYON-1** **UNITED STATES OF AMERICA**

Status at end of year : **Operational**
 Operator : PG&E (Pacific Gas and Electric Company)
 Owner : PG&E COR (PG&E Corporation)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)

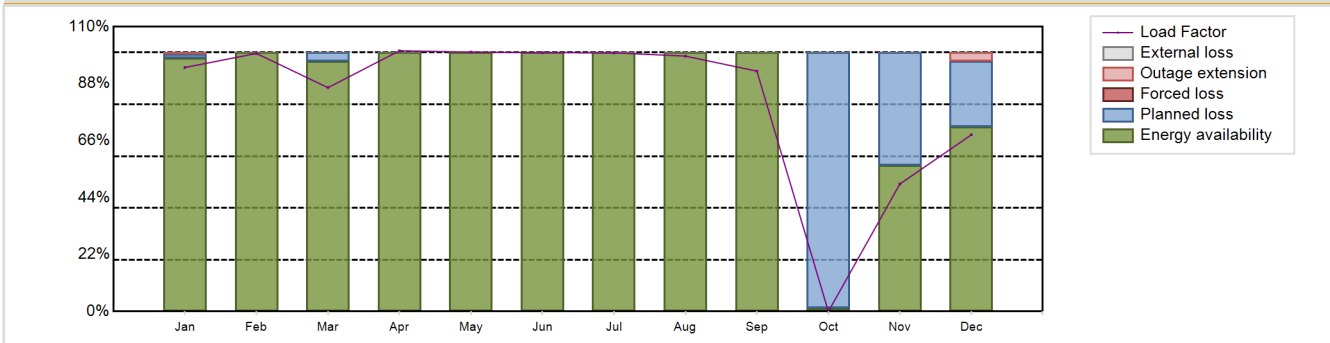


| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 4LP (DRYAMB) | Construction Date | : 1968-04-23 |
| Thermal power | : 3411 MWth | Grid Date | : 1984-11-11 |
| Gross electrical power | : 1197 MWe | Commercial Date | : 1985-05-07 |
| Reference unit power (net) | : 1138 MWe | Age at end of year | : 39 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.83 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 320 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.331 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 45000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.37 | HP cylinder inlet steam pressure [MPa] | : 5.38 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 193 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 53 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 8207.56 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 85.14 % | Unplanned Capability Loss Factor (UCL) | : 0.33 % |
| Unit Capability Factor (UCF) | : 85.14 % | Planned Unavailability Factor (PUF) | : 14.54 % |
| Load Factor (LF) | : 82.33 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 85.64 % | Total off-line time | : 1258 hours |

Annual Summary

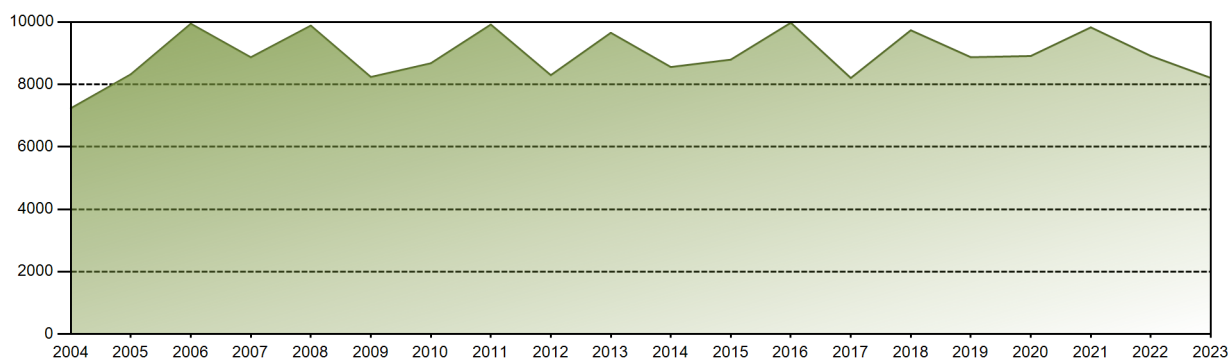


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 798.06 | 762.15 | 731.06 | 825.17 | 848.30 | 818.88 | 846.02 | 835.22 | 760.63 | 0.00 | 404.14 | 577.93 | 8207.56 |
| EAF [%] | 97.77 | 100.00 | 96.69 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 1.41 | 56.50 | 71.26 | 85.14 |
| UCF [%] | 97.77 | 100.00 | 96.69 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 1.41 | 56.50 | 71.26 | 85.14 |
| LF [%] | 94.26 | 99.66 | 86.46 | 100.71 | 100.19 | 99.94 | 99.92 | 98.65 | 92.83 | 0.00 | 49.26 | 68.26 | 82.33 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.44 | 0.00 | 55.89 | 74.19 | 85.64 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.31 | 0.33 |
| PUF [%] | 1.65 | 0.00 | 3.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 98.59 | 43.50 | 25.43 | 14.54 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 325805.09 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.07 % |
| Cumulative Energy Availability Factor (EAF) | : 88.45 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.88 % |
| Cumulative Unit Capability Factor (UCF) | : 88.49 % | Cumulative Planned Unavailability Factor (PUF) | : 9.63 % |
| Cumulative Load Factor (LF) | : 87.33 % | Cumulative Externally cause unavailability (XUF) | : 0.04 % |
| Cumulative Operating Factor (OF) | : 89.11 % | | |

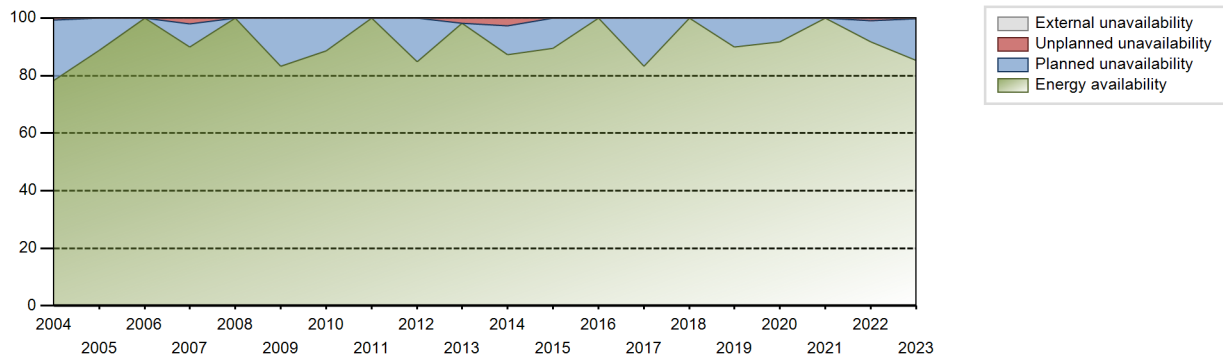
Electricity Production (net) [GWh]



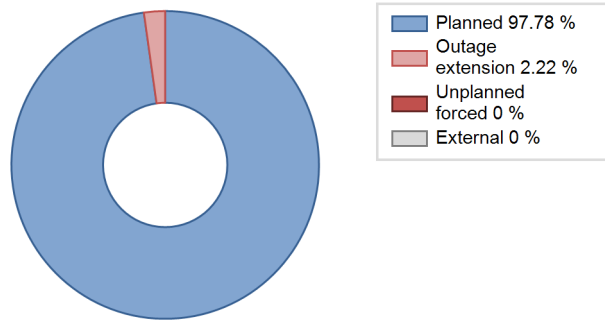
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 5234.23 | 5206 | 1073 | 90.81 | 90.81 | 85.07 | 90.79 | 4.54 | 4.31 | 4.87 | 0.00 |
| 1986 | 5316.22 | 5757 | 1073 | 65.74 | 65.74 | 56.56 | 65.72 | 1.98 | 1.33 | 32.93 | 0.00 |
| 1987 | 8284.20 | 8340 | 1073 | 95.26 | 95.26 | 88.13 | 95.21 | 4.74 | 4.74 | 0.00 | 0.00 |
| 1988 | 5276.12 | 5555 | 1073 | 34.58 | 34.58 | 55.98 | 63.24 | 46.37 | 29.90 | 35.52 | 0.00 |
| 1989 | 7199.90 | 7069 | 1073 | 80.70 | 80.70 | 76.60 | 80.70 | 0.04 | 0.03 | 19.27 | 0.00 |
| 1990 | 8713.52 | 8425 | 1073 | 96.20 | 96.20 | 92.70 | 96.18 | 3.80 | 3.80 | 0.00 | 0.00 |
| 1991 | 7366.28 | 7125 | 1073 | 80.42 | 80.42 | 78.37 | 81.34 | 1.76 | 1.44 | 18.14 | 0.00 |
| 1992 | 7454.72 | 7224 | 1073 | 82.27 | 82.27 | 79.09 | 82.24 | 1.85 | 1.55 | 16.18 | 0.00 |
| 1993 | 9028.01 | 8630 | 1073 | 98.52 | 98.52 | 96.05 | 98.52 | 1.48 | 1.48 | 0.00 | 0.00 |
| 1994 | 7371.98 | 6991 | 1073 | 79.85 | 79.85 | 78.43 | 79.81 | 5.35 | 4.51 | 15.64 | 0.00 |
| 1995 | 7451.75 | 7175 | 1073 | 81.94 | 81.94 | 79.28 | 81.91 | 2.80 | 2.36 | 15.70 | 0.00 |
| 1996 | 8786.81 | 8316 | 1073 | 94.72 | 94.72 | 93.23 | 94.67 | 4.21 | 4.17 | 1.12 | 0.00 |
| 1997 | 8195.01 | 7700 | 1073 | 87.92 | 87.92 | 87.19 | 87.90 | 0.00 | 0.00 | 12.08 | 0.00 |
| 1998 | 8967.83 | 8564 | 1073 | 97.77 | 97.77 | 95.41 | 97.76 | 2.23 | 2.23 | 0.00 | 0.00 |
| 1999 | 8224.84 | 7764 | 1073 | 88.67 | 90.31 | 87.50 | 88.63 | 0.00 | 0.00 | 9.69 | 1.64 |
| 2000 | 7853.51 | 7485 | 1073 | 85.23 | 85.23 | 83.32 | 85.21 | 4.20 | 3.73 | 11.04 | 0.00 |
| 2001 | 9504.59 | 8708 | 1087 | 99.42 | 99.42 | 100.02 | 99.41 | 0.09 | 0.09 | 0.49 | 0.00 |
| 2002 | 7048.21 | 6652 | 1087 | 75.97 | 75.97 | 74.02 | 75.94 | 1.71 | 1.32 | 22.71 | 0.00 |
| 2003 | 9585.43 | 8760 | 1087 | 100.00 | 100.00 | 100.66 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 7233.89 | 6869 | 1087 | 78.23 | 78.23 | 75.76 | 78.20 | 0.79 | 0.63 | 21.14 | 0.00 |
| 2005 | 8323.35 | 7775 | 1087 | 88.77 | 88.77 | 87.41 | 88.76 | 0.00 | 0.00 | 11.23 | 0.00 |
| 2006 | 9944.98 | 8760 | 1122 | 100.00 | 100.00 | 101.18 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 8868.35 | 7870 | 1122 | 89.87 | 89.87 | 90.23 | 89.84 | 2.14 | 1.97 | 8.16 | 0.00 |
| 2008 | 9884.24 | 8784 | 1122 | 100.00 | 100.00 | 100.29 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 8237.57 | 7295 | 1122 | 83.29 | 83.29 | 83.81 | 83.28 | 0.00 | 0.00 | 16.71 | 0.00 |
| 2010 | 8677.45 | 7753 | 1122 | 88.53 | 88.53 | 88.29 | 88.50 | 0.00 | 0.00 | 11.47 | 0.00 |
| 2011 | 9916.75 | 8760 | 1122 | 100.00 | 100.00 | 100.90 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 8295.66 | 7450 | 1122 | 84.84 | 84.84 | 84.17 | 84.81 | 0.00 | 0.00 | 15.16 | 0.00 |
| 2013 | 9653.45 | 8606 | 1122 | 98.24 | 98.24 | 98.21 | 98.23 | 1.76 | 1.76 | 0.00 | 0.00 |
| 2014 | 8556.89 | 7652 | 1122 | 87.35 | 87.35 | 87.06 | 87.35 | 3.13 | 2.82 | 9.83 | 0.00 |
| 2015 | 8793.72 | 7828 | 1138 | 89.50 | 89.50 | 88.21 | 89.36 | 0.00 | 0.00 | 10.50 | 0.00 |
| 2016 | 9974.63 | 8784 | 1138 | 100.00 | 100.00 | 99.78 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 8204.54 | 7296 | 1138 | 83.29 | 83.29 | 82.30 | 83.29 | 0.00 | 0.00 | 16.71 | 0.00 |
| 2018 | 9733.67 | 8760 | 1138 | 100.00 | 100.00 | 97.64 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 8871.17 | 7886 | 1138 | 90.03 | 90.03 | 88.99 | 90.02 | 0.00 | 0.00 | 9.97 | 0.00 |
| 2020 | 8910.58 | 8064 | 1138 | 91.81 | 91.81 | 89.14 | 91.80 | 0.00 | 0.00 | 8.19 | 0.00 |
| 2021 | 9827.85 | 8760 | 1138 | 100.00 | 100.00 | 98.59 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 8912.10 | 8040 | 1138 | 91.78 | 91.78 | 89.40 | 91.78 | 1.10 | 1.02 | 7.20 | 0.00 |
| 2023 | 8207.56 | 7502 | 1138 | 85.14 | 85.14 | 82.33 | 85.64 | 0.00 | 0.33 | 14.54 | 0.00 |

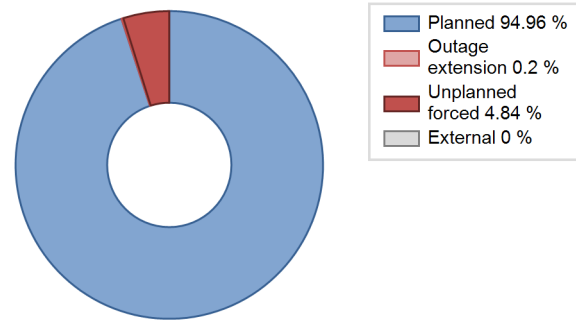
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 152 | |
| B. Refuelling without maintenance | | | | 35 | | |
| C. Inspection, maintenance or repair combined with refuelling | 216 | | | 737 | | |
| D. Inspection, maintenance or repair without refuelling | 1065 | | | 85 | | |
| E. Testing of plant systems or components | | | | 0 | 2 | |
| H. Nuclear regulatory requirements | | | | | 4 | |
| L. Human factor related | | | | | 8 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| P. Fire | | | | | 2 | |
| Z. Other | | | | | 3 | |
| Subtotal | 1281 | | | 857 | 171 | 4 |
| Total | | 1281 | | | 1032 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 4 |
| 12. Reactor I&C Systems | | 2 |
| 13. Reactor Auxiliary Systems | | 5 |
| 14. Safety Systems | | 7 |
| 15. Reactor Cooling Systems | | 11 |
| 16. Steam generation systems | | 1 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 10 |
| 32. Feedwater and Main Steam System | | 74 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 36 |
| Total | | 162 |

2023 Operating Experience

US-323

DIABLO CANYON-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : PG&E (Pacific Gas and Electric Company)
 Owner : PG&E COR (PG&E Corporation)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3411 MWth
 Gross electrical power : 1197 MWe
 Reference unit power (net) : 1118 MWe

Key Dates

Construction Date : 1970-12-09
 Grid Date : 1985-10-20
 Commercial Date : 1986-03-13
 Age at end of year : 38 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.83
 Reactor outlet temperature [°C] : 321
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.331

Secondary systems

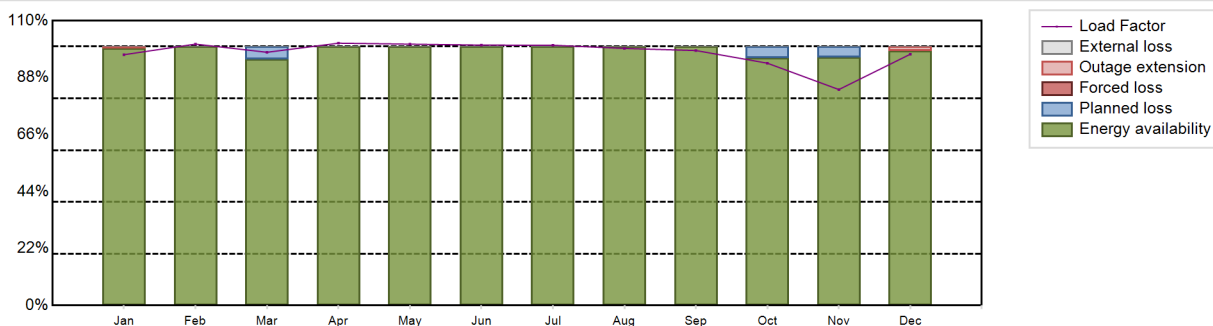
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.38
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9554.55 GW(e).h
 Energy Availability Factor (EAF) : 98.69 %
 Unit Capability Factor (UCF) : 98.69 %
 Load Factor (LF) : 97.56 %
 Operating Factor (OF) : 99.73 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0.19 %
 Planned Unavailability Factor (PUF) : 1.12 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 24 hours

Annual Summary

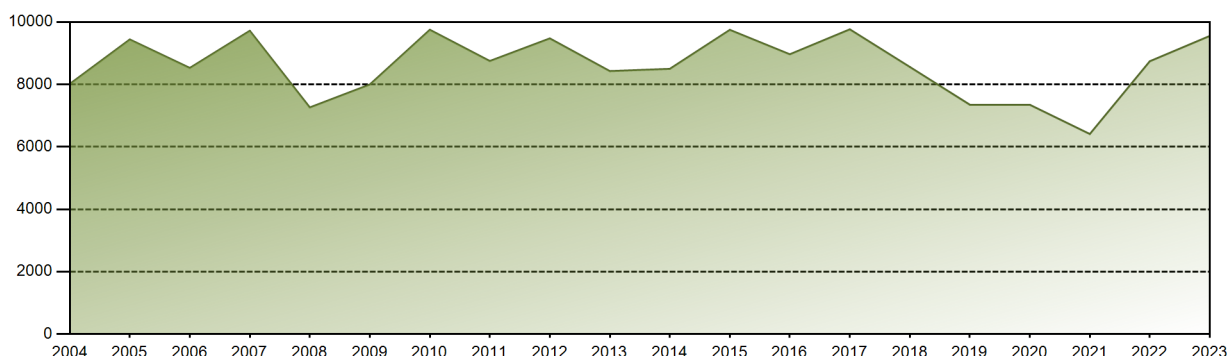


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 805.75 | 758.53 | 812.50 | 815.53 | 839.73 | 809.53 | 836.09 | 825.90 | 792.71 | 778.51 | 672.38 | 807.40 | 9554.55 |
| EAF [%] | 99.42 | 100.00 | 95.15 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.55 | 96.01 | 98.29 | 98.69 |
| UCF [%] | 99.42 | 100.00 | 95.15 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 95.55 | 96.01 | 98.29 | 98.69 |
| LF [%] | 96.87 | 100.96 | 97.81 | 101.31 | 100.95 | 100.57 | 100.52 | 99.29 | 98.48 | 93.59 | 83.41 | 97.07 | 97.56 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.77 | 100.00 | 100.00 | 99.73 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.71 | 0.19 |
| PUF [%] | 0.00 | 0.00 | 4.85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.45 | 3.99 | 0.00 | 1.12 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

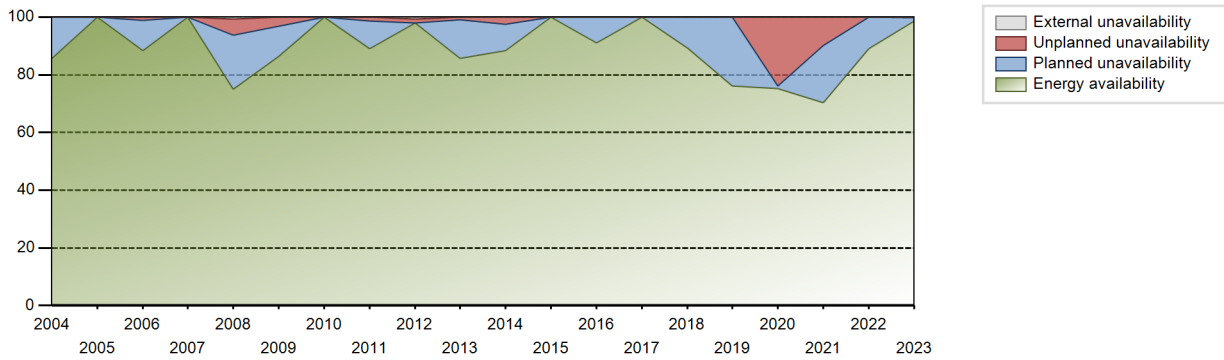
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 317111.71 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.86 % |
| Cumulative Energy Availability Factor (EAF) | : 88.62 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.62 % |
| Cumulative Unit Capability Factor (UCF) | : 88.71 % | Cumulative Planned Unavailability Factor (PUF) | : 8.68 % |
| Cumulative Load Factor (LF) | : 86.87 % | Cumulative Externally cause unavailability (XUF) | : 0.09 % |
| Cumulative Operating Factor (OF) | : 88.61 % | | |

Electricity Production (net) [GWh]

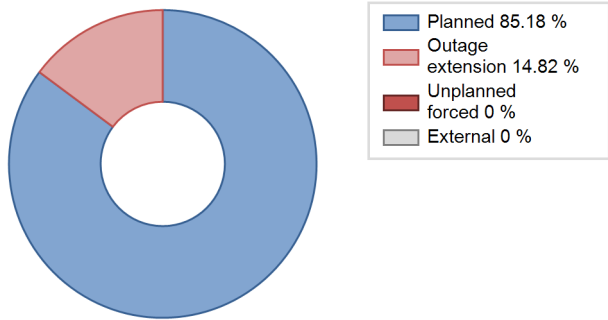


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 6757.71 | 7078 | 1080 | 95.39 | 95.39 | 86.22 | 95.41 | 4.21 | 4.19 | 0.42 | 0.00 |
| 1987 | 5728.78 | 5752 | 1079 | 65.44 | 65.44 | 60.61 | 65.66 | 9.03 | 6.50 | 28.06 | 0.00 |
| 1988 | 6243.35 | 6086 | 1087 | 69.33 | 69.33 | 65.39 | 69.29 | 10.10 | 7.79 | 22.88 | 0.00 |
| 1989 | 8615.97 | 8072 | 1087 | 92.18 | 92.18 | 90.48 | 92.15 | 5.91 | 5.79 | 2.03 | 0.00 |
| 1990 | 7578.08 | 7284 | 1087 | 83.15 | 83.15 | 79.58 | 83.15 | 0.29 | 0.24 | 16.61 | 0.00 |
| 1991 | 7718.47 | 7420 | 1087 | 84.70 | 84.70 | 81.06 | 84.70 | 0.00 | 0.00 | 15.30 | 0.00 |
| 1992 | 9247.73 | 8651 | 1087 | 98.50 | 98.50 | 96.85 | 98.49 | 1.50 | 1.50 | 0.00 | 0.00 |
| 1993 | 7796.19 | 7324 | 1087 | 83.64 | 83.64 | 81.87 | 83.61 | 1.00 | 0.84 | 15.51 | 0.00 |
| 1994 | 7896.10 | 7439 | 1087 | 84.98 | 84.98 | 82.92 | 84.92 | 6.18 | 5.59 | 9.43 | 0.00 |
| 1995 | 8820.98 | 8430 | 1087 | 96.28 | 96.28 | 92.64 | 96.23 | 3.72 | 3.72 | 0.00 | 0.00 |
| 1996 | 7932.91 | 7459 | 1087 | 84.96 | 84.96 | 83.08 | 84.92 | 2.12 | 1.84 | 13.19 | 0.00 |
| 1997 | 8883.55 | 8441 | 1087 | 96.39 | 96.39 | 93.29 | 96.36 | 3.61 | 3.61 | 0.00 | 0.00 |
| 1998 | 8158.97 | 7624 | 1087 | 87.06 | 87.06 | 85.68 | 87.03 | 1.67 | 1.48 | 11.46 | 0.00 |
| 1999 | 8443.69 | 7902 | 1087 | 90.22 | 91.31 | 88.67 | 90.21 | 0.00 | 0.00 | 8.69 | 1.09 |
| 2000 | 9188.54 | 8512 | 1087 | 96.91 | 96.91 | 96.23 | 96.90 | 2.67 | 2.66 | 0.43 | 0.00 |
| 2001 | 8658.37 | 8051 | 1087 | 91.93 | 91.93 | 90.93 | 91.91 | 0.00 | 0.00 | 8.07 | 0.00 |
| 2002 | 9286.06 | 8663 | 1087 | 98.90 | 99.58 | 97.52 | 98.89 | 0.42 | 0.42 | 0.00 | 0.67 |
| 2003 | 7725.23 | 7225 | 1087 | 82.50 | 82.50 | 81.13 | 82.48 | 4.07 | 3.50 | 14.01 | 0.00 |
| 2004 | 8017.93 | 7535 | 1087 | 85.79 | 85.79 | 83.97 | 85.78 | 0.00 | 0.00 | 14.21 | 0.00 |
| 2005 | 9441.73 | 8760 | 1087 | 100.00 | 100.00 | 99.14 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2006 | 8529.60 | 7734 | 1087 | 88.30 | 88.30 | 89.58 | 88.29 | 1.20 | 1.07 | 10.63 | 0.00 |
| 2007 | 9720.14 | 8760 | 1118 | 100.00 | 100.00 | 99.25 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 7263.10 | 6578 | 1118 | 74.93 | 75.65 | 73.96 | 74.89 | 6.79 | 5.51 | 18.83 | 0.72 |
| 2009 | 7998.16 | 7565 | 1118 | 86.41 | 86.41 | 81.67 | 86.36 | 3.62 | 3.25 | 10.34 | 0.00 |
| 2010 | 9752.48 | 8760 | 1118 | 100.00 | 100.00 | 99.58 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 8751.61 | 7789 | 1118 | 88.94 | 88.94 | 89.36 | 88.92 | 1.41 | 1.27 | 9.79 | 0.00 |
| 2012 | 9474.76 | 8609 | 1118 | 98.02 | 98.79 | 96.48 | 98.01 | 1.21 | 1.21 | 0.00 | 0.77 |
| 2013 | 8428.27 | 7499 | 1118 | 85.61 | 85.61 | 86.05 | 85.60 | 1.16 | 1.00 | 13.39 | 0.00 |
| 2014 | 8499.41 | 7742 | 1118 | 88.38 | 88.38 | 86.78 | 88.38 | 2.84 | 2.58 | 9.03 | 0.00 |
| 2015 | 9749.16 | 8757 | 1118 | 99.96 | 99.96 | 99.55 | 99.97 | 0.00 | 0.00 | 0.04 | 0.00 |
| 2016 | 8966.24 | 8001 | 1118 | 91.09 | 91.09 | 91.30 | 91.09 | 0.00 | 0.00 | 8.91 | 0.00 |
| 2017 | 9765.30 | 8760 | 1118 | 100.00 | 100.00 | 99.71 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 8560.44 | 7765 | 1118 | 89.29 | 89.29 | 87.41 | 88.64 | 0.00 | 0.00 | 10.71 | 0.00 |
| 2019 | 7350.12 | 6664 | 1118 | 76.08 | 76.08 | 75.05 | 76.07 | 0.00 | 0.00 | 23.92 | 0.00 |
| 2020 | 7348.12 | 6613 | 1118 | 75.28 | 75.28 | 74.82 | 75.28 | 24.17 | 24.00 | 0.72 | 0.00 |
| 2021 | 6411.51 | 6160 | 1118 | 70.32 | 70.32 | 65.47 | 70.32 | 12.24 | 9.81 | 19.88 | 0.00 |
| 2022 | 8743.28 | 7803 | 1118 | 89.07 | 89.07 | 89.27 | 89.08 | 0.00 | 0.00 | 10.93 | 0.00 |

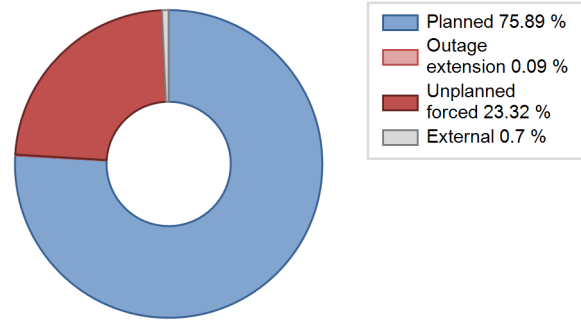
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 133 | |
| B. Refuelling without maintenance | | | | 71 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 676 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 13 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 8 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 16 |
| Z. Other | | | | | 108 | |
| Subtotal | | | | 761 | 249 | 17 |
| Total | | 0 | | | 1027 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 5 |
| 15. Reactor Cooling Systems | | 4 |
| 31. Turbine and auxiliaries | | 14 |
| 32. Feedwater and Main Steam System | | 27 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | | 6 |
| 35. All other I&C Systems | | 6 |
| 41. Main Generator Systems | | 7 |
| 42. Electrical Power Supply Systems | | 63 |
| Total | | 146 |

2023 Operating Experience

US-237

DRESDEN-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : BWR / BWR-3 (Mark 1)
 Thermal power : 2957 MWth
 Gross electrical power : 950 MWe
 Reference unit power (net) : 894 MWe

Key Dates

Construction Date : 1966-01-10
 Grid Date : 1970-04-13
 Commercial Date : 1970-06-09
 Age at end of year : 53 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 35
 Average discharge burnup [MWd/t] : 47000
 Active core diameter [m] : 4.55
 Active core height/length [m] : 3.6
 Number of fissile fuel assemblies/bundles : 724
 Fuel linear heat generation rate [kW/m] : -
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.1
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : 0.43

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.57
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

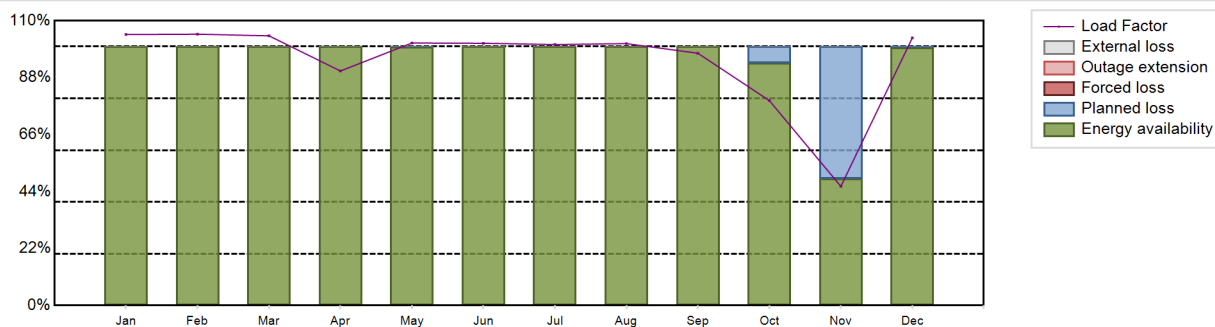
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7408.14 GW(e).h
 Energy Availability Factor (EAF) : 95.22 %
 Unit Capability Factor (UCF) : 95.22 %
 Load Factor (LF) : 94.59 %
 Operating Factor (OF) : 94.27 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 4.78 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 502 hours

Annual Summary

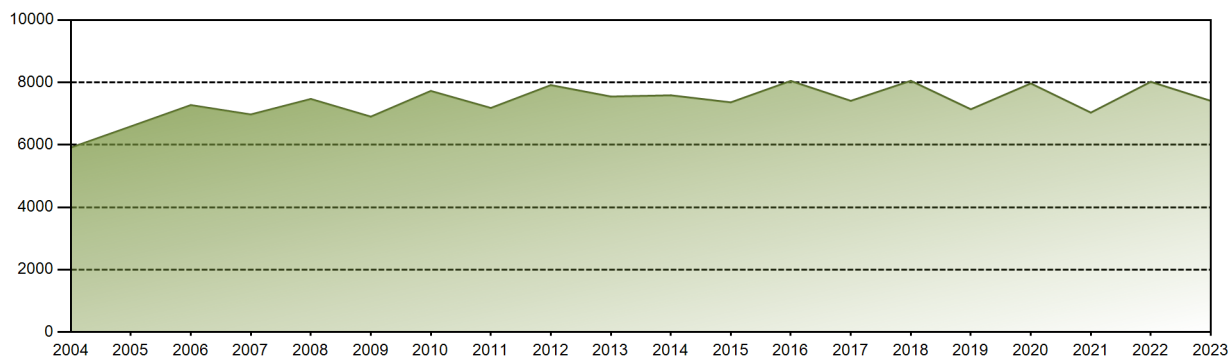


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 696.05 | 629.55 | 691.95 | 583.05 | 674.35 | 651.91 | 670.49 | 672.88 | 627.18 | 526.42 | 296.58 | 687.73 | 7408.14 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.81 | 100.00 | 100.00 | 100.00 | 100.00 | 93.72 | 49.04 | 99.59 | 95.22 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 99.81 | 100.00 | 100.00 | 100.00 | 100.00 | 93.72 | 49.04 | 99.59 | 95.22 |
| LF [%] | 104.65 | 104.79 | 104.17 | 90.58 | 101.38 | 101.28 | 100.81 | 101.16 | 97.44 | 79.15 | 46.01 | 103.40 | 94.59 |
| OF [%] | 100.00 | 100.00 | 100.00 | 89.44 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.55 | 47.57 | 100.00 | 94.27 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 6.28 | 50.96 | 0.41 | 4.78 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 292464.08 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.75 % |
| Cumulative Energy Availability Factor (EAF) | : 82.99 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.01 % |
| Cumulative Unit Capability Factor (UCF) | : 83.01 % | Cumulative Planned Unavailability Factor (PUF) | : 10.98 % |
| Cumulative Load Factor (LF) | : 76.1 % | Cumulative Externally cause unavailability (XUF) | : 0.03 % |
| Cumulative Operating Factor (OF) | : 81.17 % | | |

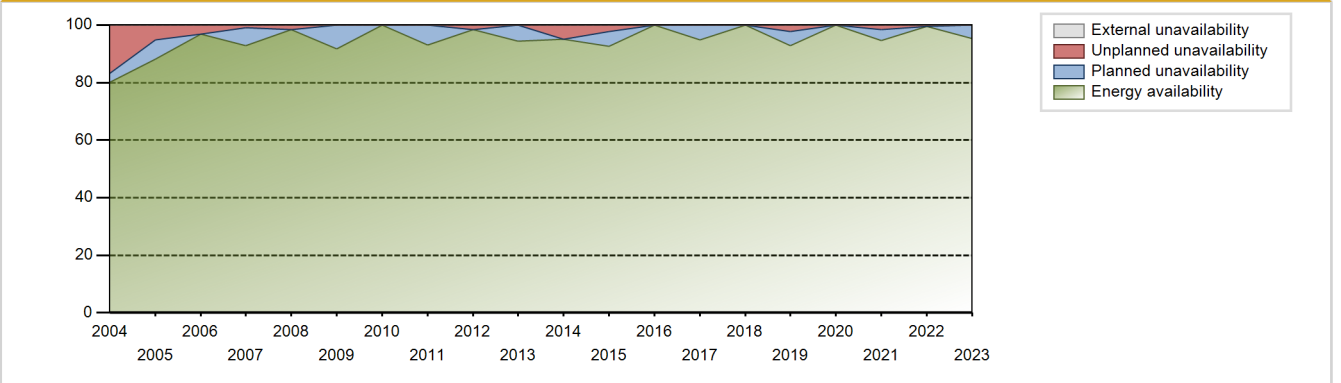
Electricity Production (net) [GWh]



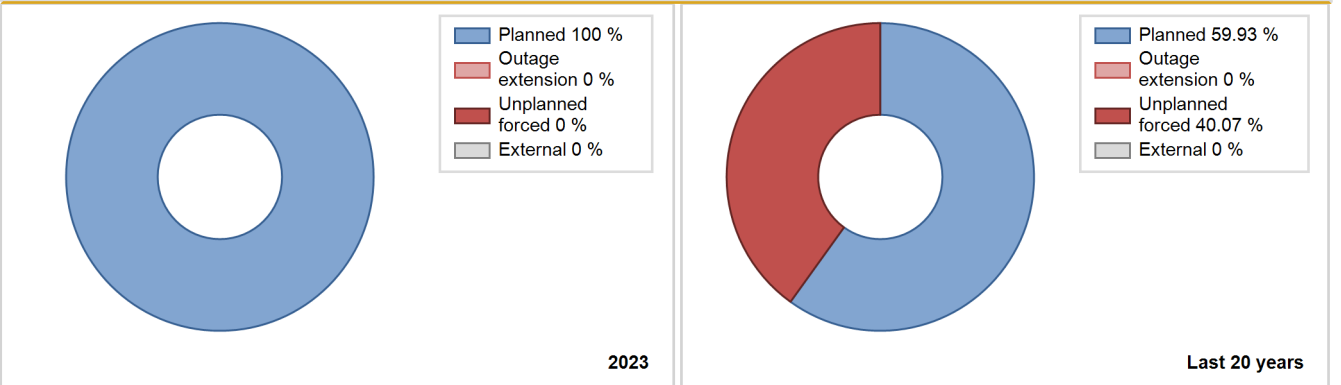
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1970 | 1253.00 | 2558 | 804 | 100.00 | 100.00 | 23.94 | 37.87 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1971 | 2806.30 | 5694 | 815 | 100.00 | 100.00 | 39.31 | 65.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1972 | 3370.50 | 5240 | 815 | 100.00 | 100.00 | 47.08 | 59.65 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | 5014.50 | 7672 | 800 | 90.77 | 90.77 | 71.55 | 87.58 | 3.23 | 3.03 | 6.20 | 0.00 |
| 1974 | 3376.00 | 5113 | 800 | 58.33 | 58.33 | 48.17 | 58.37 | 28.52 | 23.27 | 18.40 | 0.00 |
| 1975 | 2957.00 | 4826 | 800 | 42.24 | 42.24 | 42.19 | 55.09 | 21.18 | 11.35 | 46.42 | 0.00 |
| 1976 | 4374.40 | 6660 | 781 | 64.08 | 64.08 | 63.76 | 75.82 | 14.77 | 11.11 | 24.82 | 0.00 |
| 1977 | 3538.10 | 6297 | 772 | 52.38 | 52.38 | 52.32 | 71.88 | 25.03 | 17.48 | 30.14 | 0.00 |
| 1978 | 5704.50 | 8244 | 772 | 84.39 | 84.39 | 84.35 | 94.11 | 14.03 | 13.78 | 1.83 | 0.00 |
| 1979 | 4942.90 | 7141 | 772 | 73.09 | 73.09 | 73.09 | 81.52 | 9.04 | 7.27 | 19.64 | 0.00 |
| 1980 | 4580.40 | 8193 | 772 | 93.53 | 93.53 | 67.55 | 93.27 | 4.90 | 4.82 | 1.65 | 0.00 |
| 1981 | 3416.00 | 5260 | 772 | 60.11 | 60.68 | 50.51 | 60.05 | 6.66 | 4.33 | 34.99 | 0.57 |
| 1982 | 5123.10 | 8094 | 772 | 92.42 | 92.98 | 75.76 | 92.40 | 5.86 | 5.79 | 1.23 | 0.56 |
| 1983 | 3402.20 | 5076 | 772 | 58.91 | 59.23 | 50.31 | 57.95 | 15.72 | 11.05 | 29.73 | 0.32 |
| 1984 | 4468.36 | 6402 | 772 | 72.91 | 72.91 | 65.89 | 72.88 | 4.33 | 3.30 | 23.79 | 0.00 |
| 1985 | 3105.97 | 4678 | 772 | 54.52 | 54.52 | 45.93 | 53.40 | 12.95 | 8.11 | 37.36 | 0.00 |
| 1986 | 4655.67 | 6761 | 772 | 77.22 | 77.22 | 68.84 | 77.18 | 15.21 | 13.85 | 8.93 | 0.00 |
| 1987 | 3362.64 | 5342 | 772 | 61.03 | 61.03 | 49.72 | 60.98 | 8.49 | 5.67 | 33.31 | 0.00 |
| 1988 | 4325.16 | 6931 | 772 | 78.92 | 78.92 | 63.78 | 78.90 | 0.10 | 0.08 | 20.99 | 0.00 |
| 1989 | 4751.70 | 7023 | 772 | 80.19 | 80.19 | 70.26 | 80.17 | 2.74 | 2.26 | 17.55 | 0.00 |
| 1990 | 4116.85 | 5920 | 772 | 67.60 | 67.60 | 60.88 | 67.58 | 6.89 | 5.00 | 27.40 | 0.00 |
| 1991 | 2984.21 | 5031 | 772 | 57.96 | 57.96 | 44.13 | 57.43 | 34.46 | 30.48 | 11.56 | 0.00 |
| 1992 | 4185.75 | 7419 | 772 | 84.47 | 84.47 | 61.73 | 84.46 | 15.53 | 15.53 | 0.00 | 0.00 |
| 1993 | 3058.56 | 4790 | 772 | 54.69 | 54.69 | 45.23 | 54.68 | 15.70 | 10.18 | 35.13 | 0.00 |
| 1994 | 4086.10 | 5808 | 772 | 66.31 | 66.31 | 60.42 | 66.30 | 33.69 | 33.69 | 0.00 | 0.00 |
| 1995 | 1890.54 | 2938 | 772 | 33.54 | 33.54 | 27.96 | 33.54 | 20.62 | 8.71 | 57.75 | 0.00 |
| 1996 | 2161.41 | 3731 | 772 | 42.49 | 42.49 | 31.87 | 42.47 | 37.92 | 25.96 | 31.56 | 0.00 |
| 1997 | 5578.45 | 7738 | 772 | 89.44 | 89.44 | 82.49 | 88.33 | 10.56 | 10.56 | 0.00 | 0.00 |
| 1998 | 5632.86 | 7496 | 772 | 85.57 | 85.57 | 83.29 | 85.57 | 3.40 | 3.01 | 11.42 | 0.00 |
| 1999 | 6229.52 | 8122 | 772 | 92.72 | 92.72 | 92.12 | 92.72 | 0.00 | 0.00 | 7.28 | 0.00 |
| 2000 | 6867.43 | 8747 | 772 | 99.58 | 99.58 | 101.27 | 99.58 | 0.42 | 0.42 | 0.00 | 0.00 |
| 2001 | 6072.69 | 8005 | 772 | 91.21 | 91.21 | 89.80 | 91.38 | 3.47 | 3.28 | 5.50 | 0.00 |
| 2002 | 7527.47 | 8760 | 850 | 100.00 | 100.00 | 101.09 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 6703.11 | 7999 | 850 | 91.96 | 91.96 | 90.02 | 91.31 | 0.78 | 0.72 | 7.32 | 0.00 |
| 2004 | 5909.32 | 7045 | 850 | 80.20 | 80.20 | 79.15 | 80.20 | 17.35 | 16.84 | 2.96 | 0.00 |
| 2005 | 6590.08 | 7710 | 850 | 88.04 | 88.04 | 88.51 | 88.01 | 5.56 | 5.18 | 6.77 | 0.00 |
| 2006 | 7273.22 | 8485 | 867 | 96.88 | 96.88 | 95.76 | 96.86 | 3.12 | 3.12 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|------|------|
| 2007 | 6972.69 | 8132 | 867 | 92.84 | 92.84 | 91.81 | 92.83 | 1.09 | 1.02 | 6.13 | 0.00 |
| 2008 | 7469.52 | 8639 | 867 | 98.37 | 98.37 | 98.08 | 98.35 | 1.63 | 1.63 | 0.00 | 0.00 |
| 2009 | 6902.62 | 8033 | 867 | 91.71 | 91.71 | 90.88 | 91.70 | 0.00 | 0.00 | 8.29 | 0.00 |
| 2010 | 7726.88 | 8760 | 867 | 100.00 | 100.00 | 101.74 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 7181.34 | 8150 | 883 | 93.07 | 93.07 | 94.26 | 93.04 | 0.00 | 0.00 | 6.93 | 0.00 |
| 2012 | 7912.78 | 8634 | 883 | 98.30 | 98.30 | 102.02 | 98.29 | 1.70 | 1.70 | 0.00 | 0.00 |
| 2013 | 7546.81 | 8266 | 883 | 94.36 | 94.36 | 97.55 | 94.35 | 0.00 | 0.00 | 5.64 | 0.00 |
| 2014 | 7585.87 | 8315 | 894 | 94.99 | 94.99 | 96.86 | 94.92 | 5.01 | 5.01 | 0.00 | 0.00 |
| 2015 | 7360.79 | 8106 | 894 | 92.53 | 92.53 | 93.99 | 92.53 | 2.35 | 2.23 | 5.24 | 0.00 |
| 2016 | 8047.97 | 8784 | 894 | 100.00 | 100.00 | 102.48 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 7409.85 | 8299 | 902 | 94.78 | 94.78 | 93.78 | 94.74 | 0.00 | 0.00 | 5.22 | 0.00 |
| 2018 | 8051.49 | 8760 | 894 | 100.00 | 100.00 | 102.81 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 7139.16 | 8128 | 894 | 92.80 | 92.80 | 91.16 | 92.79 | 2.35 | 2.24 | 4.97 | 0.00 |
| 2020 | 7966.53 | 8674 | 894 | 99.97 | 99.97 | 101.45 | 98.75 | 0.03 | 0.03 | 0.00 | 0.00 |
| 2021 | 7032.49 | 8285 | 894 | 94.58 | 94.58 | 89.80 | 94.58 | 1.63 | 1.57 | 3.85 | 0.00 |
| 2022 | 8019.51 | 8712 | 894 | 99.45 | 99.45 | 102.40 | 99.45 | 0.55 | 0.55 | 0.00 | 0.00 |
| 2023 | 7408.14 | 8258 | 894 | 95.22 | 95.22 | 94.59 | 94.27 | 0.00 | 0.00 | 4.78 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1970 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 462 | |
| B. Refuelling without maintenance | | | | 6 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1065 | | | 989 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 50 | | |
| E. Testing of plant systems or components | | | | 9 | 32 | |
| H. Nuclear regulatory requirements | | | | | 2 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 14 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| Z. Other | | | | | 10 | 1 |
| Subtotal | 1065 | | | 1054 | 520 | 4 |
| Total | | 1065 | | | 1578 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1970 to 2023 | |
|--|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 54 |
| 12. Reactor I&C Systems | | | | 56 |
| 13. Reactor Auxiliary Systems | | | | 10 |
| 14. Safety Systems | | | | 19 |
| 15. Reactor Cooling Systems | | | | 75 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 1 |
| 31. Turbine and auxiliaries | | | | 111 |
| 32. Feedwater and Main Steam System | | | | 29 |
| 34. Miscellaneous Systems | | | | 36 |
| 35. All other I&C Systems | | | | 15 |
| 41. Main Generator Systems | | | | 43 |
| 42. Electrical Power Supply Systems | | | | 50 |
| Total | | | | 499 |

2023 Operating Experience

US-249

DRESDEN-3

UNITED STATES OF AMERICA

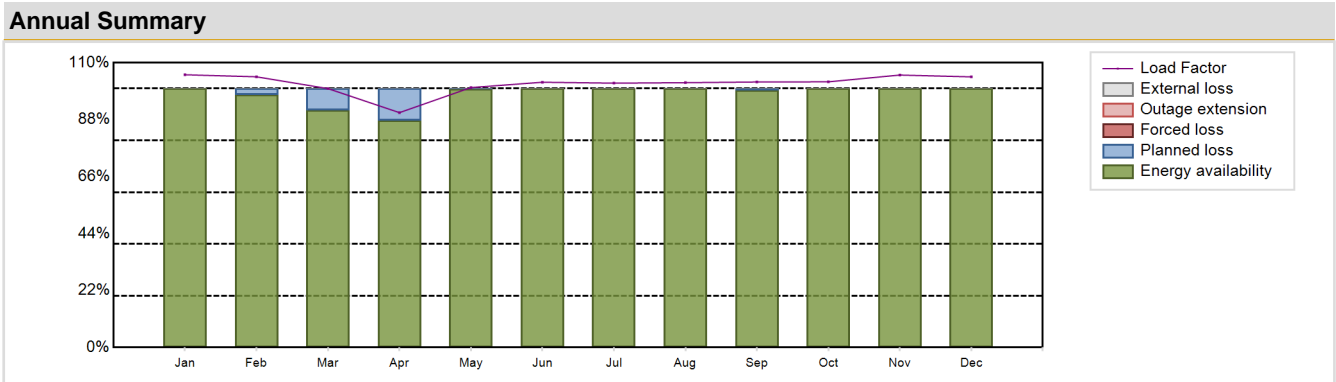
Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-3 (Mark 1) | Construction Date | : 1966-10-14 |
| Thermal power | : 2957 MWth | Grid Date | : 1971-07-22 |
| Gross electrical power | : 935 MWe | Commercial Date | : 1971-11-16 |
| Reference unit power (net) | : 879 MWe | Age at end of year | : 52 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.1 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 286 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.43 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 35 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 47000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.55 | HP cylinder inlet steam pressure [MPa] | : 6.57 |
| Active core height/length [m] | : 3.6 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 724 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : - | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 89 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|------------|
| Net Energy Production | : 7845.87 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 98.01 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 98.01 % | Planned Unavailability Factor (PUF) | : 1.99 % |
| Load Factor (LF) | : 101.89 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 99.03 % | Total off-line time | : 85 hours |

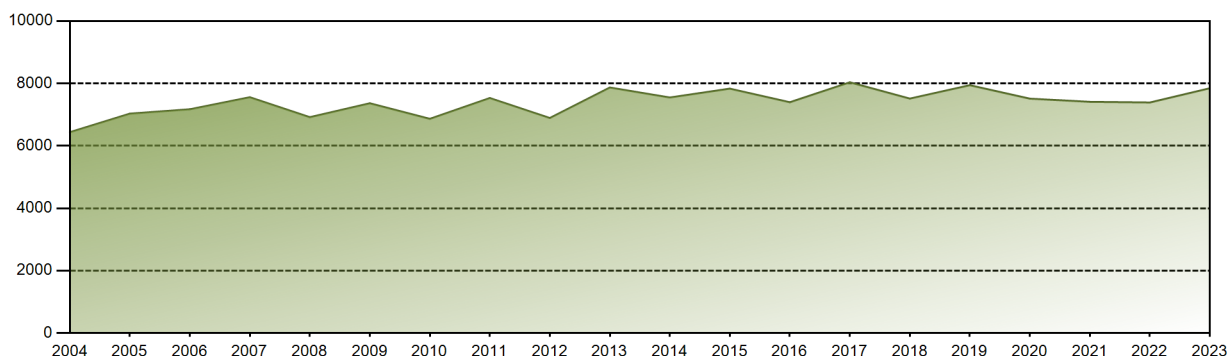


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 688.88 | 617.57 | 653.10 | 574.14 | 656.58 | 648.41 | 667.71 | 668.93 | 649.02 | 671.09 | 666.91 | 683.53 | 7845.87 |
| EAF [%] | 100.00 | 97.60 | 91.70 | 87.61 | 99.74 | 100.00 | 100.00 | 100.00 | 99.31 | 100.00 | 100.00 | 100.00 | 98.01 |
| UCF [%] | 100.00 | 97.60 | 91.70 | 87.61 | 99.74 | 100.00 | 100.00 | 100.00 | 99.31 | 100.00 | 100.00 | 100.00 | 98.01 |
| LF [%] | 105.34 | 104.55 | 100.00 | 90.72 | 100.40 | 102.45 | 102.10 | 102.29 | 102.55 | 102.62 | 105.23 | 104.52 | 101.89 |
| OF [%] | 100.00 | 100.00 | 100.00 | 88.75 | 99.46 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.03 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 2.40 | 8.30 | 12.39 | 0.26 | 0.00 | 0.00 | 0.00 | 0.69 | 0.00 | 0.00 | 0.00 | 1.99 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 284929.16 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.07 % |
| Cumulative Energy Availability Factor (EAF) | : 80.62 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 6.13 % |
| Cumulative Unit Capability Factor (UCF) | : 80.64 % | Cumulative Planned Unavailability Factor (PUF) | : 13.23 % |
| Cumulative Load Factor (LF) | : 76.53 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 81.14 % | | |

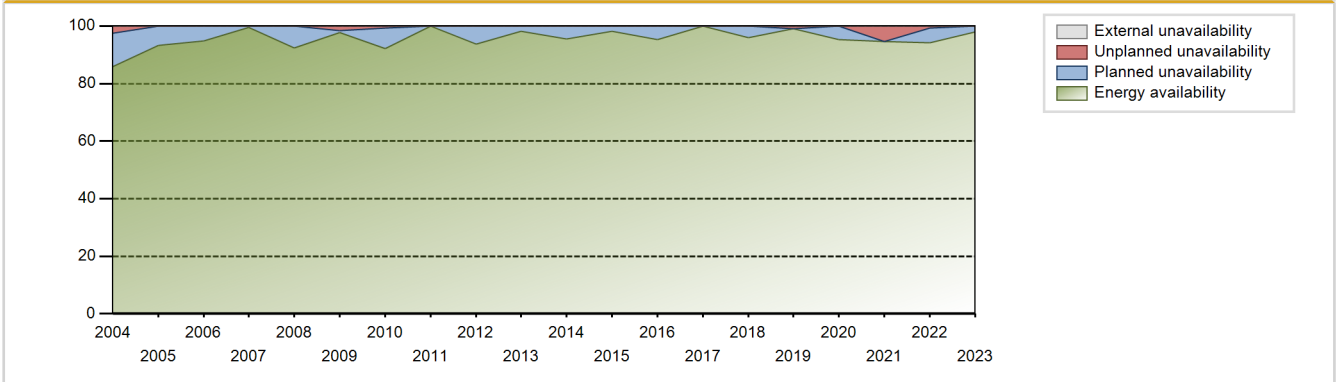
Electricity Production (net) [GWh]



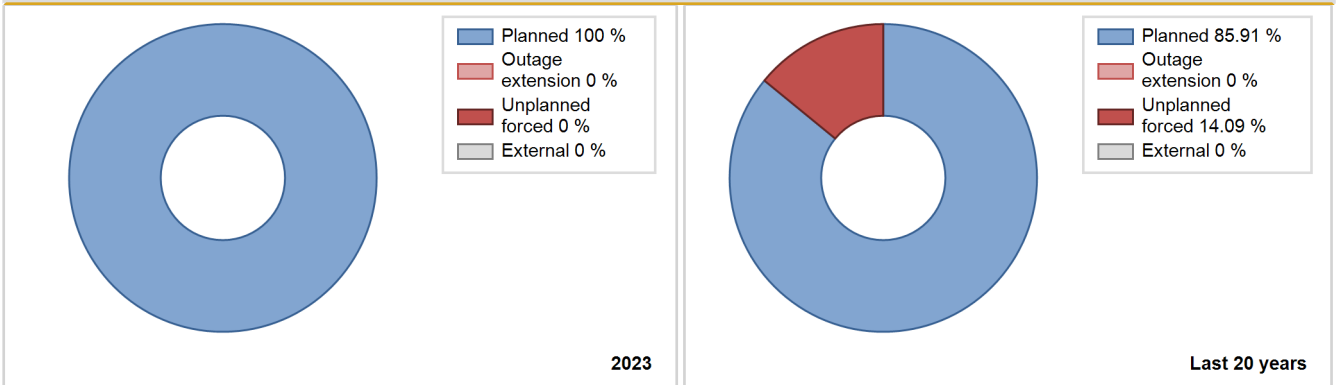
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1971 | 1188.60 | 2137 | 794 | 100.00 | 100.00 | 27.90 | 32.39 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1972 | 5175.60 | 7549 | 815 | 100.00 | 100.00 | 72.30 | 85.94 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | 3703.60 | 5905 | 800 | 69.20 | 69.20 | 52.85 | 67.41 | 3.22 | 2.30 | 28.50 | 0.00 |
| 1974 | 3608.90 | 5778 | 800 | 65.78 | 65.78 | 51.50 | 65.96 | 12.31 | 9.24 | 24.99 | 0.00 |
| 1975 | 2211.20 | 4505 | 800 | 31.54 | 31.54 | 31.55 | 51.43 | 39.55 | 20.64 | 47.82 | 0.00 |
| 1976 | 4037.20 | 7231 | 781 | 58.75 | 58.75 | 58.85 | 82.32 | 21.91 | 16.48 | 24.77 | 0.00 |
| 1977 | 5186.40 | 8072 | 773 | 76.64 | 76.64 | 76.59 | 92.15 | 20.11 | 19.29 | 4.07 | 0.00 |
| 1978 | 3835.30 | 6280 | 773 | 56.63 | 56.63 | 56.64 | 71.69 | 22.30 | 16.25 | 27.12 | 0.00 |
| 1979 | 3482.90 | 5930 | 773 | 51.43 | 51.43 | 51.43 | 67.69 | 42.55 | 38.09 | 10.47 | 0.00 |
| 1980 | 4335.50 | 6307 | 773 | 72.31 | 72.31 | 63.85 | 71.80 | 2.52 | 1.87 | 25.82 | 0.00 |
| 1981 | 5177.70 | 8256 | 773 | 94.49 | 95.11 | 76.46 | 94.25 | 4.89 | 4.89 | 0.00 | 0.62 |
| 1982 | 3896.40 | 5562 | 773 | 63.79 | 64.34 | 57.54 | 63.49 | 3.40 | 2.27 | 33.39 | 0.55 |
| 1983 | 4159.70 | 6401 | 773 | 73.10 | 73.10 | 61.43 | 73.07 | 2.21 | 1.65 | 25.25 | 0.00 |
| 1984 | 2135.50 | 3309 | 773 | 37.72 | 37.72 | 31.45 | 37.67 | 14.16 | 6.22 | 56.06 | 0.00 |
| 1985 | 4401.33 | 6618 | 773 | 75.58 | 75.58 | 65.00 | 75.55 | 5.73 | 4.59 | 19.83 | 0.00 |
| 1986 | 1498.30 | 2456 | 773 | 28.06 | 28.06 | 22.13 | 28.04 | 15.97 | 5.33 | 66.61 | 0.00 |
| 1987 | 4395.50 | 6591 | 773 | 75.30 | 75.30 | 64.91 | 75.24 | 23.78 | 23.50 | 1.20 | 0.00 |
| 1988 | 4168.36 | 6278 | 773 | 71.50 | 71.50 | 61.39 | 71.47 | 0.00 | 0.00 | 28.50 | 0.00 |
| 1989 | 5119.46 | 7235 | 773 | 82.62 | 82.62 | 75.60 | 82.59 | 3.07 | 2.62 | 14.77 | 0.00 |
| 1990 | 5149.79 | 7272 | 773 | 83.01 | 83.01 | 76.05 | 83.01 | 4.75 | 4.14 | 12.84 | 0.00 |
| 1991 | 2584.21 | 5247 | 773 | 59.91 | 59.91 | 38.16 | 59.90 | 2.24 | 1.37 | 38.72 | 0.00 |
| 1992 | 3077.06 | 5364 | 773 | 61.08 | 61.08 | 45.32 | 61.07 | 10.64 | 7.27 | 31.65 | 0.00 |
| 1993 | 4969.04 | 7040 | 773 | 80.39 | 80.39 | 73.38 | 80.37 | 19.61 | 19.61 | 0.00 | 0.00 |
| 1994 | 1666.36 | 3009 | 773 | 34.35 | 34.35 | 24.61 | 34.35 | 0.00 | 0.00 | 65.65 | 0.00 |
| 1995 | 3477.26 | 5209 | 773 | 59.46 | 59.46 | 51.35 | 59.46 | 40.54 | 40.54 | 0.00 | 0.00 |
| 1996 | 2962.14 | 4273 | 773 | 48.88 | 48.88 | 43.62 | 48.65 | 51.12 | 51.12 | 0.00 | 0.00 |
| 1997 | 4046.20 | 5900 | 773 | 68.55 | 68.55 | 59.75 | 67.35 | 11.27 | 8.71 | 22.74 | 0.00 |
| 1998 | 6234.59 | 8157 | 773 | 93.12 | 93.12 | 92.07 | 93.12 | 3.26 | 3.14 | 3.75 | 0.00 |
| 1999 | 6129.96 | 7978 | 773 | 91.07 | 91.07 | 90.53 | 91.07 | 1.69 | 1.56 | 7.36 | 0.00 |
| 2000 | 6365.12 | 8243 | 773 | 93.84 | 93.84 | 93.74 | 93.84 | 0.73 | 0.69 | 5.46 | 0.00 |
| 2001 | 6465.95 | 8359 | 773 | 95.36 | 95.36 | 95.49 | 95.42 | 3.98 | 3.95 | 0.69 | 0.00 |
| 2002 | 6060.87 | 7915 | 850 | 90.46 | 90.46 | 87.31 | 90.35 | 2.39 | 2.21 | 7.33 | 0.00 |
| 2003 | 6963.86 | 8206 | 850 | 94.17 | 94.17 | 93.52 | 93.68 | 2.16 | 2.07 | 3.76 | 0.00 |
| 2004 | 6436.94 | 7544 | 850 | 85.88 | 85.88 | 86.21 | 85.88 | 2.87 | 2.54 | 11.58 | 0.00 |
| 2005 | 7032.37 | 8169 | 850 | 93.28 | 93.28 | 94.43 | 93.24 | 0.15 | 0.14 | 6.59 | 0.00 |
| 2006 | 7171.93 | 8298 | 867 | 94.73 | 94.73 | 94.43 | 94.73 | 0.00 | 0.00 | 5.27 | 0.00 |
| 2007 | 7558.09 | 8715 | 867 | 99.49 | 99.49 | 99.52 | 99.49 | 0.00 | 0.00 | 0.51 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|------|------|
| 2008 | 6919.05 | 8118 | 867 | 92.43 | 92.43 | 90.85 | 92.42 | 0.00 | 0.00 | 7.57 | 0.00 |
| 2009 | 7364.79 | 8557 | 867 | 97.70 | 97.70 | 96.97 | 97.68 | 1.65 | 1.64 | 0.66 | 0.00 |
| 2010 | 6866.24 | 8076 | 867 | 92.21 | 92.21 | 90.41 | 92.19 | 0.79 | 0.73 | 7.05 | 0.00 |
| 2011 | 7533.02 | 8760 | 867 | 100.00 | 100.00 | 99.18 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 6892.73 | 8218 | 867 | 93.69 | 93.69 | 90.51 | 93.56 | 0.00 | 0.00 | 6.31 | 0.00 |
| 2013 | 7869.99 | 8590 | 867 | 98.10 | 98.10 | 103.61 | 98.05 | 0.00 | 0.00 | 1.90 | 0.00 |
| 2014 | 7549.85 | 8361 | 879 | 95.51 | 95.51 | 98.05 | 95.45 | 0.00 | 0.00 | 4.49 | 0.00 |
| 2015 | 7832.94 | 8595 | 879 | 98.11 | 98.11 | 101.73 | 98.12 | 0.00 | 0.00 | 1.89 | 0.00 |
| 2016 | 7397.58 | 8376 | 879 | 95.35 | 95.35 | 95.81 | 95.36 | 0.00 | 0.00 | 4.65 | 0.00 |
| 2017 | 8036.77 | 8760 | 895 | 100.00 | 100.00 | 102.51 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 7514.36 | 8401 | 879 | 95.94 | 95.94 | 97.59 | 95.90 | 0.00 | 0.00 | 4.06 | 0.00 |
| 2019 | 7942.88 | 8674 | 879 | 99.03 | 99.03 | 103.15 | 99.02 | 0.97 | 0.97 | 0.00 | 0.00 |
| 2020 | 7512.35 | 8372 | 879 | 95.30 | 95.30 | 97.30 | 95.31 | 0.00 | 0.00 | 4.70 | 0.00 |
| 2021 | 7411.09 | 8286 | 879 | 94.59 | 94.59 | 96.25 | 94.59 | 5.41 | 5.41 | 0.00 | 0.00 |
| 2022 | 7389.45 | 8251 | 879 | 94.19 | 94.19 | 95.97 | 94.19 | 0.76 | 0.72 | 5.09 | 0.00 |
| 2023 | 7845.87 | 8675 | 879 | 98.01 | 98.01 | 101.89 | 99.03 | 0.00 | 0.00 | 1.99 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1971 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 484 | |
| B. Refuelling without maintenance | | | | 21 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1012 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 88 | | |
| E. Testing of plant systems or components | | | | 2 | 7 | |
| H. Nuclear regulatory requirements | | | | | 2 | |
| L. Human factor related | | | | | 17 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 1 | | |
| Z. Other | | | | | 21 | |
| Subtotal | | | | 1124 | 531 | 1 |
| Total | | 0 | | | 1656 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1971 to 2023 | |
|--|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 7 |
| 12. Reactor I&C Systems | | | | 14 |
| 13. Reactor Auxiliary Systems | | | | 2 |
| 14. Safety Systems | | | | 42 |
| 15. Reactor Cooling Systems | | | | 42 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 47 |
| 31. Turbine and auxiliaries | | | | 154 |
| 32. Feedwater and Main Steam System | | | | 46 |
| 33. Circulating Water System | | | | 5 |
| 34. Miscellaneous Systems | | | | 59 |
| 35. All other I&C Systems | | | | 1 |
| 41. Main Generator Systems | | | | 12 |
| 42. Electrical Power Supply Systems | | | | 68 |
| Total | | | | 499 |

2023 Operating Experience

US-348 **FARLEY-1** **UNITED STATES OF AMERICA**

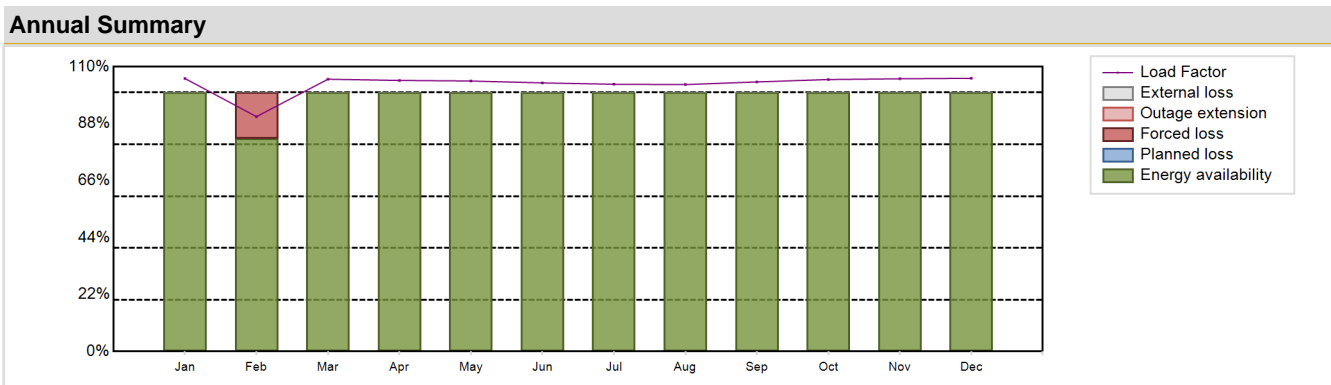
Status at end of year : **Operational**
 Operator : SOUTHERN (Southern Nuclear Operating Company, Inc.)
 Owner : APCO (Alabama Power Company)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP (DRYAMB) | Construction Date | : 1970-10-01 |
| Thermal power | : 2775 MWth | Grid Date | : 1977-08-18 |
| Gross electrical power | : 918 MWe | Commercial Date | : 1977-12-01 |
| Reference unit power (net) | : 874 MWe | Age at end of year | : 46 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 322 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.38 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.02 | HP cylinder inlet steam pressure [MPa] | : 5.27 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 17.1 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 45 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|------------|
| Net Energy Production | : 7922.18 GW(e).h | Forced Loss Rate (FLR) | : 1.37 % |
| Energy Availability Factor (EAF) | : 98.63 % | Unplanned Capability Loss Factor (UCL) | : 1.37 % |
| Unit Capability Factor (UCF) | : 98.63 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 103.47 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 99.04 % | Total off-line time | : 84 hours |

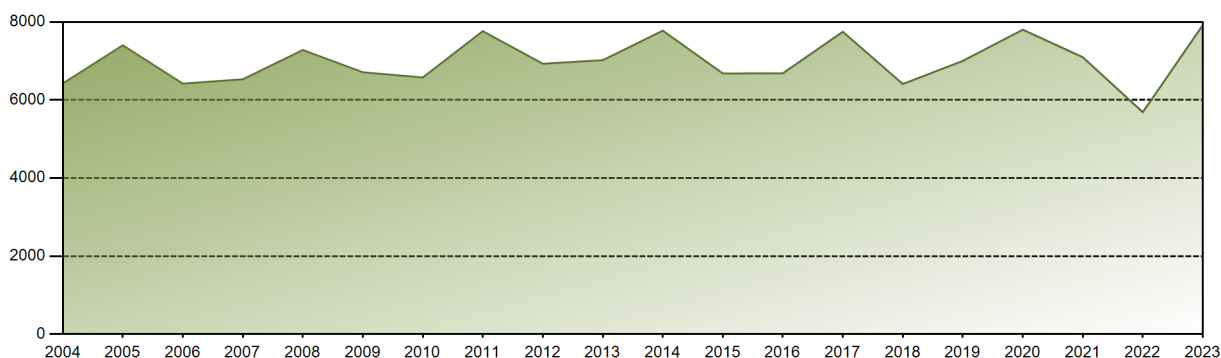


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 685.60 | 532.82 | 682.94 | 658.86 | 679.34 | 652.89 | 671.18 | 670.38 | 655.23 | 683.09 | 663.74 | 686.11 | 7922.18 |
| EAF [%] | 100.00 | 82.14 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.63 |
| UCF [%] | 100.00 | 82.14 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.63 |
| LF [%] | 105.44 | 90.72 | 105.17 | 104.70 | 104.47 | 103.75 | 103.22 | 103.10 | 104.12 | 105.05 | 105.33 | 105.51 | 103.47 |
| OF [%] | 100.00 | 87.50 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.04 |
| FLR [%] | 0.00 | 17.86 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.37 |
| UCL [%] | 0.00 | 17.86 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.37 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 288060.15 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.82 % |
| Cumulative Energy Availability Factor (EAF) | : 85.99 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.5 % |
| Cumulative Unit Capability Factor (UCF) | : 86.09 % | Cumulative Planned Unavailability Factor (PUF) | : 11.41 % |
| Cumulative Load Factor (LF) | : 85.04 % | Cumulative Externally cause unavailability (XUF) | : 0.1 % |
| Cumulative Operating Factor (OF) | : 85.98 % | | |

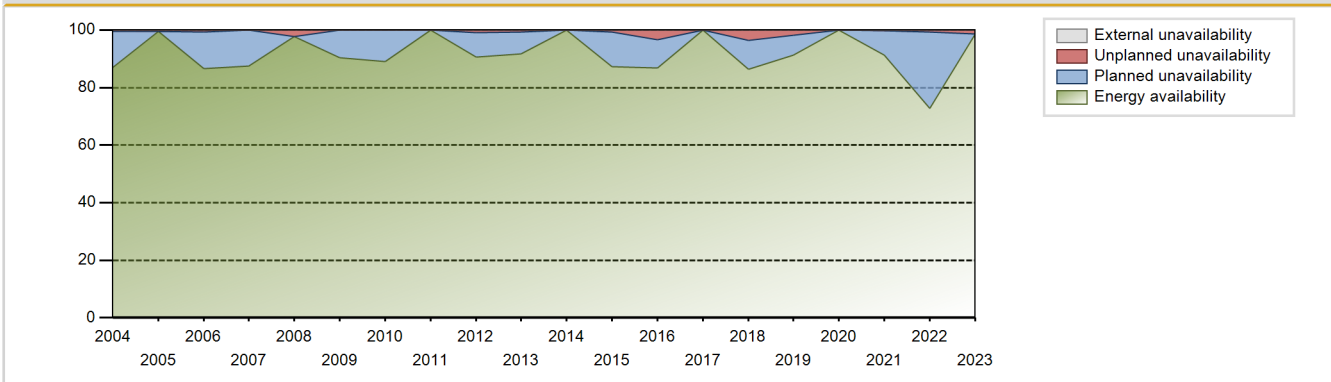
Electricity Production (net) [GWh]



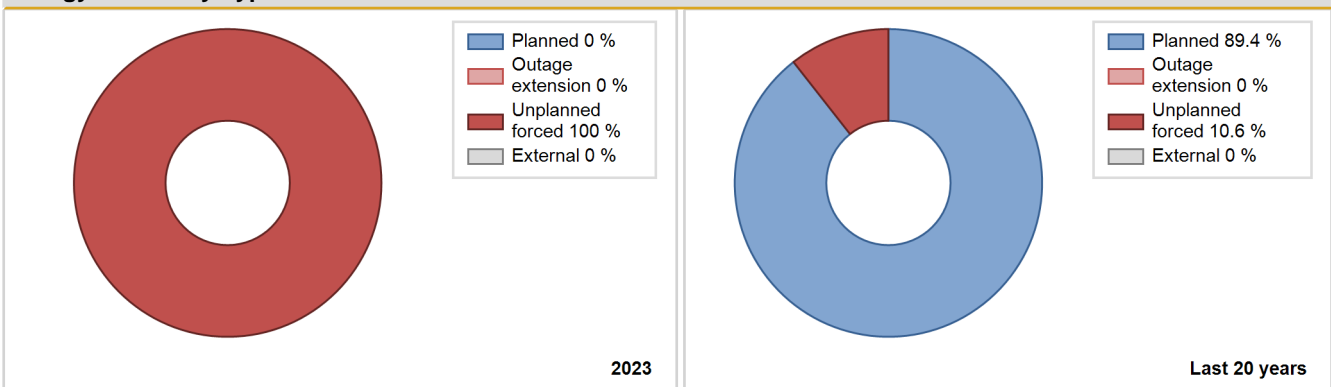
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1977 | 1047.90 | 1747 | 820 | 100.00 | 100.00 | 64.19 | 68.82 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1978 | 5919.80 | 7568 | 829 | 81.52 | 81.52 | 81.52 | 86.39 | 11.24 | 10.32 | 8.16 | 0.00 |
| 1979 | 1732.40 | 2502 | 829 | 23.85 | 23.85 | 23.86 | 28.56 | 14.61 | 4.08 | 72.07 | 0.00 |
| 1980 | 4607.80 | 6110 | 814 | 70.17 | 74.38 | 64.44 | 69.56 | 5.04 | 3.94 | 21.68 | 4.21 |
| 1981 | 2653.00 | 3624 | 804 | 41.54 | 41.54 | 37.67 | 41.37 | 45.41 | 34.56 | 23.90 | 0.00 |
| 1982 | 5233.30 | 6936 | 804 | 79.29 | 79.29 | 74.30 | 79.18 | 20.47 | 20.41 | 0.31 | 0.00 |
| 1983 | 5268.60 | 6832 | 804 | 77.73 | 77.73 | 74.81 | 77.99 | 1.31 | 1.03 | 21.24 | 0.00 |
| 1984 | 5432.66 | 6920 | 804 | 78.50 | 78.50 | 76.92 | 78.78 | 1.16 | 0.92 | 20.58 | 0.00 |
| 1985 | 5868.67 | 7378 | 816 | 84.29 | 84.29 | 82.10 | 84.22 | 1.82 | 1.56 | 14.15 | 0.00 |
| 1986 | 5738.56 | 7247 | 827 | 82.41 | 82.41 | 79.21 | 82.73 | 1.58 | 1.32 | 16.27 | 0.00 |
| 1987 | 6444.86 | 8201 | 825 | 93.68 | 93.68 | 89.17 | 93.62 | 3.77 | 3.67 | 2.64 | 0.00 |
| 1988 | 5908.21 | 7363 | 813 | 83.80 | 83.80 | 82.73 | 83.82 | 0.68 | 0.58 | 15.62 | 0.00 |
| 1989 | 6022.64 | 7520 | 824 | 86.02 | 86.02 | 83.44 | 85.84 | 1.01 | 0.88 | 13.10 | 0.00 |
| 1990 | 6908.57 | 8681 | 824 | 99.11 | 99.11 | 95.71 | 99.10 | 0.89 | 0.89 | 0.00 | 0.00 |
| 1991 | 5416.06 | 6870 | 814 | 78.44 | 78.90 | 75.95 | 78.42 | 1.68 | 1.35 | 19.75 | 0.46 |
| 1992 | 5667.94 | 7119 | 812 | 80.98 | 80.98 | 79.47 | 81.05 | 0.46 | 0.38 | 18.65 | 0.00 |
| 1993 | 6873.90 | 8522 | 812 | 97.28 | 97.28 | 96.64 | 97.28 | 2.72 | 2.72 | 0.00 | 0.00 |
| 1994 | 6059.84 | 7546 | 812 | 86.11 | 86.11 | 85.19 | 86.14 | 0.00 | 0.00 | 13.89 | 0.00 |
| 1995 | 5751.98 | 7220 | 812 | 82.41 | 82.41 | 80.86 | 82.42 | 4.72 | 4.08 | 13.51 | 0.00 |
| 1996 | 7142.30 | 8740 | 812 | 99.50 | 99.50 | 100.14 | 99.50 | 0.00 | 0.00 | 0.50 | 0.00 |
| 1997 | 5433.98 | 6803 | 821 | 77.72 | 77.72 | 75.54 | 77.66 | 0.00 | 0.00 | 22.28 | 0.00 |
| 1998 | 5237.94 | 6539 | 822 | 74.81 | 74.81 | 72.74 | 74.65 | 6.58 | 5.27 | 19.92 | 0.00 |
| 1999 | 7226.52 | 8695 | 847 | 99.26 | 99.26 | 97.40 | 99.26 | 0.74 | 0.74 | 0.00 | 0.00 |
| 2000 | 5204.09 | 6775 | 828 | 76.82 | 76.82 | 71.55 | 77.13 | 0.42 | 0.32 | 22.86 | 0.00 |
| 2001 | 6392.53 | 7736 | 833 | 88.33 | 88.33 | 87.60 | 88.31 | 0.00 | 0.00 | 11.67 | 0.00 |
| 2002 | 7221.79 | 8641 | 833 | 98.65 | 98.65 | 98.97 | 98.64 | 1.35 | 1.35 | 0.00 | 0.00 |
| 2003 | 6609.90 | 7909 | 830 | 90.30 | 90.30 | 90.91 | 90.29 | 0.00 | 0.00 | 9.70 | 0.00 |
| 2004 | 6423.88 | 7627 | 851 | 86.99 | 86.99 | 86.83 | 86.83 | 0.53 | 0.46 | 12.54 | 0.00 |
| 2005 | 7402.19 | 8709 | 833 | 99.42 | 99.42 | 101.43 | 99.41 | 0.58 | 0.58 | 0.00 | 0.00 |
| 2006 | 6419.32 | 7578 | 851 | 86.53 | 86.53 | 86.11 | 86.51 | 0.71 | 0.62 | 12.85 | 0.00 |
| 2007 | 6530.77 | 7663 | 851 | 87.49 | 87.49 | 87.61 | 87.48 | 0.00 | 0.00 | 12.51 | 0.00 |
| 2008 | 7281.47 | 8579 | 851 | 97.68 | 97.68 | 97.41 | 97.67 | 2.32 | 2.32 | 0.00 | 0.00 |
| 2009 | 6711.12 | 7922 | 851 | 90.46 | 90.46 | 90.02 | 90.43 | 0.00 | 0.00 | 9.54 | 0.00 |
| 2010 | 6577.44 | 7806 | 851 | 89.13 | 89.13 | 88.23 | 89.11 | 0.00 | 0.00 | 10.87 | 0.00 |
| 2011 | 7764.30 | 8760 | 874 | 100.00 | 100.00 | 101.41 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 6929.42 | 7967 | 874 | 90.71 | 90.71 | 90.26 | 90.70 | 0.99 | 0.91 | 8.38 | 0.00 |
| 2013 | 7021.41 | 8033 | 874 | 91.70 | 91.70 | 91.70 | 91.69 | 0.66 | 0.61 | 7.69 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2014 | 7777.43 | 8760 | 874 | 100.00 | 100.00 | 101.58 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 6680.66 | 7652 | 874 | 87.35 | 87.35 | 87.26 | 87.35 | 0.82 | 0.73 | 11.93 | 0.00 |
| 2016 | 6684.05 | 7617 | 874 | 86.72 | 86.72 | 87.06 | 86.71 | 3.78 | 3.41 | 9.87 | 0.00 |
| 2017 | 7750.07 | 8760 | 874 | 100.00 | 100.00 | 101.23 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 6409.66 | 7567 | 874 | 86.37 | 86.37 | 83.72 | 86.38 | 4.03 | 3.63 | 10.00 | 0.00 |
| 2019 | 7003.19 | 7993 | 874 | 91.26 | 91.26 | 91.47 | 91.24 | 1.92 | 1.79 | 6.95 | 0.00 |
| 2020 | 7802.41 | 8783 | 874 | 100.00 | 100.00 | 101.63 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 7096.20 | 7987 | 874 | 91.17 | 91.17 | 92.69 | 91.18 | 0.39 | 0.36 | 8.47 | 0.00 |
| 2022 | 5688.30 | 6367 | 874 | 72.68 | 72.68 | 74.30 | 72.68 | 0.96 | 0.71 | 26.61 | 0.00 |
| 2023 | 7922.18 | 8676 | 874 | 98.63 | 98.63 | 103.47 | 99.04 | 1.37 | 1.37 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1977 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 120 | | | 186 | |
| B. Refuelling without maintenance | | | | 16 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 884 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 49 | | |
| E. Testing of plant systems or components | | | | 2 | 0 | |
| H. Nuclear regulatory requirements | | | | 51 | 18 | |
| L. Human factor related | | | | | 11 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| Z. Other | | | | | 3 | |
| Subtotal | | 120 | | 1002 | 218 | 4 |
| Total | | 120 | | | 1224 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1977 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 120 | 5 |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 3 |
| 15. Reactor Cooling Systems | | 8 |
| 16. Steam generation systems | | 20 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 75 |
| 32. Feedwater and Main Steam System | | 16 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 10 |
| 42. Electrical Power Supply Systems | | 50 |
| Total | 120 | 200 |

2023 Operating Experience

US-364

FARLEY-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : SOUTHERN (Southern Nuclear Operating Company, Inc.)
 Owner : APCO (Alabama Power Company)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 3LP (DRYAMB)
 Thermal power : 2775 MWth
 Gross electrical power : 928 MWe
 Reference unit power (net) : 883 MWe

Key Dates

Construction Date : 1970-10-01
 Grid Date : 1981-05-25
 Commercial Date : 1981-07-30
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.02
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.1
 Number of control rod assemblies : 45
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 322
 Number of SG : 3
 Containment type : Single
 Containment design pressure [MPa] : 0.38

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.27
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

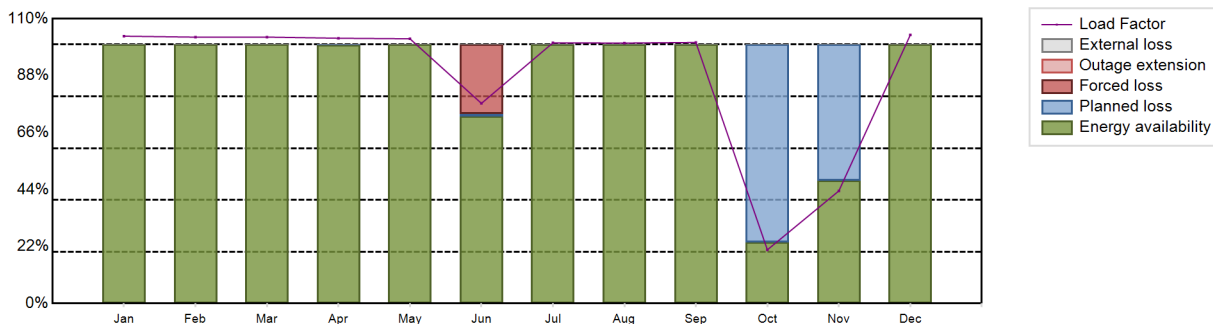
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6836.35 GW(e).h
 Energy Availability Factor (EAF) : 86.93 %
 Unit Capability Factor (UCF) : 86.93 %
 Load Factor (LF) : 88.38 %
 Operating Factor (OF) : 87.5 %

Forced Loss Rate (FLR) : 2.46 %
 Unplanned Capability Loss Factor (UCL) : 2.19 %
 Planned Unavailability Factor (PUF) : 10.88 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1095 hours

Annual Summary

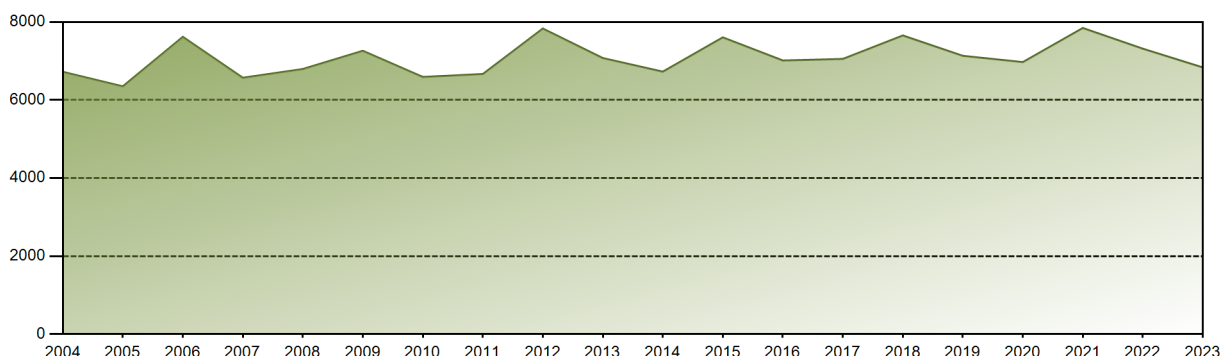


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 678.33 | 610.44 | 675.09 | 651.40 | 671.72 | 491.47 | 661.39 | 660.76 | 641.01 | 136.31 | 276.87 | 681.56 | 6836.35 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 99.97 | 100.00 | 72.33 | 100.00 | 100.00 | 100.00 | 23.66 | 47.59 | 100.00 | 86.93 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 99.97 | 100.00 | 72.33 | 100.00 | 100.00 | 100.00 | 23.66 | 47.59 | 100.00 | 86.93 |
| LF [%] | 103.25 | 102.88 | 102.90 | 102.46 | 102.25 | 77.30 | 100.68 | 100.58 | 100.83 | 20.75 | 43.49 | 103.75 | 88.38 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 79.31 | 100.00 | 100.00 | 100.00 | 23.66 | 47.57 | 100.00 | 87.50 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.46 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.19 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 76.34 | 52.41 | 0.00 | 10.88 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 278075.4 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.68 % |
| Cumulative Energy Availability Factor (EAF) | : 89.42 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.52 % |
| Cumulative Unit Capability Factor (UCF) | : 89.44 % | Cumulative Planned Unavailability Factor (PUF) | : 9.04 % |
| Cumulative Load Factor (LF) | : 88.02 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 89.17 % | | |

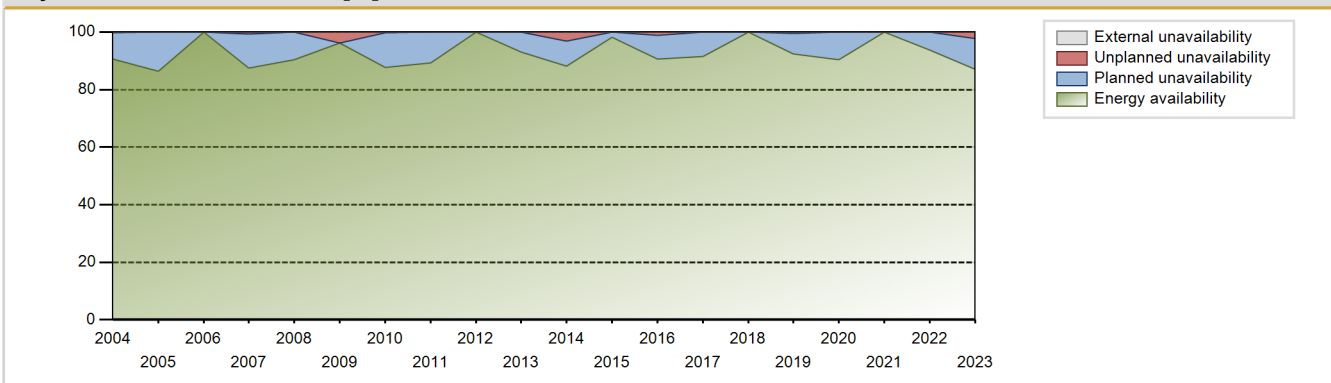
Electricity Production (net) [GWh]



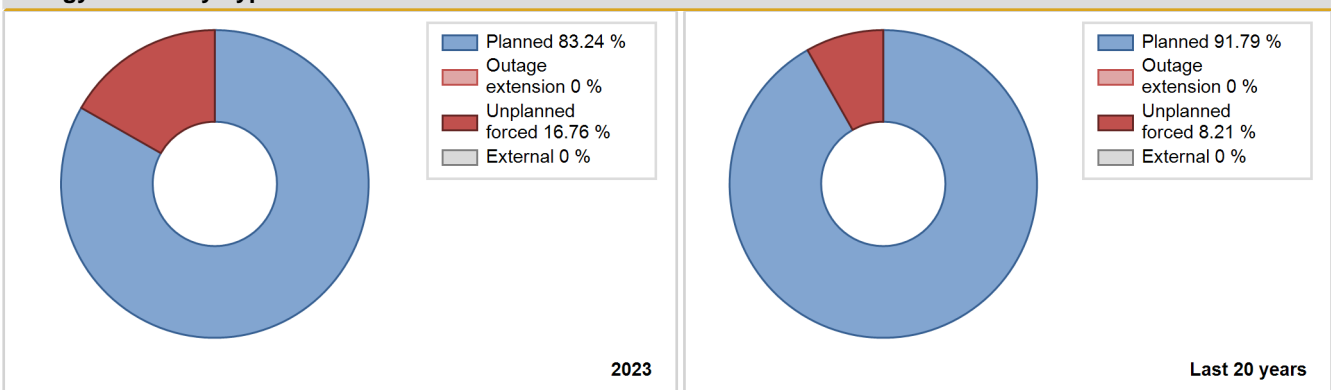
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 2920.80 | 3665 | 825 | 99.28 | 99.28 | 95.08 | 98.48 | 0.72 | 0.72 | 0.00 | 0.00 |
| 1982 | 5311.30 | 6931 | 814 | 79.41 | 79.41 | 74.49 | 79.12 | 10.30 | 9.12 | 11.47 | 0.00 |
| 1983 | 5984.10 | 7696 | 814 | 87.72 | 87.72 | 83.92 | 87.85 | 1.97 | 1.77 | 10.52 | 0.00 |
| 1984 | 6618.90 | 8276 | 814 | 94.18 | 94.41 | 92.57 | 94.22 | 5.59 | 5.59 | 0.00 | 0.22 |
| 1985 | 5474.18 | 6813 | 809 | 77.36 | 77.85 | 77.24 | 77.77 | 1.59 | 1.26 | 20.89 | 0.49 |
| 1986 | 5959.87 | 7455 | 829 | 85.22 | 85.22 | 82.07 | 85.10 | 2.41 | 2.11 | 12.67 | 0.00 |
| 1987 | 4910.40 | 6396 | 824 | 73.02 | 73.02 | 68.00 | 73.01 | 11.35 | 9.35 | 17.64 | 0.00 |
| 1988 | 6550.39 | 8039 | 823 | 100.00 | 100.00 | 90.59 | 91.52 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1989 | 5621.62 | 7037 | 830 | 80.48 | 80.48 | 77.32 | 80.33 | 4.66 | 3.94 | 15.59 | 0.00 |
| 1990 | 5276.96 | 6478 | 828 | 71.77 | 71.77 | 72.75 | 73.95 | 4.34 | 3.25 | 24.98 | 0.00 |
| 1991 | 6739.94 | 8376 | 824 | 95.64 | 95.96 | 93.37 | 95.62 | 2.60 | 2.56 | 1.48 | 0.32 |
| 1992 | 5409.94 | 6987 | 824 | 79.53 | 79.53 | 74.74 | 79.54 | 2.77 | 2.27 | 18.20 | 0.00 |
| 1993 | 5248.51 | 6644 | 822 | 75.76 | 75.76 | 72.87 | 75.84 | 6.60 | 5.35 | 18.89 | 0.00 |
| 1994 | 7147.21 | 8660 | 822 | 98.88 | 98.88 | 99.26 | 98.86 | 1.12 | 1.12 | 0.00 | 0.00 |
| 1995 | 5091.35 | 6984 | 822 | 79.74 | 79.74 | 70.71 | 79.73 | 4.21 | 3.51 | 16.75 | 0.00 |
| 1996 | 5741.28 | 7160 | 822 | 81.46 | 81.46 | 79.51 | 81.51 | 0.00 | 0.00 | 18.54 | 0.00 |
| 1997 | 7280.91 | 8760 | 822 | 100.00 | 100.00 | 101.11 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1998 | 6271.42 | 7514 | 824 | 85.82 | 85.82 | 86.83 | 85.78 | 0.00 | 0.00 | 14.18 | 0.00 |
| 1999 | 5356.22 | 7242 | 852 | 82.68 | 82.68 | 71.77 | 82.67 | 0.95 | 0.80 | 16.52 | 0.00 |
| 2000 | 7362.56 | 8736 | 839 | 99.45 | 99.45 | 99.88 | 99.45 | 0.55 | 0.55 | 0.00 | 0.00 |
| 2001 | 5777.73 | 6921 | 842 | 79.03 | 79.03 | 78.33 | 79.01 | 0.79 | 0.63 | 20.34 | 0.00 |
| 2002 | 6463.44 | 7682 | 842 | 87.71 | 87.71 | 87.63 | 87.69 | 0.00 | 0.00 | 12.29 | 0.00 |
| 2003 | 7379.36 | 8687 | 839 | 99.18 | 99.18 | 100.40 | 99.17 | 0.46 | 0.45 | 0.37 | 0.00 |
| 2004 | 6724.10 | 7949 | 849 | 90.53 | 90.53 | 90.70 | 90.49 | 0.31 | 0.28 | 9.19 | 0.00 |
| 2005 | 6351.74 | 7566 | 842 | 86.39 | 86.39 | 86.11 | 86.37 | 0.00 | 0.00 | 13.61 | 0.00 |
| 2006 | 7620.30 | 8760 | 860 | 100.00 | 100.00 | 101.15 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 6572.09 | 7660 | 860 | 87.46 | 87.46 | 87.24 | 87.44 | 0.75 | 0.67 | 11.87 | 0.00 |
| 2008 | 6795.52 | 7956 | 860 | 90.47 | 90.47 | 89.96 | 90.57 | 0.14 | 0.12 | 9.41 | 0.00 |
| 2009 | 7262.45 | 8427 | 860 | 96.22 | 96.22 | 96.40 | 96.20 | 3.78 | 3.78 | 0.00 | 0.00 |
| 2010 | 6592.24 | 7682 | 860 | 87.71 | 87.71 | 87.50 | 87.69 | 0.38 | 0.34 | 11.95 | 0.00 |
| 2011 | 6666.95 | 7826 | 860 | 89.37 | 89.37 | 88.50 | 89.34 | 0.00 | 0.00 | 10.63 | 0.00 |
| 2012 | 7833.57 | 8784 | 883 | 100.00 | 100.00 | 101.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 7076.62 | 8142 | 883 | 92.95 | 92.95 | 91.48 | 92.93 | 0.00 | 0.00 | 7.05 | 0.00 |
| 2014 | 6727.96 | 7718 | 883 | 88.10 | 88.10 | 86.98 | 88.11 | 3.46 | 3.15 | 8.75 | 0.00 |
| 2015 | 7606.92 | 8610 | 883 | 98.28 | 98.28 | 98.34 | 98.29 | 0.00 | 0.00 | 1.72 | 0.00 |
| 2016 | 7014.26 | 7954 | 883 | 90.55 | 90.55 | 90.43 | 90.55 | 1.15 | 1.05 | 8.39 | 0.00 |
| 2017 | 7054.03 | 8019 | 883 | 91.54 | 91.54 | 91.20 | 91.54 | 0.00 | 0.00 | 8.46 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2018 | 7655.38 | 8760 | 883 | 100.00 | 100.00 | 98.97 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 7133.77 | 8091 | 883 | 92.38 | 92.38 | 92.23 | 92.36 | 0.48 | 0.44 | 7.18 | 0.00 |
| 2020 | 6973.38 | 7938 | 883 | 90.37 | 90.37 | 89.91 | 90.37 | 0.00 | 0.00 | 9.63 | 0.00 |
| 2021 | 7847.08 | 8760 | 883 | 100.00 | 100.00 | 101.45 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 7316.70 | 8204 | 883 | 93.66 | 93.66 | 94.59 | 93.65 | 0.00 | 0.00 | 6.34 | 0.00 |
| 2023 | 6836.35 | 7665 | 883 | 86.93 | 86.93 | 88.38 | 87.50 | 2.46 | 2.19 | 10.88 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 119 | |
| B. Refuelling without maintenance | | | | 20 | | |
| C. Inspection, maintenance or repair combined with refuelling | 945 | | | 737 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 29 | | |
| E. Testing of plant systems or components | | | | 5 | | |
| H. Nuclear regulatory requirements | | | | 13 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 10 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 0 | |
| Z. Other | | | | | 1 | 1 |
| Subtotal | 945 | | | 804 | 130 | 2 |
| Total | | 945 | | | 936 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 1 |
| 12. Reactor I&C Systems | | 14 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 14 |
| 15. Reactor Cooling Systems | | 33 |
| 16. Steam generation systems | | 19 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 10 |
| 32. Feedwater and Main Steam System | | 13 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 5 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | | 126 |

2023 Operating Experience

US-341

FERMI-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : DTEDISON (DETROIT EDISON CO.)
 Owner : DTE (DTE Energy Co.)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GECTG (GEC TURBINE GENERATORS, LTD.)



Reactor Unit Details

Reactor type and model : BWR / BWR-4 (Mark 1)
 Thermal power : 3486 MWth
 Gross electrical power : 1198 MWe
 Reference unit power (net) : 1115 MWe

Key Dates

Construction Date : 1972-09-26
 Grid Date : 1986-09-21
 Commercial Date : 1988-01-23
 Age at end of year : 37 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 19404
 Active core diameter [m] : 4.75
 Active core height/length [m] : 3.8
 Number of fissile fuel assemblies/bundles : 764
 Fuel linear heat generation rate [kW/m] : 37.73
 Number of control rod assemblies : 185
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.3
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : 0.44

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.8
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

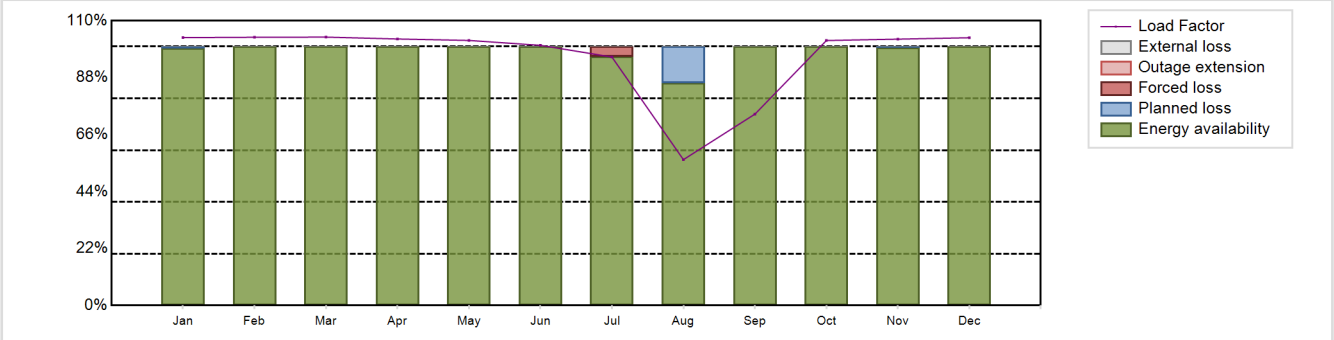
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9366.83 GW(e).h
 Energy Availability Factor (EAF) : 98.41 %
 Unit Capability Factor (UCF) : 98.41 %
 Load Factor (LF) : 95.9 %
 Operating Factor (OF) : 94.78 %

Forced Loss Rate (FLR) : 0.33 %
 Unplanned Capability Loss Factor (UCL) : 0.32 %
 Planned Unavailability Factor (PUF) : 1.26 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 457 hours

Annual Summary

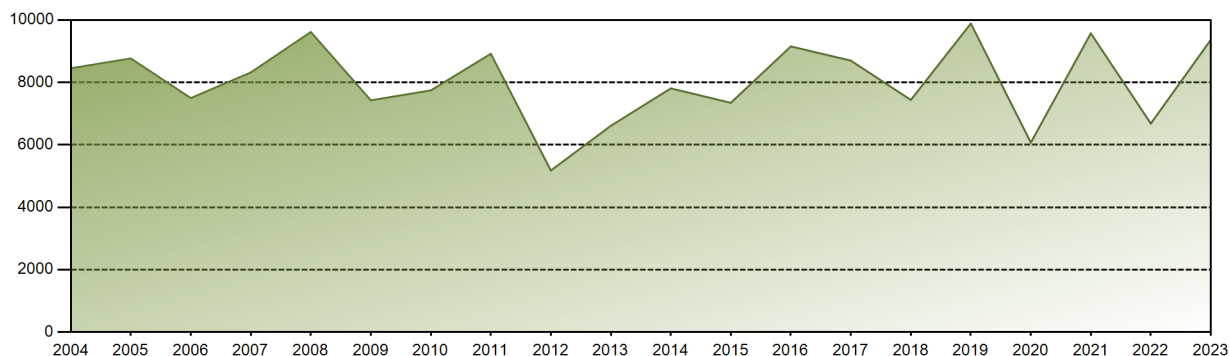


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 858.34 | 776.29 | 858.88 | 826.45 | 849.29 | 806.75 | 796.22 | 467.39 | 593.32 | 849.01 | 827.03 | 857.88 | 9366.83 |
| EAF [%] | 99.37 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.20 | 86.07 | 100.00 | 100.00 | 99.67 | 100.00 | 98.41 |
| UCF [%] | 99.37 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.20 | 86.07 | 100.00 | 100.00 | 99.67 | 100.00 | 98.41 |
| LF [%] | 103.47 | 103.60 | 103.67 | 102.95 | 102.38 | 100.49 | 95.98 | 56.34 | 73.91 | 102.34 | 102.87 | 103.41 | 95.90 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 63.31 | 74.44 | 100.00 | 100.00 | 100.00 | 94.78 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 |
| PUF [%] | 0.63 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.93 | 0.00 | 0.00 | 0.33 | 0.00 | 1.26 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

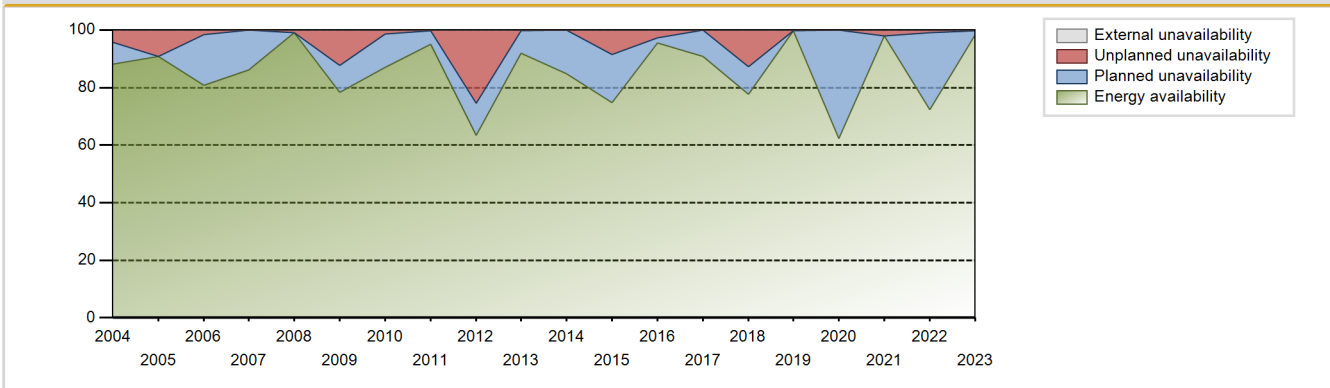
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 265178.67 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 9.51 % |
| Cumulative Energy Availability Factor (EAF) | : 80.79 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 8.49 % |
| Cumulative Unit Capability Factor (UCF) | : 80.79 % | Cumulative Planned Unavailability Factor (PUF) | : 10.71 % |
| Cumulative Load Factor (LF) | : 77.58 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 80.5 % | | |

Electricity Production (net) [GWh]

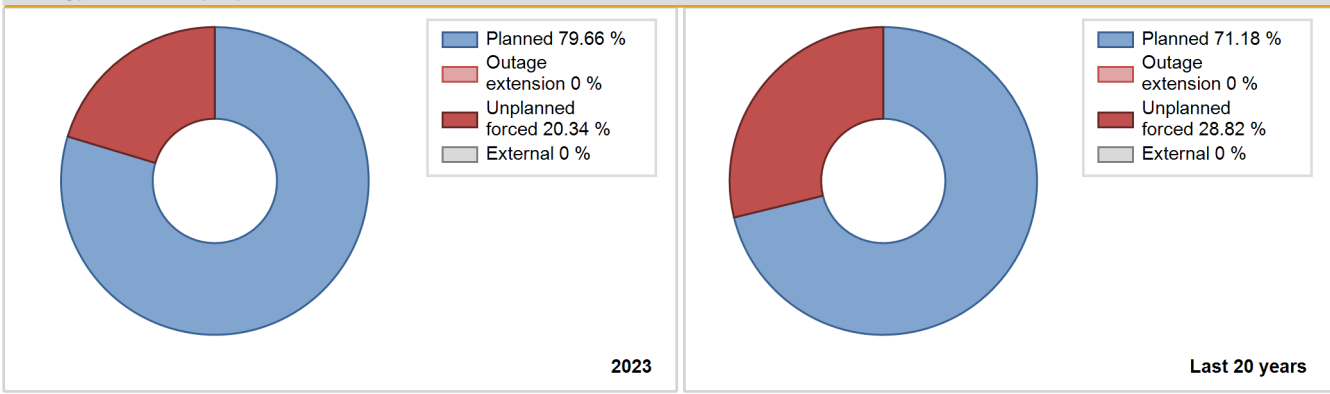


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|-------|--------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 4060.06 | 4719 | 1093 | 55.90 | 55.90 | 43.95 | 56.13 | 42.89 | 41.98 | 2.11 | 0.00 |
| 1989 | 5230.72 | 5575 | 1093 | 63.42 | 63.42 | 54.63 | 63.64 | 11.35 | 8.12 | 28.46 | 0.00 |
| 1990 | 7118.28 | 7266 | 1059 | 82.30 | 82.30 | 76.70 | 82.95 | 1.82 | 1.53 | 16.17 | 0.00 |
| 1991 | 6180.93 | 6466 | 1059 | 72.83 | 72.83 | 66.63 | 73.81 | 1.19 | 0.88 | 26.29 | 0.00 |
| 1992 | 7356.77 | 7019 | 1060 | 79.15 | 79.15 | 79.01 | 79.91 | 2.84 | 2.32 | 18.54 | 0.00 |
| 1993 | 8284.71 | 8076 | 1085 | 92.10 | 92.10 | 87.17 | 92.19 | 4.48 | 4.32 | 3.59 | 0.00 |
| 1994 | 0.00 | 0 | 1085 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 84.69 | 15.31 | 0.00 |
| 1995 | 5132.02 | 6509 | 997 | 71.75 | 71.75 | 58.74 | 74.30 | 26.14 | 25.39 | 2.86 | 0.00 |
| 1996 | 4790.02 | 5859 | 876 | 58.23 | 58.23 | 62.25 | 66.70 | 28.83 | 23.59 | 18.18 | 0.00 |
| 1997 | 5579.95 | 5461 | 1000 | 70.45 | 70.45 | 63.60 | 62.34 | 28.62 | 28.24 | 1.30 | 0.00 |
| 1998 | 7146.77 | 6868 | 1098 | 78.39 | 78.39 | 74.30 | 78.40 | 7.84 | 6.67 | 14.95 | 0.00 |
| 1999 | 9484.66 | 8698 | 1081 | 99.29 | 99.29 | 100.11 | 99.29 | 0.71 | 0.71 | 0.00 | 0.00 |
| 2000 | 8237.80 | 7514 | 1083 | 85.72 | 85.72 | 86.59 | 85.54 | 0.00 | 0.00 | 14.28 | 0.00 |
| 2001 | 8564.03 | 7837 | 1089 | 89.27 | 89.27 | 89.77 | 89.46 | 0.60 | 0.54 | 10.19 | 0.00 |
| 2002 | 9302.88 | 8630 | 1089 | 98.49 | 98.49 | 97.52 | 98.52 | 1.51 | 1.51 | 0.00 | 0.00 |
| 2003 | 8127.82 | 7479 | 1089 | 85.28 | 85.28 | 85.20 | 85.38 | 3.59 | 3.18 | 11.54 | 0.00 |
| 2004 | 8453.11 | 7764 | 1089 | 88.18 | 88.18 | 88.37 | 88.39 | 4.58 | 4.23 | 7.58 | 0.00 |
| 2005 | 8767.61 | 7955 | 1111 | 90.85 | 90.85 | 90.08 | 90.80 | 9.15 | 9.15 | 0.00 | 0.00 |
| 2006 | 7497.33 | 7095 | 1111 | 80.86 | 80.86 | 77.67 | 80.99 | 1.83 | 1.50 | 17.63 | 0.00 |
| 2007 | 8318.37 | 7542 | 1122 | 86.11 | 86.11 | 84.63 | 86.10 | 0.00 | 0.00 | 13.89 | 0.00 |
| 2008 | 9614.34 | 8706 | 1122 | 99.14 | 99.14 | 97.55 | 99.11 | 0.86 | 0.86 | 0.00 | 0.00 |
| 2009 | 7424.68 | 6855 | 1122 | 78.29 | 78.29 | 75.54 | 78.25 | 13.62 | 12.34 | 9.37 | 0.00 |
| 2010 | 7743.27 | 7373 | 1106 | 87.05 | 87.05 | 79.92 | 84.17 | 1.62 | 1.43 | 11.52 | 0.00 |
| 2011 | 8916.72 | 8334 | 1085 | 95.08 | 95.08 | 93.52 | 95.14 | 0.16 | 0.16 | 4.77 | 0.00 |
| 2012 | 5176.46 | 5562 | 1037 | 63.37 | 63.37 | 56.83 | 63.32 | 28.68 | 25.48 | 11.15 | 0.00 |
| 2013 | 6609.50 | 8063 | 1037 | 92.04 | 92.04 | 72.75 | 92.03 | 0.19 | 0.17 | 7.78 | 0.00 |
| 2014 | 7809.50 | 7311 | 1122 | 84.71 | 84.71 | 79.46 | 83.46 | 0.00 | 0.00 | 15.29 | 0.00 |
| 2015 | 7346.14 | 6551 | 1122 | 74.79 | 74.79 | 74.74 | 74.78 | 10.18 | 8.48 | 16.74 | 0.00 |
| 2016 | 9153.92 | 8396 | 1122 | 95.58 | 95.58 | 92.88 | 95.58 | 2.77 | 2.73 | 1.69 | 0.00 |
| 2017 | 8698.33 | 7952 | 1122 | 90.77 | 90.77 | 88.50 | 90.78 | 0.00 | 0.00 | 9.23 | 0.00 |
| 2018 | 7438.80 | 6773 | 1115 | 77.73 | 77.73 | 76.16 | 77.32 | 14.08 | 12.74 | 9.54 | 0.00 |
| 2019 | 9886.26 | 8743 | 1115 | 99.81 | 99.81 | 101.22 | 99.81 | 0.19 | 0.19 | 0.00 | 0.00 |
| 2020 | 6070.78 | 5475 | 1115 | 62.35 | 62.35 | 61.98 | 62.33 | 0.00 | 0.00 | 37.65 | 0.00 |
| 2021 | 9572.97 | 8574 | 1115 | 97.88 | 97.88 | 98.01 | 97.88 | 2.13 | 2.13 | 0.00 | 0.00 |
| 2022 | 6681.70 | 6332 | 1115 | 72.28 | 72.28 | 68.41 | 72.28 | 1.34 | 0.98 | 26.74 | 0.00 |
| 2023 | 9366.83 | 8303 | 1115 | 98.41 | 98.41 | 95.90 | 94.78 | 0.33 | 0.32 | 1.26 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 744 | |
| B. Refuelling without maintenance | | | | 165 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 595 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 171 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 11 |
| L. Human factor related | | | | | 5 | |
| P. Fire | | | | | 1 | |
| Z. Other | | | | | 5 | |
| Subtotal | | | | 931 | 755 | 11 |
| Total | | 0 | | | 1697 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 25 |
| 12. Reactor I&C Systems | | 14 |
| 13. Reactor Auxiliary Systems | | 34 |
| 14. Safety Systems | | 21 |
| 15. Reactor Cooling Systems | | 17 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 12 |
| 31. Turbine and auxiliaries | | 278 |
| 32. Feedwater and Main Steam System | | 26 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 44 |
| 35. All other I&C Systems | | 10 |
| 41. Main Generator Systems | | 182 |
| 42. Electrical Power Supply Systems | | 83 |
| Total | | 748 |

2023 Operating Experience

US-333

FITZPATRICK

UNITED STATES OF AMERICA

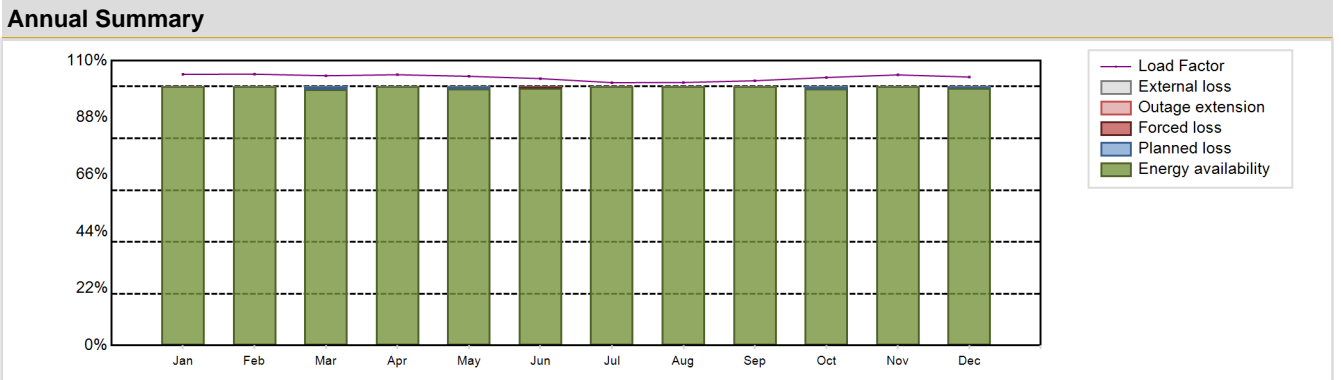
Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 1) | Construction Date | : 1968-09-01 |
| Thermal power | : 2536 MWth | Grid Date | : 1975-02-01 |
| Gross electrical power | : 849 MWe | Commercial Date | : 1975-07-28 |
| Reference unit power (net) | : 813 MWe | Age at end of year | : 48 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.06 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 287 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.44 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 25 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 31800 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.26 | HP cylinder inlet steam pressure [MPa] | : 6.8 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 560 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 19 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 137 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 7373.13 GW(e).h | Forced Loss Rate (FLR) | : 0.06 % |
| Energy Availability Factor (EAF) | : 99.63 % | Unplanned Capability Loss Factor (UCL) | : 0.06 % |
| Unit Capability Factor (UCF) | : 99.63 % | Planned Unavailability Factor (PUF) | : 0.31 % |
| Load Factor (LF) | : 103.53 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

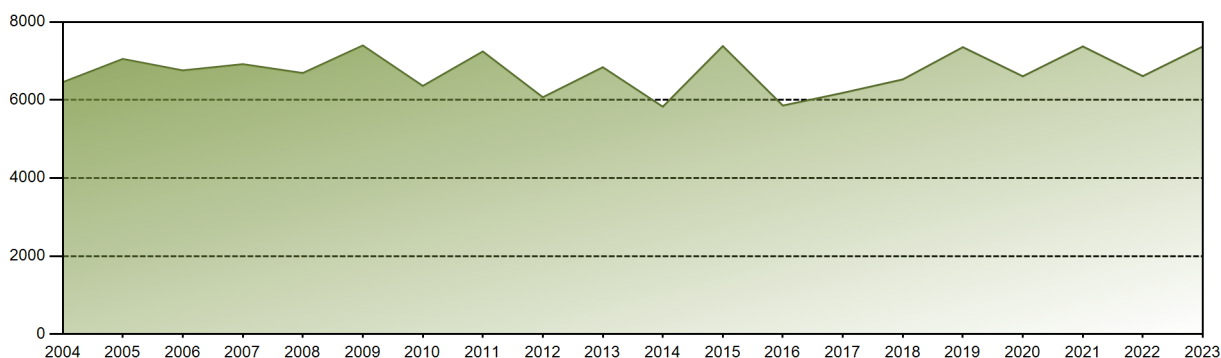


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 633.62 | 572.52 | 629.41 | 612.20 | 628.88 | 603.35 | 614.16 | 614.43 | 598.62 | 626.14 | 612.65 | 627.15 | 7373.13 |
| EAF [%] | 100.00 | 100.00 | 98.80 | 100.00 | 99.13 | 99.27 | 100.00 | 100.00 | 100.00 | 99.16 | 100.00 | 99.29 | 99.63 |
| UCF [%] | 100.00 | 100.00 | 98.80 | 100.00 | 99.13 | 99.27 | 100.00 | 100.00 | 100.00 | 99.16 | 100.00 | 99.29 | 99.63 |
| LF [%] | 104.75 | 104.79 | 104.20 | 104.58 | 103.97 | 103.07 | 101.54 | 101.58 | 102.26 | 103.52 | 104.52 | 103.68 | 103.53 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 |
| PUF [%] | 0.00 | 0.00 | 1.20 | 0.00 | 0.87 | 0.00 | 0.00 | 0.00 | 0.00 | 0.84 | 0.00 | 0.71 | 0.31 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 272799.51 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.99 % |
| Cumulative Energy Availability Factor (EAF) | : 82.41 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.37 % |
| Cumulative Unit Capability Factor (UCF) | : 82.55 % | Cumulative Planned Unavailability Factor (PUF) | : 12.08 % |
| Cumulative Load Factor (LF) | : 79.86 % | Cumulative Externally cause unavailability (XUF) | : 0.14 % |
| Cumulative Operating Factor (OF) | : 82.45 % | | |

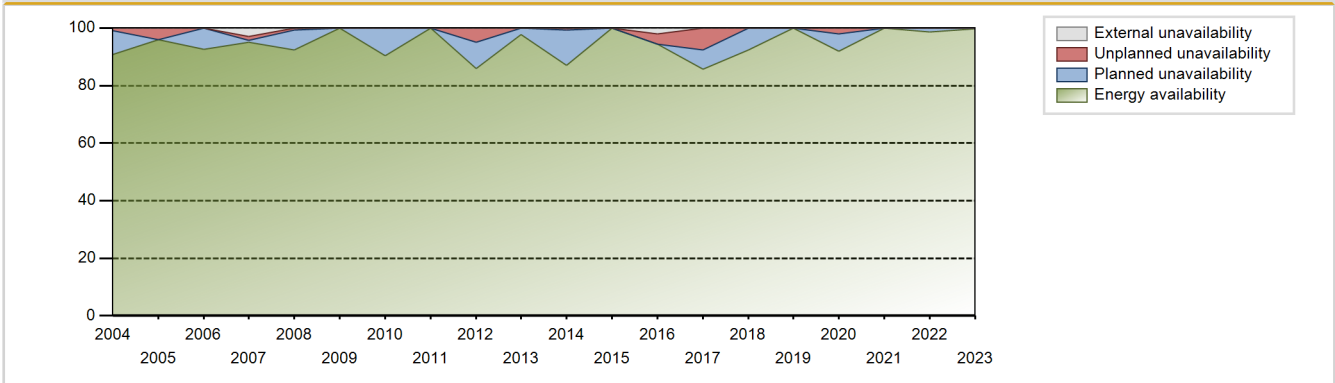
Electricity Production (net) [GWh]



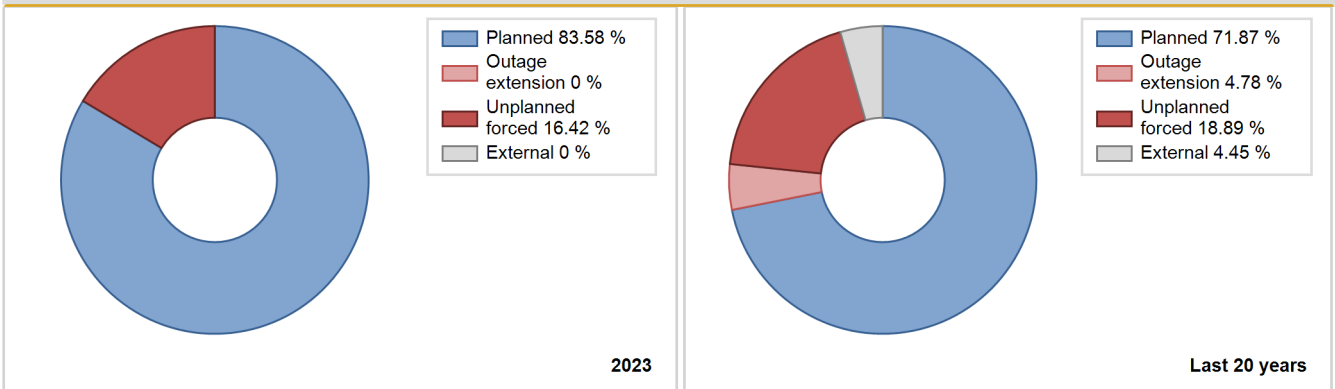
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 2153.70 | 4369 | 819 | 100.00 | 100.00 | 50.37 | 70.13 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1976 | 4156.40 | 6284 | 670 | 70.45 | 70.45 | 70.62 | 71.54 | 21.74 | 19.58 | 9.97 | 0.00 |
| 1977 | 3893.40 | 5986 | 770 | 57.72 | 57.72 | 57.72 | 68.33 | 29.58 | 24.25 | 18.03 | 0.00 |
| 1978 | 4197.40 | 6311 | 800 | 59.87 | 59.87 | 59.89 | 72.04 | 11.41 | 7.71 | 32.41 | 0.00 |
| 1979 | 2964.70 | 4450 | 800 | 42.30 | 42.30 | 42.30 | 50.80 | 55.65 | 53.08 | 4.61 | 0.00 |
| 1980 | 4334.10 | 6162 | 802 | 70.45 | 71.04 | 61.52 | 70.15 | 3.77 | 2.78 | 26.18 | 0.59 |
| 1981 | 4779.70 | 6539 | 810 | 74.75 | 74.75 | 67.36 | 74.65 | 9.98 | 8.29 | 16.96 | 0.00 |
| 1982 | 4959.70 | 6570 | 810 | 75.28 | 75.28 | 69.90 | 75.00 | 7.76 | 6.33 | 18.39 | 0.00 |
| 1983 | 4634.30 | 6183 | 810 | 70.66 | 70.66 | 65.31 | 70.58 | 5.08 | 3.78 | 25.56 | 0.00 |
| 1984 | 4899.36 | 6745 | 810 | 76.88 | 76.88 | 68.86 | 76.79 | 5.04 | 4.08 | 19.04 | 0.00 |
| 1985 | 4166.52 | 5576 | 810 | 64.08 | 64.08 | 58.72 | 63.65 | 10.19 | 7.27 | 28.65 | 0.00 |
| 1986 | 6015.61 | 7931 | 797 | 90.52 | 90.52 | 86.14 | 90.54 | 1.77 | 1.63 | 7.84 | 0.00 |
| 1987 | 4198.34 | 5891 | 795 | 67.11 | 67.11 | 60.27 | 67.25 | 5.61 | 3.99 | 28.90 | 0.00 |
| 1988 | 4356.87 | 5844 | 780 | 66.53 | 66.53 | 63.54 | 66.53 | 5.94 | 4.20 | 29.26 | 0.00 |
| 1989 | 6155.35 | 7944 | 757 | 90.27 | 90.27 | 92.82 | 90.68 | 3.65 | 3.42 | 6.31 | 0.00 |
| 1990 | 4601.93 | 6045 | 782 | 68.42 | 68.42 | 67.18 | 69.01 | 5.93 | 4.32 | 27.26 | 0.00 |
| 1991 | 3376.75 | 4534 | 780 | 55.98 | 55.98 | 49.42 | 51.76 | 42.41 | 41.22 | 2.80 | 0.00 |
| 1992 | 0.00 | 0 | 780 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1993 | 4746.46 | 6301 | 780 | 71.57 | 71.57 | 69.47 | 71.93 | 13.52 | 11.19 | 17.24 | 0.00 |
| 1994 | 4972.63 | 7224 | 774 | 81.91 | 81.91 | 73.34 | 82.47 | 0.00 | 0.00 | 18.09 | 0.00 |
| 1995 | 4804.03 | 6336 | 777 | 71.58 | 71.58 | 70.53 | 72.33 | 6.06 | 4.62 | 23.81 | 0.00 |
| 1996 | 5290.38 | 7036 | 765 | 79.26 | 79.26 | 78.63 | 80.10 | 8.37 | 7.24 | 13.50 | 0.00 |
| 1997 | 6624.58 | 8310 | 799 | 94.89 | 96.32 | 94.65 | 94.86 | 1.65 | 1.61 | 2.07 | 1.43 |
| 1998 | 4930.50 | 6613 | 785 | 75.21 | 75.21 | 71.70 | 75.49 | 8.50 | 6.99 | 17.81 | 0.00 |
| 1999 | 6567.39 | 8205 | 799 | 93.52 | 93.52 | 93.73 | 93.66 | 6.48 | 6.48 | 0.00 | 0.00 |
| 2000 | 6024.77 | 7617 | 813 | 86.63 | 86.63 | 84.36 | 86.71 | 3.18 | 2.84 | 10.53 | 0.00 |
| 2001 | 7090.50 | 8639 | 813 | 98.61 | 98.61 | 99.56 | 98.62 | 0.00 | 0.00 | 1.39 | 0.00 |
| 2002 | 6595.02 | 8112 | 813 | 92.36 | 92.36 | 92.60 | 92.60 | 0.00 | 0.00 | 7.64 | 0.00 |
| 2003 | 6965.97 | 8435 | 813 | 96.19 | 96.19 | 97.81 | 96.29 | 3.81 | 3.81 | 0.00 | 0.00 |
| 2004 | 6455.92 | 7984 | 813 | 90.80 | 90.80 | 90.40 | 90.89 | 0.99 | 0.91 | 8.30 | 0.00 |
| 2005 | 7052.31 | 8403 | 825 | 95.94 | 95.94 | 97.57 | 95.91 | 4.06 | 4.06 | 0.00 | 0.00 |
| 2006 | 6758.75 | 8108 | 852 | 92.58 | 92.58 | 90.56 | 92.56 | 0.00 | 0.00 | 7.42 | 0.00 |
| 2007 | 6918.35 | 8318 | 852 | 94.98 | 97.81 | 92.70 | 94.95 | 1.56 | 1.55 | 0.64 | 2.83 |
| 2008 | 6691.05 | 8105 | 852 | 92.28 | 92.28 | 89.41 | 92.27 | 0.72 | 0.67 | 7.05 | 0.00 |
| 2009 | 7398.07 | 8760 | 854 | 100.00 | 100.00 | 98.89 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 6361.48 | 7908 | 855 | 90.30 | 90.30 | 84.94 | 90.27 | 0.00 | 0.00 | 9.70 | 0.00 |
| 2011 | 7243.97 | 8760 | 855 | 100.00 | 100.00 | 96.72 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2012 | 6070.46 | 7536 | 813 | 85.81 | 85.81 | 85.00 | 85.79 | 5.48 | 4.97 | 9.22 | 0.00 |
| 2013 | 6839.79 | 8557 | 813 | 97.68 | 97.68 | 96.03 | 97.67 | 0.00 | 0.00 | 2.32 | 0.00 |
| 2014 | 5828.69 | 7627 | 813 | 87.08 | 87.08 | 81.84 | 87.07 | 0.85 | 0.75 | 12.18 | 0.00 |
| 2015 | 7382.19 | 8760 | 813 | 100.00 | 100.00 | 103.66 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 5857.96 | 8302 | 813 | 94.50 | 96.49 | 82.03 | 94.51 | 3.51 | 3.51 | 0.00 | 1.98 |
| 2017 | 6183.13 | 7708 | 813 | 85.78 | 85.78 | 86.82 | 87.99 | 2.54 | 7.55 | 6.67 | 0.00 |
| 2018 | 6527.73 | 8096 | 813 | 92.43 | 92.43 | 91.66 | 92.42 | 0.00 | 0.00 | 7.57 | 0.00 |
| 2019 | 7354.21 | 8760 | 813 | 100.00 | 100.00 | 103.26 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 6608.23 | 8083 | 813 | 92.03 | 92.03 | 92.53 | 92.02 | 2.22 | 2.09 | 5.87 | 0.00 |
| 2021 | 7372.93 | 8760 | 813 | 100.00 | 100.00 | 103.53 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 6612.74 | 8241 | 813 | 98.63 | 98.63 | 92.85 | 94.08 | 0.00 | 0.00 | 1.37 | 0.00 |
| 2023 | 7373.13 | 8760 | 813 | 99.63 | 99.63 | 103.53 | 100.00 | 0.06 | 0.06 | 0.31 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 313 | |
| B. Refuelling without maintenance | | | | 35 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 868 | | |
| D. Inspection, maintenance or repair without refuelling | 24 | | | 170 | | |
| E. Testing of plant systems or components | | | | 2 | 3 | |
| H. Nuclear regulatory requirements | | | | | 96 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 39 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 11 |
| Z. Other | | | | 3 | 18 | |
| Subtotal | 24 | | | 1078 | 469 | 14 |
| Total | | 24 | | | 1561 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 17 |
| 12. Reactor I&C Systems | | 16 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | | 59 |
| 15. Reactor Cooling Systems | | 39 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 0 |
| 21. Fuel Handling and Storage Facilities | | 14 |
| 31. Turbine and auxiliaries | | 50 |
| 32. Feedwater and Main Steam System | | 28 |
| 33. Circulating Water System | | 5 |
| 34. Miscellaneous Systems | | 24 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 17 |
| 42. Electrical Power Supply Systems | | 45 |
| Total | | 324 |

2023 Operating Experience

US-244

GINNA

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 2LP (DRYAMB)
 Thermal power : 1775 MWth
 Gross electrical power : 608 MWe
 Reference unit power (net) : 560 MWe

Key Dates

Construction Date : 1966-04-25
 Grid Date : 1969-12-02
 Commercial Date : 1970-07-01
 Age at end of year : 54 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 74
 Average discharge burnup [MWd/t] : 39000
 Active core diameter [m] : 2.46
 Active core height/length [m] : 3.59
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 19.02
 Number of control rod assemblies : 17
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.82
 Reactor outlet temperature [°C] : 317
 Number of SG : 2
 Containment type : -
 Containment design pressure [MPa] : 0.423

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.1
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

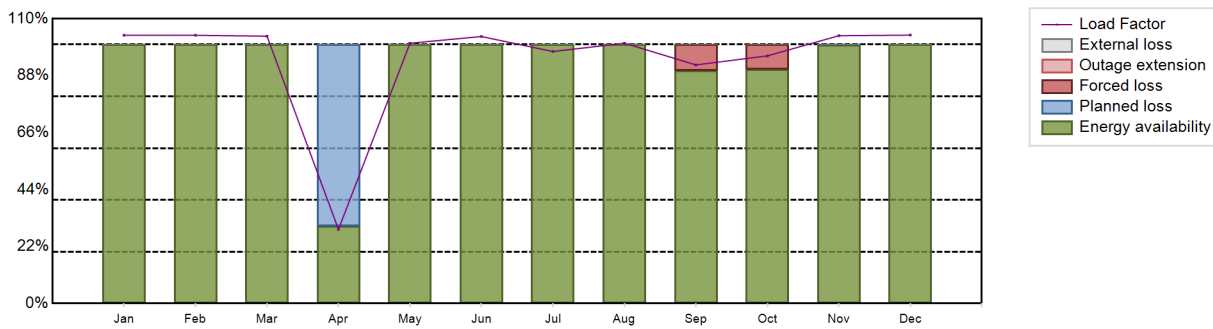
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 4644.95 GW(e).h
 Energy Availability Factor (EAF) : 92.6 %
 Unit Capability Factor (UCF) : 92.6 %
 Load Factor (LF) : 94.69 %
 Operating Factor (OF) : 93.08 %

Forced Loss Rate (FLR) : 1.74 %
 Unplanned Capability Loss Factor (UCL) : 1.64 %
 Planned Unavailability Factor (PUF) : 5.76 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 606 hours

Annual Summary

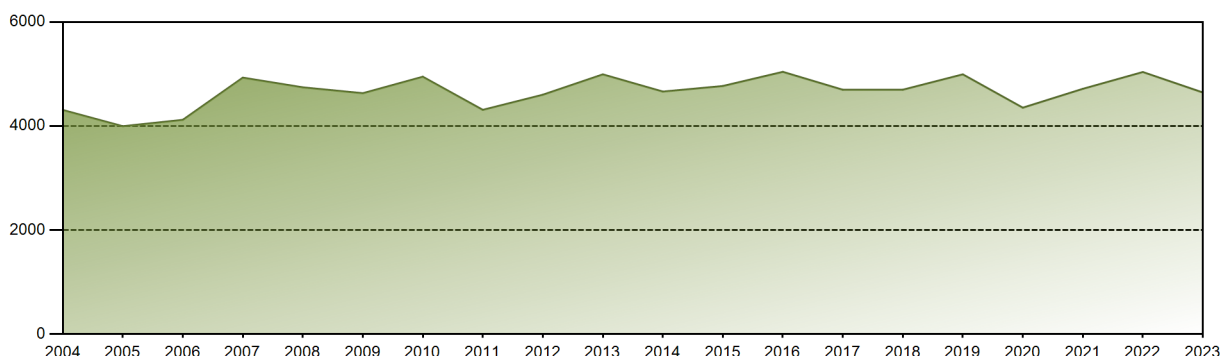


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 431.59 | 389.82 | 429.58 | 115.36 | 418.84 | 415.79 | 405.49 | 418.90 | 371.56 | 398.49 | 417.62 | 431.92 | 4644.95 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 30.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.00 | 90.32 | 99.97 | 100.00 | 92.60 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 30.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.00 | 90.32 | 99.97 | 100.00 | 92.60 |
| LF [%] | 103.59 | 103.59 | 103.25 | 28.61 | 100.53 | 103.12 | 97.32 | 100.54 | 92.15 | 95.64 | 103.43 | 103.67 | 94.69 |
| OF [%] | 100.00 | 100.00 | 100.00 | 30.00 | 99.46 | 100.00 | 100.00 | 100.00 | 92.22 | 94.35 | 100.00 | 100.00 | 93.08 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | 9.68 | 0.00 | 0.00 | 1.74 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | 9.68 | 0.00 | 0.00 | 1.64 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 70.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 5.76 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 204414.41 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.47 % |
| Cumulative Energy Availability Factor (EAF) | : 87.75 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.22 % |
| Cumulative Unit Capability Factor (UCF) | : 87.76 % | Cumulative Planned Unavailability Factor (PUF) | : 10.01 % |
| Cumulative Load Factor (LF) | : 85.99 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 86.83 % | | |

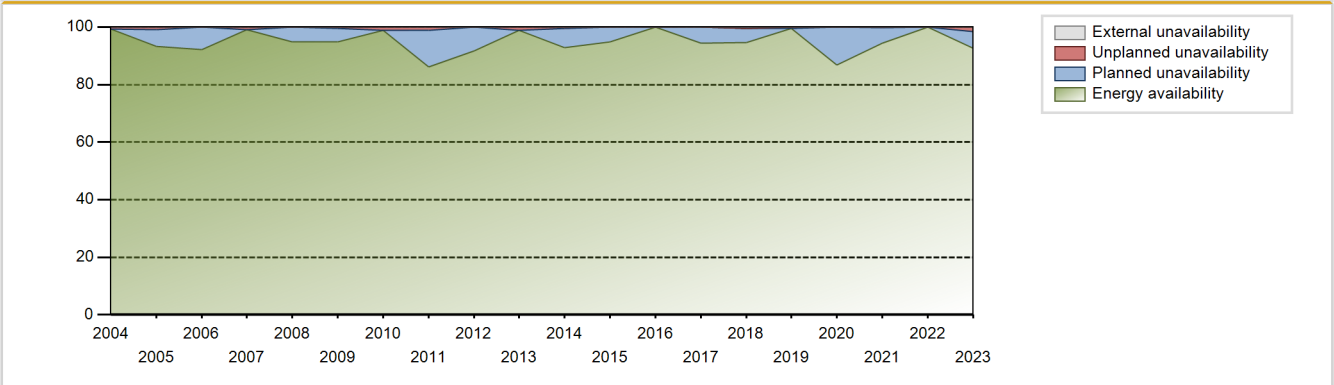
Electricity Production (net) [GWh]



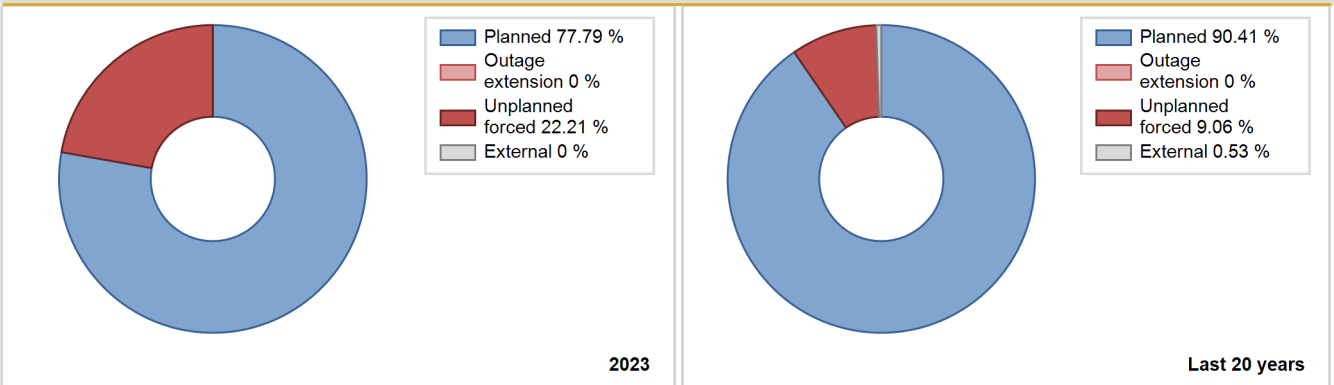
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1970 | 2313.00 | 6079 | 448 | 100.00 | 100.00 | 80.72 | 87.59 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1971 | 2871.80 | 6592 | 493 | 100.00 | 100.00 | 66.50 | 75.25 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1972 | 2572.10 | 6029 | 504 | 100.00 | 100.00 | 58.10 | 68.64 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | 3398.80 | 8325 | 490 | 95.04 | 95.04 | 79.18 | 95.03 | 4.96 | 4.96 | 0.00 | 0.00 |
| 1974 | 2097.20 | 5465 | 490 | 48.86 | 48.86 | 48.86 | 62.39 | 23.21 | 14.77 | 36.37 | 0.00 |
| 1975 | 3041.10 | 6709 | 470 | 73.39 | 73.39 | 73.86 | 76.59 | 6.78 | 5.34 | 21.27 | 0.00 |
| 1976 | 2060.80 | 5113 | 470 | 49.73 | 49.73 | 49.92 | 58.21 | 37.28 | 29.55 | 20.72 | 0.00 |
| 1977 | 3028.50 | 7489 | 470 | 73.59 | 73.59 | 73.56 | 85.49 | 10.47 | 8.61 | 17.80 | 0.00 |
| 1978 | 3218.70 | 7058 | 470 | 77.49 | 77.49 | 78.18 | 80.57 | 5.96 | 4.91 | 17.59 | 0.00 |
| 1979 | 2960.50 | 6375 | 470 | 71.26 | 71.26 | 71.91 | 72.77 | 6.50 | 4.96 | 23.78 | 0.00 |
| 1980 | 3093.50 | 6673 | 470 | 76.00 | 76.00 | 74.93 | 75.97 | 0.00 | 0.00 | 24.00 | 0.00 |
| 1981 | 3322.50 | 7194 | 470 | 82.15 | 82.15 | 80.70 | 82.12 | 0.42 | 0.35 | 17.50 | 0.00 |
| 1982 | 2408.00 | 5150 | 470 | 58.91 | 58.91 | 58.49 | 58.79 | 3.35 | 2.04 | 39.05 | 0.00 |
| 1983 | 3040.10 | 6529 | 470 | 74.88 | 74.88 | 73.84 | 74.53 | 0.30 | 0.23 | 24.90 | 0.00 |
| 1984 | 3156.78 | 6779 | 470 | 77.19 | 77.19 | 76.46 | 77.17 | 4.19 | 3.38 | 19.43 | 0.00 |
| 1985 | 3620.30 | 7700 | 470 | 87.93 | 87.93 | 87.93 | 87.90 | 1.85 | 1.66 | 10.41 | 0.00 |
| 1986 | 3610.27 | 7659 | 470 | 87.45 | 87.45 | 87.69 | 87.43 | 1.04 | 0.92 | 11.63 | 0.00 |
| 1987 | 3797.70 | 7994 | 470 | 91.26 | 91.26 | 92.24 | 91.26 | 0.00 | 0.00 | 8.74 | 0.00 |
| 1988 | 3533.17 | 7592 | 470 | 86.45 | 86.45 | 85.58 | 86.43 | 4.26 | 3.84 | 9.71 | 0.00 |
| 1989 | 3073.45 | 6569 | 470 | 75.03 | 75.03 | 74.65 | 74.99 | 5.89 | 4.70 | 20.27 | 0.00 |
| 1990 | 3451.38 | 7325 | 470 | 83.63 | 83.63 | 83.83 | 83.62 | 4.59 | 4.02 | 12.35 | 0.00 |
| 1991 | 3483.25 | 7536 | 470 | 86.04 | 86.04 | 84.60 | 86.03 | 0.40 | 0.34 | 13.62 | 0.00 |
| 1992 | 3483.38 | 7536 | 470 | 85.80 | 85.80 | 84.37 | 85.79 | 2.04 | 1.79 | 12.41 | 0.00 |
| 1993 | 3499.44 | 7509 | 470 | 85.72 | 85.72 | 85.00 | 85.72 | 2.11 | 1.85 | 12.43 | 0.00 |
| 1994 | 3373.71 | 7219 | 470 | 82.44 | 82.44 | 81.94 | 82.41 | 5.66 | 4.94 | 12.61 | 0.00 |
| 1995 | 3638.58 | 7776 | 470 | 88.79 | 88.79 | 88.38 | 88.77 | 0.58 | 0.51 | 10.70 | 0.00 |
| 1996 | 2898.05 | 6175 | 470 | 70.39 | 70.39 | 70.20 | 70.30 | 12.58 | 10.13 | 19.48 | 0.00 |
| 1997 | 3894.65 | 8011 | 480 | 91.65 | 91.65 | 92.62 | 91.45 | 0.00 | 0.00 | 8.35 | 0.00 |
| 1998 | 4308.56 | 8760 | 480 | 100.00 | 100.00 | 102.47 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1999 | 3534.05 | 7444 | 480 | 85.31 | 85.31 | 84.05 | 84.98 | 0.74 | 0.63 | 14.06 | 0.00 |
| 2000 | 3814.15 | 8001 | 480 | 91.02 | 91.02 | 90.46 | 91.09 | 0.28 | 0.26 | 8.73 | 0.00 |
| 2001 | 4286.28 | 8760 | 480 | 100.00 | 100.00 | 101.94 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2002 | 3843.35 | 7951 | 480 | 90.44 | 90.44 | 91.40 | 90.76 | 0.45 | 0.41 | 9.14 | 0.00 |
| 2003 | 3868.59 | 7925 | 480 | 90.13 | 90.13 | 92.00 | 90.47 | 1.16 | 1.06 | 8.81 | 0.00 |
| 2004 | 4308.49 | 8733 | 480 | 99.40 | 99.40 | 102.19 | 99.42 | 0.60 | 0.60 | 0.00 | 0.00 |
| 2005 | 3996.68 | 8166 | 498 | 93.26 | 93.26 | 91.60 | 93.21 | 0.98 | 0.92 | 5.82 | 0.00 |
| 2006 | 4119.17 | 8157 | 560 | 92.21 | 92.21 | 95.31 | 93.12 | 0.00 | 0.00 | 7.79 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2007 | 4930.53 | 8675 | 560 | 99.15 | 99.15 | 100.51 | 99.03 | 0.85 | 0.85 | 0.00 | 0.00 |
| 2008 | 4744.00 | 8280 | 560 | 94.92 | 94.92 | 96.44 | 94.26 | 0.00 | 0.00 | 5.08 | 0.00 |
| 2009 | 4630.90 | 8235 | 580 | 94.87 | 94.87 | 91.15 | 94.01 | 0.45 | 0.43 | 4.70 | 0.00 |
| 2010 | 4948.36 | 8654 | 580 | 98.79 | 98.79 | 97.39 | 98.79 | 1.21 | 1.21 | 0.00 | 0.00 |
| 2011 | 4311.21 | 7539 | 580 | 86.08 | 86.08 | 84.85 | 86.06 | 1.25 | 1.09 | 12.83 | 0.00 |
| 2012 | 4601.72 | 8055 | 580 | 91.71 | 91.71 | 90.32 | 91.70 | 0.00 | 0.00 | 8.29 | 0.00 |
| 2013 | 4993.29 | 8668 | 581 | 98.95 | 98.95 | 98.10 | 98.94 | 1.05 | 1.05 | 0.00 | 0.00 |
| 2014 | 4662.50 | 8142 | 580 | 92.94 | 92.94 | 91.77 | 92.95 | 0.62 | 0.58 | 6.48 | 0.00 |
| 2015 | 4769.42 | 8313 | 580 | 94.89 | 94.89 | 93.87 | 94.90 | 0.00 | 0.00 | 5.11 | 0.00 |
| 2016 | 5042.06 | 8784 | 580 | 100.00 | 100.00 | 98.97 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 4697.68 | 8261 | 580 | 94.31 | 94.31 | 92.46 | 94.30 | 0.00 | 0.00 | 5.69 | 0.00 |
| 2018 | 4698.44 | 8283 | 560 | 94.55 | 95.08 | 95.78 | 94.55 | 0.00 | 0.00 | 4.92 | 0.53 |
| 2019 | 4993.69 | 8713 | 560 | 99.47 | 99.47 | 101.80 | 99.46 | 0.53 | 0.53 | 0.00 | 0.00 |
| 2020 | 4353.10 | 7618 | 560 | 86.73 | 86.73 | 88.49 | 86.73 | 0.00 | 0.00 | 13.27 | 0.00 |
| 2021 | 4715.12 | 8274 | 560 | 94.46 | 94.46 | 96.12 | 94.45 | 0.27 | 0.26 | 5.28 | 0.00 |
| 2022 | 5038.60 | 8760 | 560 | 100.00 | 100.00 | 102.71 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 4644.95 | 8154 | 560 | 92.60 | 92.60 | 94.69 | 93.08 | 1.74 | 1.64 | 5.76 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1970 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 72 | | | 156 | |
| B. Refuelling without maintenance | | | | 30 | | |
| C. Inspection, maintenance or repair combined with refuelling | 508 | | | 883 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 53 | | |
| E. Testing of plant systems or components | | | | 14 | 0 | |
| H. Nuclear regulatory requirements | | | | | 0 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 4 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| Z. Other | | | | | 7 | |
| Subtotal | 508 | 72 | | 980 | 167 | 2 |
| Total | | 580 | | | 1149 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1970 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 72 | | 2 |
| 12. Reactor I&C Systems | | | | 14 |
| 13. Reactor Auxiliary Systems | | | | 2 |
| 14. Safety Systems | | | | 13 |
| 15. Reactor Cooling Systems | | | | 7 |
| 16. Steam generation systems | | | | 32 |
| 31. Turbine and auxiliaries | | | | 33 |
| 32. Feedwater and Main Steam System | | | | 25 |
| 33. Circulating Water System | | | | 4 |
| 34. Miscellaneous Systems | | | | 14 |
| 35. All other I&C Systems | | | | 1 |
| 41. Main Generator Systems | | | | 2 |
| 42. Electrical Power Supply Systems | | | | 13 |
| Total | | 72 | | 162 |

2023 Operating Experience

US-416 GRAND GULF-1 UNITED STATES OF AMERICA

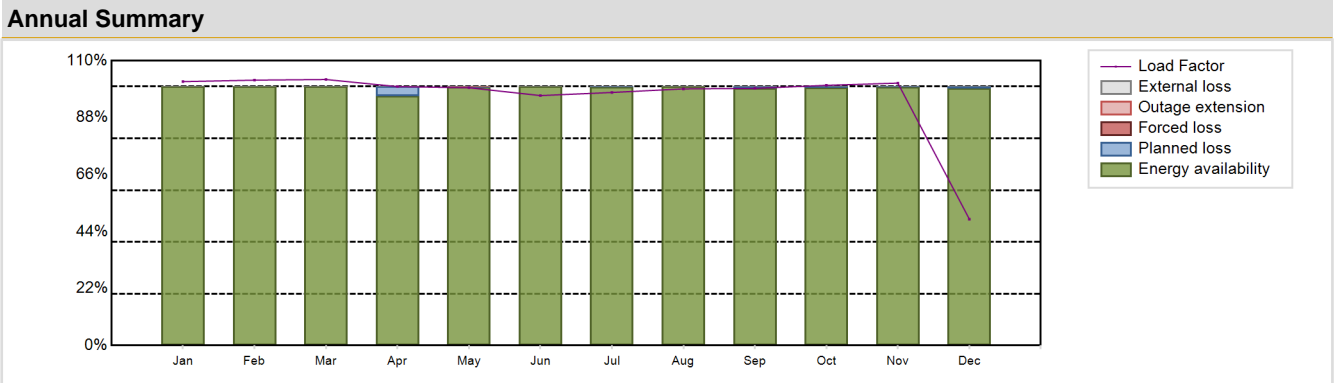
Status at end of year : **Operational**
 Operator : ENTERGY (Entergy Nuclear Operations, Inc.)
 Owner : SERI (Systems Energy Resources, Inc)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : KWU (KRAFTWERK UNION, AG)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-6 (Mark 3) | Construction Date | : 1974-05-04 |
| Thermal power | : 4408 MWth | Grid Date | : 1984-10-20 |
| Gross electrical power | : 1500 MWe | Commercial Date | : 1985-07-01 |
| Reference unit power (net) | : 1401 MWe | Age at end of year | : 39 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.31 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 288 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.105 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 25 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 28000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.8 | HP cylinder inlet steam pressure [MPa] | : 6.925 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 800 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 19.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 193 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|-------------|
| Net Energy Production | : 11750.13 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.54 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 99.54 % | Planned Unavailability Factor (PUF) | : 0.46 % |
| Load Factor (LF) | : 95.74 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 95.66 % | Total off-line time | : 380 hours |

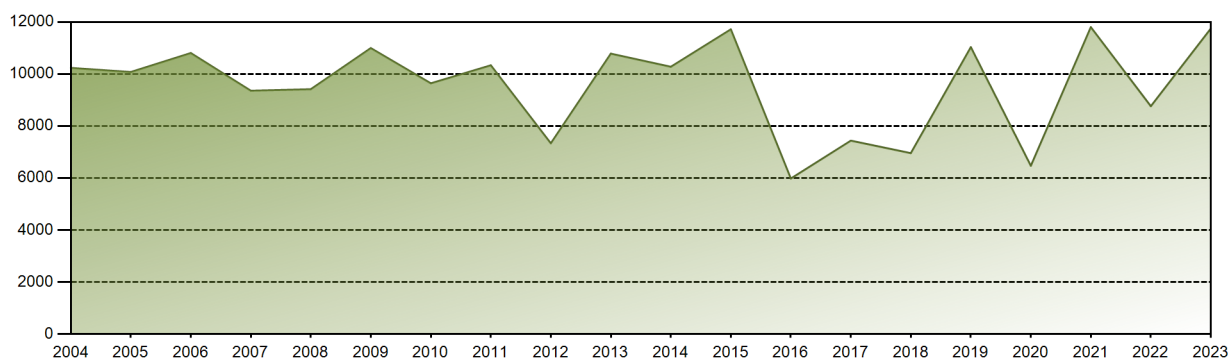


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|---------|--------|---------|---------|---------|--------|---------|---------|---------|---------|---------|--------|----------|
| GW(e)-h | 1062.25 | 964.98 | 1069.47 | 1008.60 | 1037.76 | 973.75 | 1018.64 | 1033.14 | 1001.73 | 1047.39 | 1023.74 | 508.69 | 11750.13 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 96.30 | 99.93 | 100.00 | 99.97 | 100.00 | 99.39 | 99.70 | 99.80 | 99.31 | 99.54 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 96.30 | 99.93 | 100.00 | 99.97 | 100.00 | 99.39 | 99.70 | 99.80 | 99.31 | 99.54 |
| LF [%] | 101.91 | 102.50 | 102.74 | 99.99 | 99.56 | 96.53 | 97.73 | 99.12 | 99.31 | 100.48 | 101.35 | 48.80 | 95.74 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 48.92 | 95.66 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 3.70 | 0.03 | 0.00 | 0.03 | 0.00 | 0.61 | 0.30 | 0.20 | 0.69 | 0.46 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 354441.13 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.06 % |
| Cumulative Energy Availability Factor (EAF) | : 84.84 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.5 % |
| Cumulative Unit Capability Factor (UCF) | : 84.99 % | Cumulative Planned Unavailability Factor (PUF) | : 9.51 % |
| Cumulative Load Factor (LF) | : 83.19 % | Cumulative Externally cause unavailability (XUF) | : 0.16 % |
| Cumulative Operating Factor (OF) | : 84.91 % | | |

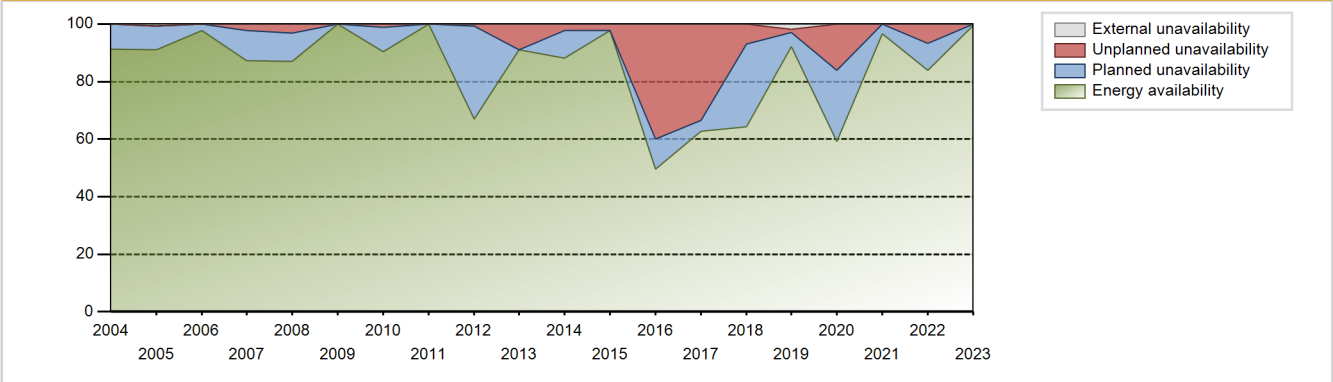
Electricity Production (net) [GWh]



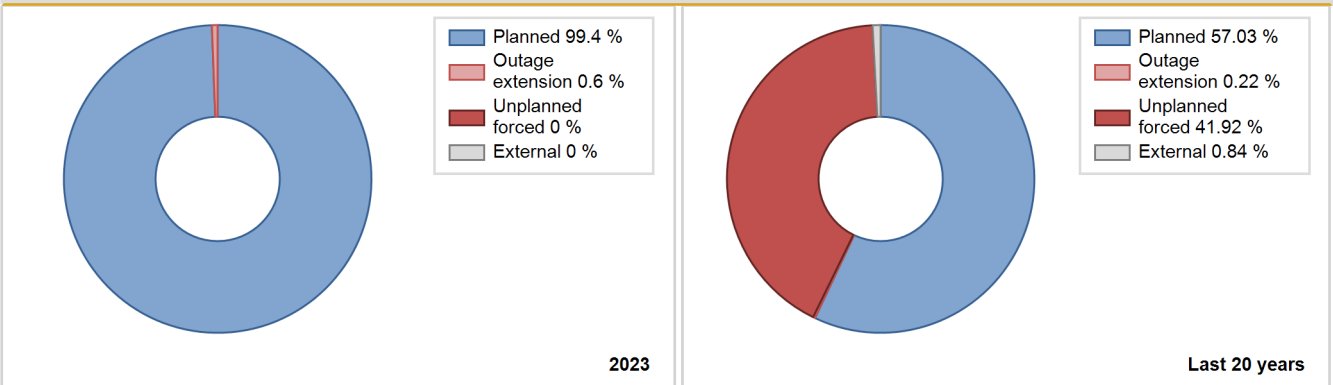
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 4316.40 | 5042 | 1108 | 58.70 | 58.70 | 54.23 | 60.92 | 11.21 | 7.41 | 33.89 | 0.00 |
| 1986 | 4098.05 | 5326 | 1108 | 60.54 | 60.54 | 42.22 | 60.80 | 11.22 | 7.65 | 31.82 | 0.00 |
| 1987 | 7726.99 | 7098 | 1130 | 80.87 | 80.87 | 78.00 | 81.03 | 2.18 | 1.80 | 17.33 | 0.00 |
| 1988 | 9590.95 | 8250 | 1142 | 93.80 | 93.80 | 95.61 | 93.92 | 4.83 | 4.76 | 1.44 | 0.00 |
| 1989 | 7846.28 | 6815 | 1142 | 76.93 | 76.93 | 78.43 | 77.80 | 4.99 | 4.04 | 19.02 | 0.00 |
| 1990 | 7404.01 | 6765 | 1142 | 76.61 | 76.61 | 74.01 | 77.23 | 9.35 | 7.90 | 15.49 | 0.00 |
| 1991 | 9118.72 | 8035 | 1142 | 88.36 | 89.62 | 91.08 | 91.72 | 10.38 | 10.38 | 0.00 | 1.27 |
| 1992 | 8171.15 | 7163 | 1143 | 81.06 | 81.06 | 81.39 | 81.55 | 4.89 | 4.17 | 14.77 | 0.00 |
| 1993 | 7898.46 | 6845 | 1143 | 77.61 | 77.61 | 78.88 | 78.14 | 9.06 | 7.74 | 14.65 | 0.00 |
| 1994 | 9614.75 | 8284 | 1143 | 94.49 | 94.49 | 96.03 | 94.57 | 5.51 | 5.51 | 0.00 | 0.00 |
| 1995 | 7809.73 | 6829 | 1153 | 77.67 | 77.67 | 77.32 | 77.96 | 7.47 | 6.27 | 16.06 | 0.00 |
| 1996 | 9224.70 | 7696 | 1175 | 87.70 | 87.70 | 89.34 | 87.61 | 3.90 | 3.56 | 8.75 | 0.00 |
| 1997 | 10817.56 | 8760 | 1200 | 100.00 | 100.00 | 102.91 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1998 | 9190.81 | 7641 | 1200 | 87.54 | 87.54 | 87.41 | 87.23 | 1.70 | 1.51 | 10.95 | 0.00 |
| 1999 | 8428.40 | 6944 | 1204 | 79.30 | 79.30 | 79.91 | 79.27 | 8.47 | 7.34 | 13.36 | 0.00 |
| 2000 | 10694.61 | 8634 | 1208 | 98.31 | 99.22 | 100.74 | 98.29 | 0.78 | 0.78 | 0.00 | 0.91 |
| 2001 | 9923.98 | 8040 | 1210 | 91.80 | 92.28 | 93.63 | 91.78 | 0.15 | 0.14 | 7.58 | 0.47 |
| 2002 | 10059.47 | 8139 | 1207 | 92.91 | 93.75 | 95.14 | 92.91 | 0.00 | 0.00 | 6.25 | 0.84 |
| 2003 | 10902.49 | 8574 | 1207 | 97.88 | 97.88 | 103.11 | 97.88 | 2.12 | 2.12 | 0.00 | 0.00 |
| 2004 | 10235.07 | 8047 | 1207 | 91.22 | 91.22 | 96.54 | 91.61 | 0.00 | 0.00 | 8.78 | 0.00 |
| 2005 | 10077.85 | 7974 | 1263 | 91.05 | 91.66 | 91.09 | 91.03 | 0.16 | 0.15 | 8.20 | 0.61 |
| 2006 | 10807.33 | 8570 | 1266 | 97.83 | 97.83 | 97.45 | 97.83 | 0.00 | 0.00 | 2.17 | 0.00 |
| 2007 | 9358.78 | 7643 | 1268 | 87.29 | 87.29 | 84.26 | 87.25 | 2.44 | 2.19 | 10.52 | 0.00 |
| 2008 | 9417.15 | 7637 | 1268 | 86.97 | 86.97 | 84.55 | 86.94 | 3.53 | 3.18 | 9.85 | 0.00 |
| 2009 | 10998.51 | 8760 | 1259 | 100.00 | 100.00 | 99.73 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 9643.24 | 7912 | 1251 | 90.28 | 90.28 | 88.00 | 90.32 | 1.23 | 1.13 | 8.59 | 0.00 |
| 2011 | 10336.52 | 8760 | 1251 | 100.00 | 100.00 | 94.32 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 7336.44 | 5740 | 1401 | 67.00 | 67.00 | 63.58 | 65.35 | 1.16 | 0.79 | 32.21 | 0.00 |
| 2013 | 10784.30 | 7891 | 1401 | 91.04 | 91.04 | 87.86 | 90.07 | 8.96 | 8.96 | 0.00 | 0.00 |
| 2014 | 10279.50 | 7744 | 1401 | 88.25 | 88.25 | 83.76 | 88.40 | 2.42 | 2.19 | 9.56 | 0.00 |
| 2015 | 11718.78 | 8563 | 1401 | 97.72 | 97.72 | 95.49 | 97.75 | 2.28 | 2.28 | 0.00 | 0.00 |
| 2016 | 5981.59 | 4407 | 1401 | 49.53 | 49.53 | 48.61 | 50.17 | 44.68 | 39.99 | 10.48 | 0.00 |
| 2017 | 7437.97 | 6208 | 1401 | 62.76 | 62.76 | 60.61 | 70.87 | 34.80 | 33.49 | 3.75 | 0.00 |
| 2018 | 6957.96 | 5664 | 1401 | 64.31 | 64.31 | 56.69 | 64.66 | 9.88 | 7.05 | 28.65 | 0.00 |
| 2019 | 11032.60 | 8068 | 1401 | 92.12 | 94.06 | 89.89 | 92.10 | 1.11 | 1.06 | 4.89 | 1.94 |
| 2020 | 6470.93 | 5202 | 1401 | 59.21 | 59.21 | 52.58 | 59.22 | 20.62 | 16.02 | 24.77 | 0.00 |
| 2021 | 11803.75 | 8473 | 1401 | 96.73 | 96.73 | 96.18 | 96.72 | 0.00 | 0.00 | 3.27 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|-------|-------|-------|-------|------|------|------|------|
| 2022 | 8761.20 | 6400 | 1401 | 83.82 | 83.82 | 71.39 | 73.06 | 7.42 | 6.72 | 9.46 | 0.00 |
| 2023 | 11750.13 | 8380 | 1401 | 99.54 | 99.54 | 95.74 | 95.66 | 0.00 | 0.00 | 0.46 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 365 | |
| B. Refuelling without maintenance | | | | 104 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 655 | 12 | |
| D. Inspection, maintenance or repair without refuelling | | | | 94 | | |
| E. Testing of plant systems or components | | | | 0 | 0 | |
| H. Nuclear regulatory requirements | | | | | 19 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 22 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 17 |
| Z. Other | | | | | 54 | 3 |
| Subtotal | | | | 853 | 472 | 22 |
| Total | | 0 | | | 1347 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 22 |
| 12. Reactor I&C Systems | | 20 |
| 13. Reactor Auxiliary Systems | | 85 |
| 14. Safety Systems | | 43 |
| 15. Reactor Cooling Systems | | 29 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 8 |
| 31. Turbine and auxiliaries | | 64 |
| 32. Feedwater and Main Steam System | | 46 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 29 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 28 |
| 42. Electrical Power Supply Systems | | 39 |
| Total | | 419 |

2023 Operating Experience

US-400 HARRIS-1 UNITED STATES OF AMERICA

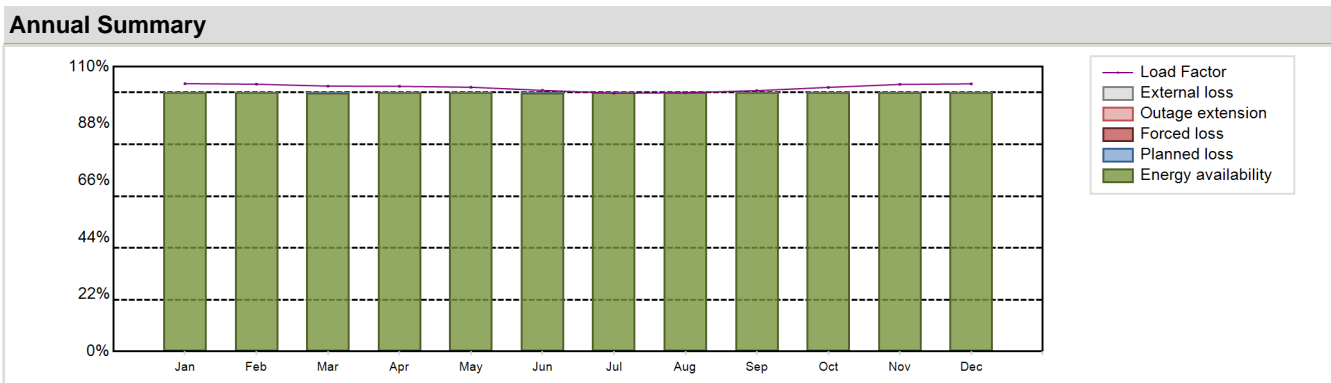
Status at end of year : **Operational**
 Operator : PROGRESS (Progress Energy)
 Owner : PROG_E_C (PROGRESS ENERGY Carolinas, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP (DRYAMB) | Construction Date | : 1978-01-28 |
| Thermal power | : 2900 MWth | Grid Date | : 1987-01-19 |
| Gross electrical power | : 980 MWe | Commercial Date | : 1987-05-02 |
| Reference unit power (net) | : 964 MWe | Age at end of year | : 36 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.7 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 326 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.32 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 31500 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.03 | HP cylinder inlet steam pressure [MPa] | : 6.56 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : - | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 52 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 8609.28 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.99 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 99.99 % | Planned Unavailability Factor (PUF) | : 0.01 % |
| Load Factor (LF) | : 101.95 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

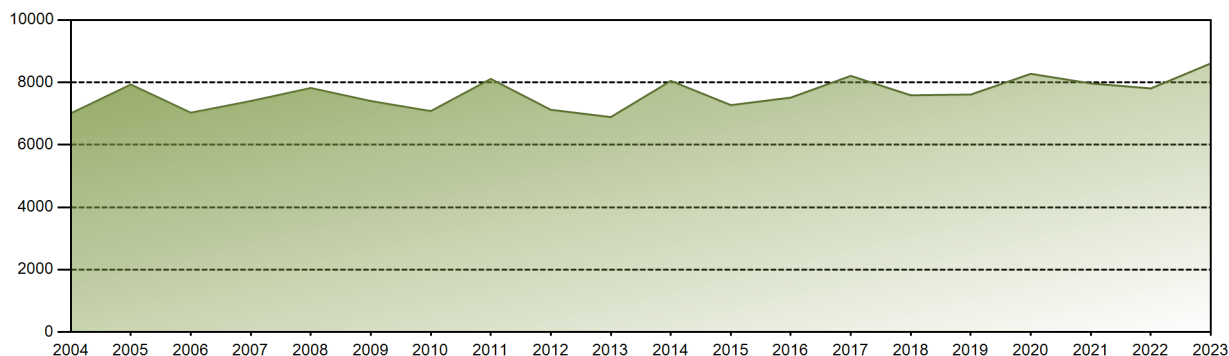


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 741.99 | 668.81 | 734.22 | 710.87 | 731.94 | 700.06 | 715.37 | 716.77 | 699.29 | 731.61 | 716.95 | 741.39 | 8609.28 |
| EAF [%] | 100.00 | 100.00 | 99.97 | 100.00 | 100.00 | 99.93 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| UCF [%] | 100.00 | 100.00 | 99.97 | 100.00 | 100.00 | 99.93 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| LF [%] | 103.45 | 103.24 | 102.51 | 102.42 | 102.05 | 100.86 | 99.74 | 99.94 | 100.75 | 102.01 | 103.15 | 103.37 | 101.95 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

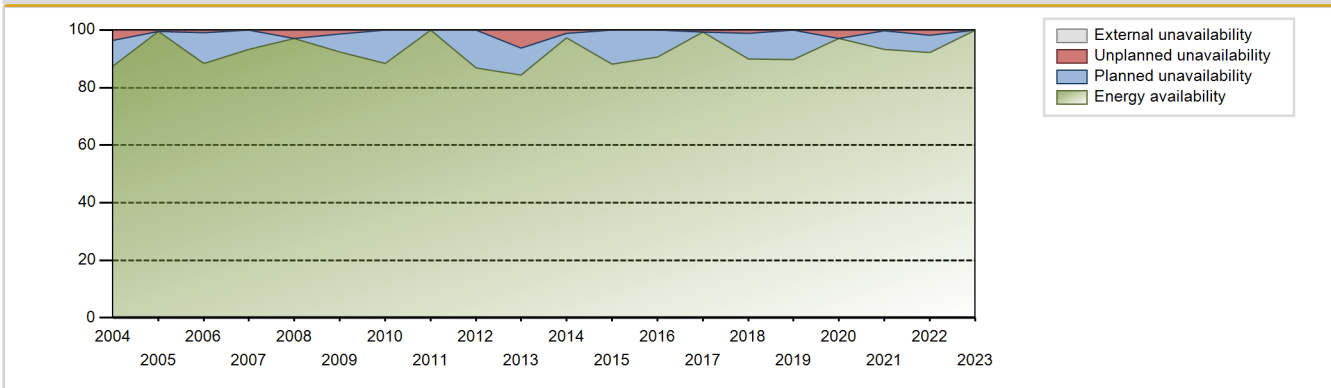
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 258497.94 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.78 % |
| Cumulative Energy Availability Factor (EAF) | : 89.94 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.63 % |
| Cumulative Unit Capability Factor (UCF) | : 89.97 % | Cumulative Planned Unavailability Factor (PUF) | : 8.41 % |
| Cumulative Load Factor (LF) | : 89.92 % | Cumulative Externally cause unavailability (XUF) | : 0.03 % |
| Cumulative Operating Factor (OF) | : 89.77 % | | |

Electricity Production (net) [GWh]

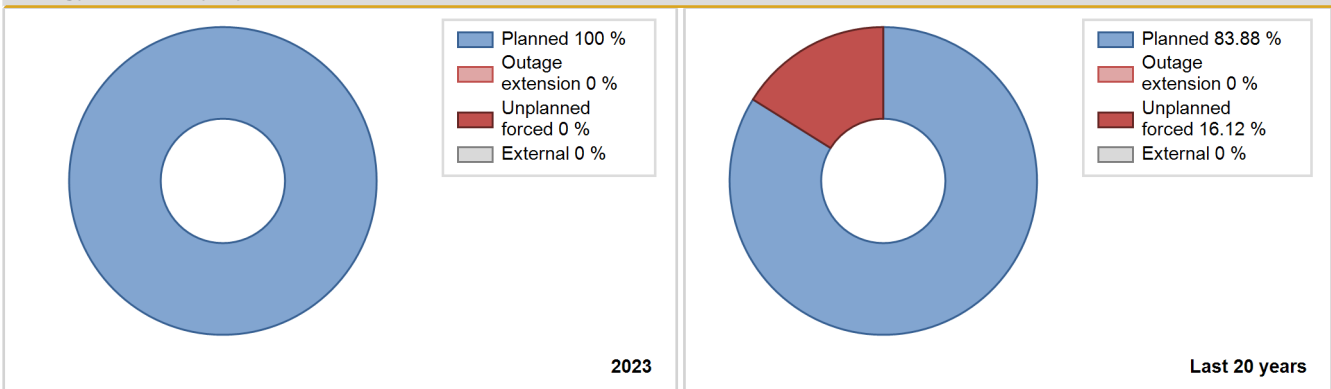


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | | | | Data not provided | | | | | | | |
| 1988 | 5345.56 | 6458 | 860 | 73.56 | 73.56 | 70.76 | 73.52 | 4.05 | 3.10 | 23.34 | 0.00 |
| 1989 | 5638.85 | 6873 | 860 | 78.49 | 78.49 | 74.85 | 78.46 | 1.86 | 1.49 | 20.02 | 0.00 |
| 1990 | 6339.00 | 7812 | 860 | 89.19 | 89.19 | 84.14 | 89.18 | 4.03 | 3.74 | 7.07 | 0.00 |
| 1991 | 5927.44 | 7080 | 860 | 80.83 | 80.83 | 78.68 | 80.82 | 0.80 | 0.65 | 18.52 | 0.00 |
| 1992 | 5427.88 | 6501 | 860 | 74.01 | 74.01 | 71.85 | 74.01 | 5.07 | 3.95 | 22.04 | 0.00 |
| 1993 | 7527.73 | 8721 | 860 | 99.55 | 99.55 | 99.92 | 99.55 | 0.00 | 0.00 | 0.45 | 0.00 |
| 1994 | 6065.06 | 7195 | 860 | 82.17 | 82.17 | 80.51 | 82.13 | 0.00 | 0.00 | 17.83 | 0.00 |
| 1995 | 5966.34 | 7279 | 860 | 83.13 | 83.13 | 79.20 | 83.09 | 4.92 | 4.30 | 12.57 | 0.00 |
| 1996 | 7067.74 | 8301 | 860 | 94.56 | 95.33 | 93.56 | 94.50 | 2.50 | 2.45 | 2.22 | 0.77 |
| 1997 | 5909.03 | 6934 | 860 | 79.20 | 79.20 | 78.44 | 79.16 | 4.09 | 3.38 | 17.42 | 0.00 |
| 1998 | 6711.57 | 7891 | 860 | 90.10 | 90.10 | 89.09 | 90.08 | 7.87 | 7.69 | 2.20 | 0.00 |
| 1999 | 7244.15 | 8484 | 860 | 96.87 | 96.87 | 96.16 | 96.85 | 3.13 | 3.13 | 0.00 | 0.00 |
| 2000 | 6877.96 | 8098 | 860 | 92.21 | 92.21 | 91.05 | 92.19 | 0.35 | 0.32 | 7.47 | 0.00 |
| 2001 | 5401.46 | 6335 | 860 | 72.32 | 72.32 | 71.70 | 72.32 | 0.00 | 0.00 | 27.68 | 0.00 |
| 2002 | 7835.04 | 8643 | 900 | 98.67 | 98.97 | 99.38 | 98.66 | 0.39 | 0.39 | 0.65 | 0.29 |
| 2003 | 7236.92 | 8082 | 900 | 92.27 | 92.27 | 91.79 | 92.26 | 1.64 | 1.53 | 6.20 | 0.00 |
| 2004 | 7008.43 | 7687 | 900 | 87.54 | 87.54 | 88.65 | 87.51 | 3.92 | 3.57 | 8.89 | 0.00 |
| 2005 | 7930.83 | 8710 | 900 | 99.43 | 99.43 | 100.58 | 99.42 | 0.57 | 0.57 | 0.00 | 0.00 |
| 2006 | 7029.27 | 7749 | 900 | 88.48 | 88.48 | 89.16 | 88.46 | 1.13 | 1.01 | 10.51 | 0.00 |
| 2007 | 7403.05 | 8176 | 900 | 93.35 | 93.35 | 93.90 | 93.33 | 0.02 | 0.02 | 6.63 | 0.00 |
| 2008 | 7821.41 | 8534 | 900 | 97.16 | 97.16 | 98.94 | 97.15 | 2.84 | 2.84 | 0.00 | 0.00 |
| 2009 | 7403.16 | 8091 | 900 | 92.38 | 92.38 | 93.90 | 92.36 | 1.43 | 1.34 | 6.28 | 0.00 |
| 2010 | 7080.62 | 7746 | 900 | 88.44 | 88.44 | 89.81 | 88.42 | 0.00 | 0.00 | 11.56 | 0.00 |
| 2011 | 8111.77 | 8760 | 900 | 100.00 | 100.00 | 102.89 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 7121.94 | 7612 | 928 | 86.87 | 86.87 | 88.70 | 86.66 | 0.00 | 0.00 | 13.13 | 0.00 |
| 2013 | 6888.36 | 7392 | 928 | 84.38 | 84.38 | 84.73 | 84.37 | 6.89 | 6.24 | 9.38 | 0.00 |
| 2014 | 8048.57 | 8522 | 928 | 97.28 | 97.28 | 99.01 | 97.28 | 1.09 | 1.08 | 1.64 | 0.00 |
| 2015 | 7272.18 | 7712 | 928 | 88.04 | 88.04 | 89.46 | 88.04 | 0.00 | 0.00 | 11.96 | 0.00 |
| 2016 | 7513.05 | 7961 | 928 | 90.63 | 90.63 | 92.17 | 90.63 | 0.00 | 0.00 | 9.37 | 0.00 |
| 2017 | 8208.57 | 8708 | 928 | 99.40 | 99.40 | 100.98 | 99.41 | 0.60 | 0.60 | 0.00 | 0.00 |
| 2018 | 7587.91 | 7843 | 964 | 89.89 | 89.89 | 89.85 | 89.53 | 1.27 | 1.16 | 8.96 | 0.00 |
| 2019 | 7610.59 | 7857 | 964 | 89.70 | 89.70 | 90.12 | 89.69 | 0.00 | 0.00 | 10.30 | 0.00 |
| 2020 | 8275.59 | 8521 | 964 | 97.02 | 97.02 | 97.73 | 97.01 | 2.98 | 2.98 | 0.00 | 0.00 |
| 2021 | 7967.06 | 8178 | 964 | 93.36 | 93.36 | 94.34 | 93.36 | 0.16 | 0.15 | 6.49 | 0.00 |
| 2022 | 7806.87 | 8078 | 964 | 92.21 | 92.21 | 92.45 | 92.21 | 1.83 | 1.72 | 6.07 | 0.00 |
| 2023 | 8609.28 | 8760 | 964 | 99.99 | 99.99 | 101.95 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 126 | |
| B. Refuelling without maintenance | | | | 31 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 672 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 45 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 1 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| Z. Other | | | | | 9 | |
| Subtotal | | | | 749 | 136 | 3 |
| Total | | 0 | | | 888 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 16 |
| 12. Reactor I&C Systems | | 8 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 4 |
| 16. Steam generation systems | | 3 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 45 |
| 32. Feedwater and Main Steam System | | 30 |
| 34. Miscellaneous Systems | | 3 |
| 41. Main Generator Systems | | 13 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | | 128 |

2023 Operating Experience

US-321

HATCH-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : SOUTHERN (Southern Nuclear Operating Company, Inc.)
 Owner : GPCO (GEORGIA POWER CO.)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : BWR / BWR-4 (Mark 1)
 Thermal power : 2804 MWth
 Gross electrical power : 911 MWe
 Reference unit power (net) : 876 MWe

Key Dates

Construction Date : 1968-09-30
 Grid Date : 1974-11-11
 Commercial Date : 1975-12-31
 Age at end of year : 49 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 25
 Average discharge burnup [MWd/t] : 17000
 Active core diameter [m] : 4.27
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 560
 Fuel linear heat generation rate [kW/m] : 18.4
 Number of control rod assemblies : 137
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.07
 Reactor outlet temperature [°C] : 279
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : 0.435

Secondary systems

Number of turbine-generators per unit/reactor : 2
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.68
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

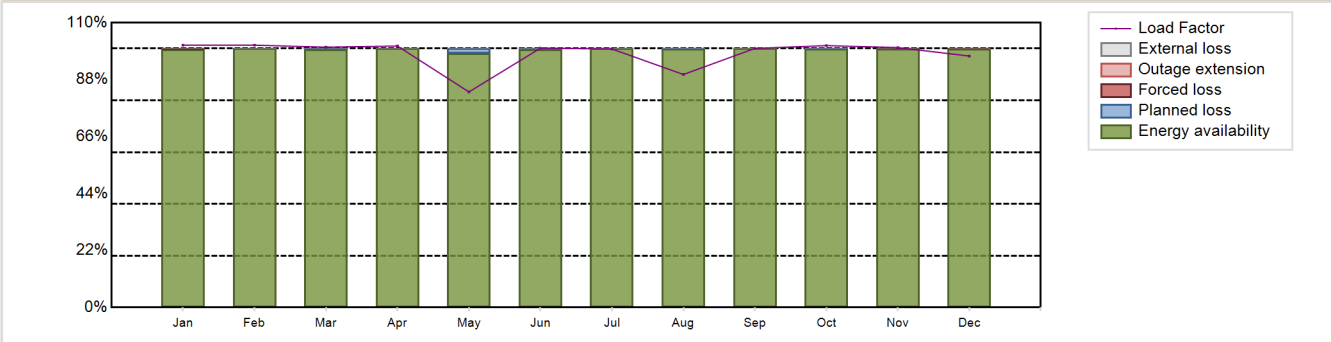
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7517.55 GW(e).h
 Energy Availability Factor (EAF) : 99.72 %
 Unit Capability Factor (UCF) : 99.72 %
 Load Factor (LF) : 97.96 %
 Operating Factor (OF) : 98.94 %

Forced Loss Rate (FLR) : 0.04 %
 Unplanned Capability Loss Factor (UCL) : 0.04 %
 Planned Unavailability Factor (PUF) : 0.24 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 93 hours

Annual Summary

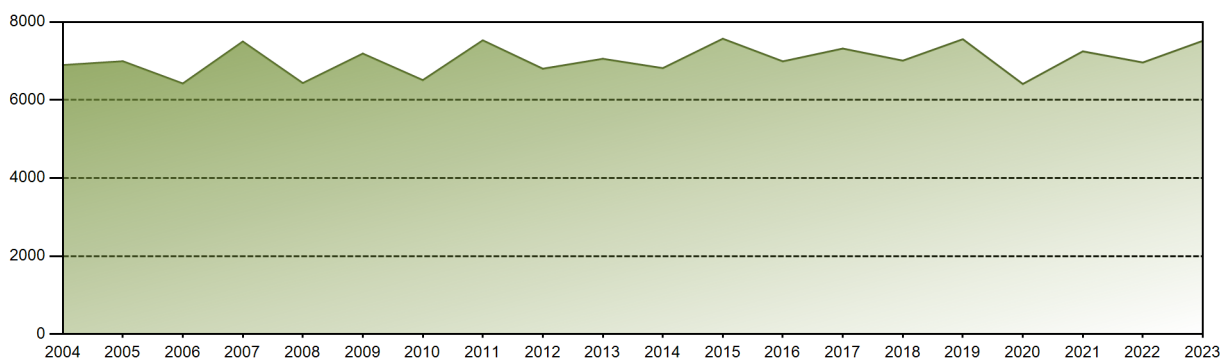


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 660.27 | 596.48 | 654.48 | 637.00 | 542.70 | 631.72 | 650.76 | 586.60 | 631.17 | 659.29 | 634.08 | 632.99 | 7517.55 |
| EAF [%] | 99.71 | 100.00 | 99.71 | 100.00 | 98.03 | 99.70 | 100.00 | 99.81 | 100.00 | 99.87 | 99.90 | 99.97 | 99.72 |
| UCF [%] | 99.71 | 100.00 | 99.71 | 100.00 | 98.03 | 99.70 | 100.00 | 99.81 | 100.00 | 99.87 | 99.90 | 99.97 | 99.72 |
| LF [%] | 101.31 | 101.33 | 100.56 | 101.00 | 83.27 | 100.16 | 99.85 | 90.00 | 100.07 | 101.16 | 100.39 | 97.12 | 97.96 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 87.50 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.94 |
| FLR [%] | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.03 | 0.04 |
| UCL [%] | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.03 | 0.04 |
| PUF [%] | 0.00 | 0.00 | 0.29 | 0.00 | 1.97 | 0.30 | 0.00 | 0.19 | 0.00 | 0.13 | 0.00 | 0.00 | 0.24 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 282407.56 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.8 % |
| Cumulative Energy Availability Factor (EAF) | : 84.52 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.26 % |
| Cumulative Unit Capability Factor (UCF) | : 84.55 % | Cumulative Planned Unavailability Factor (PUF) | : 11.2 % |
| Cumulative Load Factor (LF) | : 82.51 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 84.56 % | | |

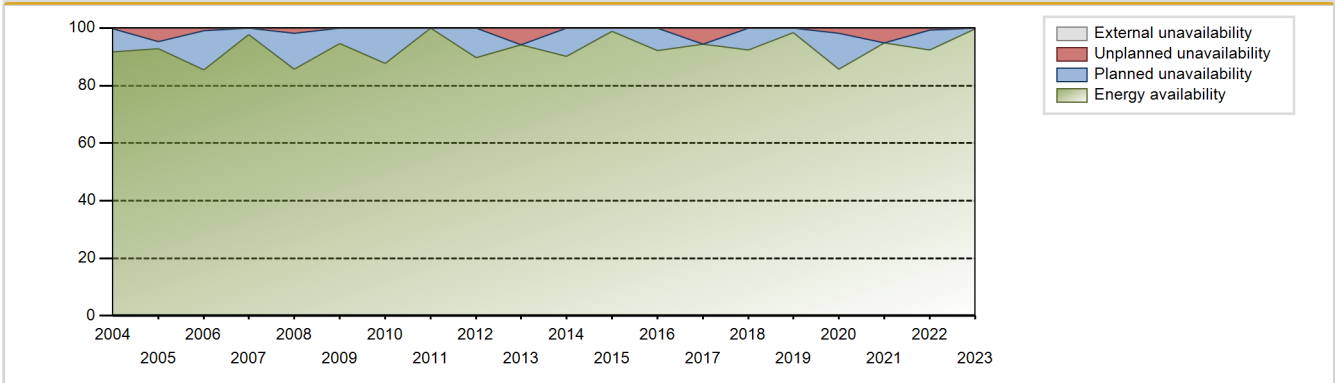
Electricity Production (net) [GWh]



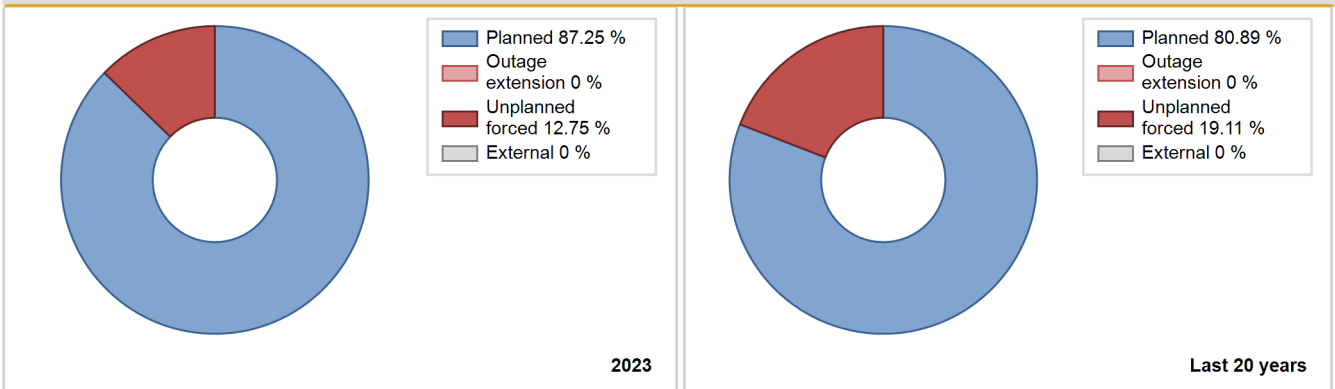
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 3095.80 | 6158 | 786 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1976 | 4133.80 | 7299 | 786 | 59.96 | 59.96 | 59.87 | 83.09 | 29.04 | 24.54 | 15.50 | 0.00 |
| 1977 | 3716.70 | 5802 | 700 | 60.16 | 60.16 | 60.61 | 66.23 | 28.13 | 23.55 | 16.29 | 0.00 |
| 1978 | 4277.20 | 6370 | 717 | 68.15 | 68.15 | 68.10 | 72.72 | 21.90 | 19.11 | 12.74 | 0.00 |
| 1979 | 3349.50 | 4781 | 739 | 51.70 | 51.70 | 51.74 | 54.58 | 16.57 | 10.27 | 38.03 | 0.00 |
| 1980 | 4790.20 | 7174 | 764 | 82.13 | 82.27 | 71.38 | 81.67 | 17.73 | 17.73 | 0.00 | 0.14 |
| 1981 | 2770.70 | 4384 | 757 | 50.56 | 50.56 | 41.78 | 50.05 | 12.31 | 7.10 | 42.35 | 0.00 |
| 1982 | 2893.90 | 4313 | 758 | 49.39 | 49.39 | 43.58 | 49.24 | 25.88 | 17.25 | 33.37 | 0.00 |
| 1983 | 3968.90 | 6240 | 764 | 71.55 | 71.55 | 59.30 | 71.23 | 5.34 | 4.03 | 24.42 | 0.00 |
| 1984 | 3609.18 | 5473 | 752 | 62.28 | 62.53 | 54.64 | 62.31 | 14.75 | 10.82 | 26.66 | 0.25 |
| 1985 | 4761.37 | 6694 | 752 | 76.47 | 76.47 | 72.28 | 76.42 | 12.33 | 10.76 | 12.77 | 0.00 |
| 1986 | 3645.39 | 5162 | 768 | 58.97 | 58.97 | 54.18 | 58.93 | 3.47 | 2.12 | 38.91 | 0.00 |
| 1987 | 5080.69 | 7043 | 750 | 80.43 | 80.43 | 77.33 | 80.40 | 2.18 | 1.80 | 17.77 | 0.00 |
| 1988 | 4115.82 | 5802 | 756 | 66.04 | 66.04 | 61.98 | 66.05 | 15.56 | 12.17 | 21.78 | 0.00 |
| 1989 | 6479.72 | 8760 | 757 | 100.00 | 100.00 | 97.71 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1990 | 4103.39 | 5722 | 753 | 65.08 | 65.08 | 62.21 | 65.32 | 5.81 | 4.02 | 30.91 | 0.00 |
| 1991 | 4707.49 | 6530 | 741 | 73.96 | 74.64 | 72.52 | 74.54 | 6.19 | 4.92 | 20.44 | 0.68 |
| 1992 | 6157.15 | 8444 | 741 | 96.08 | 96.08 | 94.60 | 96.13 | 2.98 | 2.95 | 0.97 | 0.00 |
| 1993 | 4956.71 | 6913 | 737 | 78.38 | 78.38 | 76.78 | 78.92 | 5.25 | 4.34 | 17.28 | 0.00 |
| 1994 | 5512.20 | 7542 | 741 | 85.80 | 85.80 | 84.92 | 86.10 | 1.57 | 1.37 | 12.83 | 0.00 |
| 1995 | 6465.83 | 8760 | 741 | 100.00 | 100.00 | 99.61 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1996 | 5726.66 | 7666 | 788 | 87.80 | 87.80 | 82.65 | 87.27 | 2.35 | 2.11 | 10.09 | 0.00 |
| 1997 | 6009.00 | 7637 | 800 | 87.88 | 87.88 | 85.74 | 87.18 | 0.00 | 0.00 | 12.12 | 0.00 |
| 1998 | 6951.75 | 8751 | 800 | 99.91 | 99.91 | 99.20 | 99.90 | 0.09 | 0.09 | 0.00 | 0.00 |
| 1999 | 5968.79 | 7153 | 808 | 82.16 | 82.16 | 84.29 | 81.66 | 2.48 | 2.09 | 15.76 | 0.00 |
| 2000 | 6413.39 | 7530 | 863 | 86.23 | 86.23 | 84.81 | 85.72 | 4.90 | 4.44 | 9.33 | 0.00 |
| 2001 | 7496.17 | 8689 | 863 | 99.14 | 99.14 | 99.16 | 99.19 | 0.86 | 0.86 | 0.00 | 0.00 |
| 2002 | 6627.11 | 7778 | 856 | 88.81 | 88.81 | 88.38 | 88.79 | 1.49 | 1.34 | 9.85 | 0.00 |
| 2003 | 7146.92 | 8438 | 856 | 96.33 | 96.33 | 95.31 | 96.32 | 0.00 | 0.00 | 3.67 | 0.00 |
| 2004 | 6896.11 | 8046 | 869 | 91.70 | 91.70 | 90.79 | 91.60 | 0.29 | 0.27 | 8.04 | 0.00 |
| 2005 | 6993.53 | 8121 | 856 | 92.72 | 92.72 | 93.26 | 92.71 | 4.88 | 4.76 | 2.52 | 0.00 |
| 2006 | 6422.81 | 7516 | 876 | 85.37 | 85.37 | 86.27 | 85.80 | 0.98 | 0.84 | 13.79 | 0.00 |
| 2007 | 7499.08 | 8550 | 876 | 97.63 | 97.63 | 97.72 | 97.60 | 0.00 | 0.00 | 2.37 | 0.00 |
| 2008 | 6433.74 | 7527 | 876 | 85.72 | 85.72 | 83.61 | 85.69 | 2.19 | 1.92 | 12.36 | 0.00 |
| 2009 | 7190.01 | 8289 | 876 | 94.63 | 94.63 | 93.70 | 94.62 | 0.00 | 0.00 | 5.37 | 0.00 |
| 2010 | 6509.87 | 7690 | 876 | 87.80 | 87.80 | 84.83 | 87.79 | 0.00 | 0.00 | 12.20 | 0.00 |
| 2011 | 7529.65 | 8760 | 876 | 100.00 | 100.00 | 98.12 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2012 | 6802.03 | 7876 | 876 | 89.69 | 89.69 | 88.40 | 89.66 | 0.00 | 0.00 | 10.31 | 0.00 |
| 2013 | 7056.54 | 8251 | 876 | 94.19 | 94.19 | 91.95 | 94.18 | 5.81 | 5.81 | 0.00 | 0.00 |
| 2014 | 6816.80 | 7901 | 876 | 90.20 | 90.20 | 88.83 | 90.19 | 0.00 | 0.00 | 9.80 | 0.00 |
| 2015 | 7570.54 | 8657 | 876 | 98.84 | 98.84 | 98.65 | 98.82 | 0.00 | 0.00 | 1.16 | 0.00 |
| 2016 | 6991.13 | 8096 | 876 | 92.16 | 92.16 | 90.86 | 92.17 | 0.14 | 0.13 | 7.71 | 0.00 |
| 2017 | 7318.73 | 8425 | 876 | 94.36 | 94.36 | 95.37 | 96.18 | 5.55 | 5.55 | 0.09 | 0.00 |
| 2018 | 7009.59 | 8098 | 876 | 92.44 | 92.44 | 91.34 | 92.44 | 0.00 | 0.00 | 7.56 | 0.00 |
| 2019 | 7558.09 | 8624 | 876 | 98.46 | 98.46 | 98.49 | 98.45 | 0.00 | 0.00 | 1.54 | 0.00 |
| 2020 | 6410.21 | 7518 | 876 | 85.60 | 85.60 | 83.31 | 85.59 | 2.07 | 1.81 | 12.59 | 0.00 |
| 2021 | 7247.27 | 8308 | 876 | 94.83 | 94.83 | 94.44 | 94.84 | 5.17 | 5.17 | 0.00 | 0.00 |
| 2022 | 6962.10 | 8033 | 876 | 92.28 | 92.28 | 90.73 | 91.70 | 0.86 | 0.80 | 6.92 | 0.00 |
| 2023 | 7517.55 | 8667 | 876 | 99.72 | 99.72 | 97.96 | 98.94 | 0.04 | 0.04 | 0.24 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 273 | |
| B. Refuelling without maintenance | | | | 36 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 869 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 83 | | |
| E. Testing of plant systems or components | | | | 1 | 2 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 15 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 0 |
| P. Fire | | | | | 8 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 1 | |
| Z. Other | | | | 2 | 46 | |
| Subtotal | | | | 991 | 345 | 1 |
| Total | | 0 | | | 1337 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 14 |
| 13. Reactor Auxiliary Systems | | 38 |
| 14. Safety Systems | | 25 |
| 15. Reactor Cooling Systems | | 35 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 58 |
| 32. Feedwater and Main Steam System | | 58 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 15 |
| 35. All other I&C Systems | | 6 |
| 41. Main Generator Systems | | 22 |
| 42. Electrical Power Supply Systems | | 24 |
| Total | | 299 |

2023 Operating Experience

US-366

HATCH-2

UNITED STATES OF AMERICA

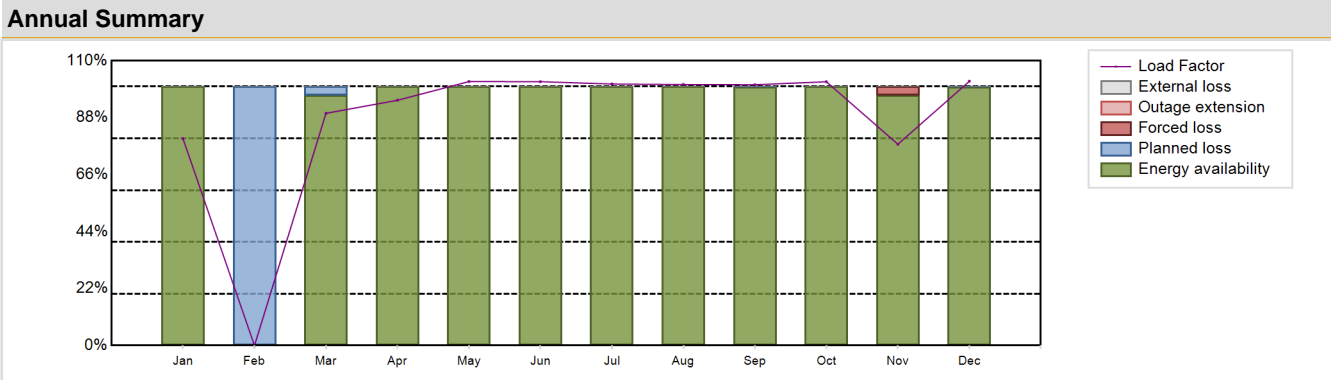
Status at end of year : **Operational**
 Operator : SOUTHERN (Southern Nuclear Operating Company, Inc.)
 Owner : GPCO (GEORGIA POWER CO.)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 1) | Construction Date | : 1972-02-01 |
| Thermal power | : 2804 MWth | Grid Date | : 1978-09-22 |
| Gross electrical power | : 921 MWe | Commercial Date | : 1979-09-05 |
| Reference unit power (net) | : 883 MWe | Age at end of year | : 45 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.07 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 279 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.435 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 2 |
| Part of the core refuelled [%] | : 25 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 18750 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.27 | HP cylinder inlet steam pressure [MPa] | : 6.68 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 560 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 18.4 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 137 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 6833.54 GW(e).h | Forced Loss Rate (FLR) | : 0.3 % |
| Energy Availability Factor (EAF) | : 91.76 % | Unplanned Capability Loss Factor (UCL) | : 0.27 % |
| Unit Capability Factor (UCF) | : 91.76 % | Planned Unavailability Factor (PUF) | : 7.96 % |
| Load Factor (LF) | : 88.34 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 89.17 % | Total off-line time | : 949 hours |

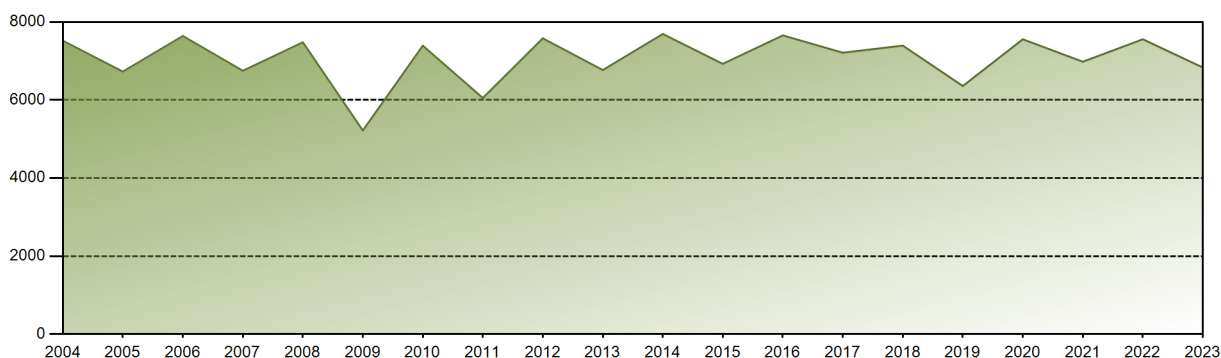


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 524.90 | 0.00 | 588.38 | 602.14 | 669.68 | 647.88 | 663.48 | 662.20 | 640.38 | 669.22 | 494.87 | 670.40 | 6833.54 |
| EAF [%] | 100.00 | 0.00 | 96.74 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.97 | 100.00 | 96.67 | 99.84 | 91.76 |
| UCF [%] | 100.00 | 0.00 | 96.74 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.97 | 100.00 | 96.67 | 99.84 | 91.76 |
| LF [%] | 79.90 | 0.00 | 89.68 | 94.71 | 101.94 | 101.91 | 100.99 | 100.80 | 100.73 | 101.87 | 77.73 | 102.05 | 88.34 |
| OF [%] | 90.32 | 0.00 | 96.50 | 94.31 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 80.86 | 100.00 | 89.17 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.33 | 0.00 | 0.30 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.33 | 0.00 | 0.27 |
| PUF [%] | 0.00 | 100.00 | 3.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.16 | 7.96 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 268882.51 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.77 % |
| Cumulative Energy Availability Factor (EAF) | : 86.01 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.45 % |
| Cumulative Unit Capability Factor (UCF) | : 86.05 % | Cumulative Planned Unavailability Factor (PUF) | : 11.5 % |
| Cumulative Load Factor (LF) | : 83.1 % | Cumulative Externally cause unavailability (XUF) | : 0.04 % |
| Cumulative Operating Factor (OF) | : 85.62 % | | |

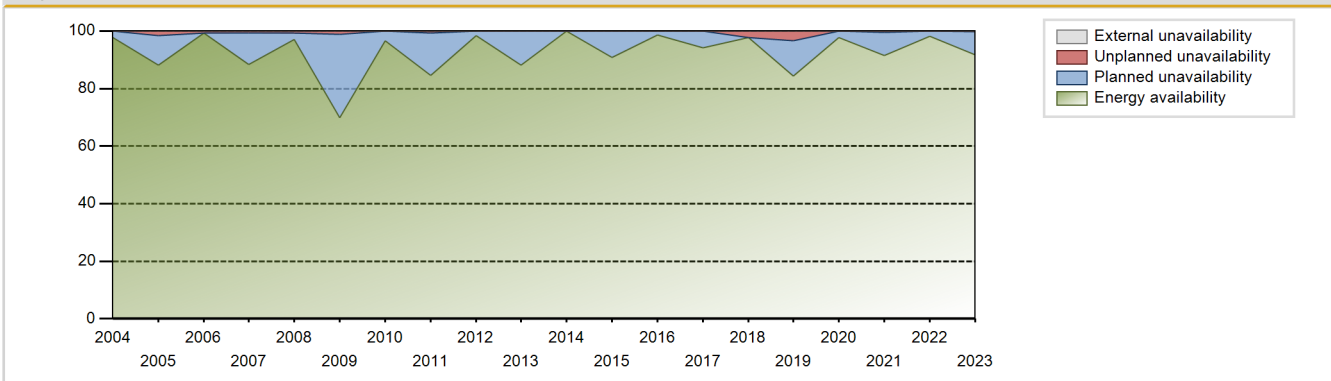
Electricity Production (net) [GWh]



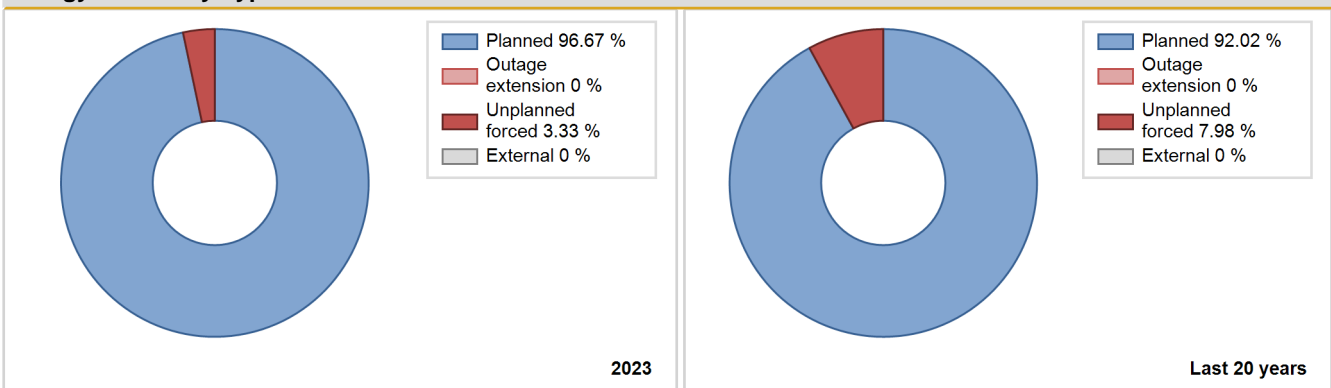
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1979 | 2632.60 | 4155 | 749 | 100.00 | 100.00 | 80.12 | 84.70 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1980 | 3653.10 | 5269 | 767 | 59.14 | 61.00 | 54.22 | 59.98 | 9.09 | 6.10 | 32.90 | 1.86 |
| 1981 | 4481.50 | 6872 | 772 | 78.68 | 78.68 | 66.27 | 78.45 | 8.17 | 7.00 | 14.33 | 0.00 |
| 1982 | 3734.20 | 5588 | 771 | 63.90 | 63.90 | 55.29 | 63.79 | 11.54 | 8.34 | 27.76 | 0.00 |
| 1983 | 3817.20 | 5774 | 771 | 66.14 | 66.14 | 56.52 | 65.91 | 16.68 | 13.24 | 20.62 | 0.00 |
| 1984 | 1893.50 | 2833 | 748 | 26.70 | 26.70 | 28.82 | 32.25 | 11.91 | 3.61 | 69.69 | 0.00 |
| 1985 | 5376.13 | 7239 | 748 | 82.65 | 82.65 | 82.05 | 82.64 | 3.03 | 2.58 | 14.77 | 0.00 |
| 1986 | 3618.71 | 6169 | 777 | 70.41 | 70.41 | 53.17 | 70.42 | 6.53 | 4.92 | 24.67 | 0.00 |
| 1987 | 5755.61 | 8388 | 761 | 95.73 | 95.73 | 86.34 | 95.75 | 3.20 | 3.16 | 1.11 | 0.00 |
| 1988 | 4254.48 | 5917 | 768 | 65.65 | 65.65 | 63.07 | 67.36 | 16.67 | 13.13 | 21.22 | 0.00 |
| 1989 | 4147.17 | 6155 | 768 | 68.60 | 68.60 | 61.64 | 70.26 | 0.39 | 0.27 | 31.13 | 0.00 |
| 1990 | 6527.75 | 8649 | 766 | 98.66 | 98.66 | 97.28 | 98.73 | 1.34 | 1.34 | 0.00 | 0.00 |
| 1991 | 4932.15 | 6656 | 761 | 74.38 | 74.38 | 73.99 | 75.98 | 4.84 | 3.78 | 21.84 | 0.00 |
| 1992 | 4692.39 | 6668 | 764 | 74.52 | 74.52 | 69.86 | 75.91 | 2.95 | 2.26 | 23.21 | 0.00 |
| 1993 | 4999.71 | 7734 | 757 | 87.45 | 87.45 | 75.40 | 88.29 | 12.55 | 12.55 | 0.00 | 0.00 |
| 1994 | 5275.59 | 7534 | 765 | 85.19 | 85.19 | 78.72 | 86.00 | 1.87 | 1.63 | 13.19 | 0.00 |
| 1995 | 5055.51 | 6888 | 768 | 77.45 | 77.45 | 75.07 | 78.63 | 6.54 | 5.42 | 17.13 | 0.00 |
| 1996 | 7021.70 | 8639 | 809 | 98.36 | 98.36 | 98.81 | 98.35 | 0.70 | 0.70 | 0.94 | 0.00 |
| 1997 | 6033.58 | 7560 | 818 | 86.43 | 86.43 | 84.20 | 86.30 | 2.77 | 2.46 | 11.11 | 0.00 |
| 1998 | 5829.91 | 7247 | 821 | 82.84 | 82.84 | 81.05 | 82.73 | 0.00 | 0.00 | 17.16 | 0.00 |
| 1999 | 7073.63 | 8173 | 855 | 93.31 | 93.31 | 94.44 | 93.30 | 5.10 | 5.01 | 1.68 | 0.00 |
| 2000 | 6900.28 | 7884 | 878 | 89.65 | 89.65 | 89.93 | 89.75 | 0.24 | 0.21 | 10.14 | 0.00 |
| 2001 | 6584.53 | 7618 | 878 | 86.29 | 86.29 | 85.61 | 86.96 | 2.95 | 2.62 | 11.09 | 0.00 |
| 2002 | 7423.29 | 8544 | 870 | 97.34 | 97.34 | 97.40 | 97.53 | 2.66 | 2.66 | 0.00 | 0.00 |
| 2003 | 6962.51 | 8052 | 883 | 91.94 | 91.94 | 91.13 | 91.92 | 0.07 | 0.07 | 7.99 | 0.00 |
| 2004 | 7520.63 | 8589 | 883 | 97.79 | 97.79 | 96.96 | 97.78 | 0.00 | 0.00 | 2.21 | 0.00 |
| 2005 | 6727.80 | 7724 | 883 | 88.20 | 88.20 | 86.97 | 88.16 | 1.78 | 1.60 | 10.20 | 0.00 |
| 2006 | 7641.83 | 8694 | 883 | 99.25 | 99.25 | 98.79 | 99.25 | 0.75 | 0.75 | 0.00 | 0.00 |
| 2007 | 6749.03 | 7744 | 883 | 88.41 | 88.41 | 87.25 | 88.40 | 0.73 | 0.65 | 10.94 | 0.00 |
| 2008 | 7479.80 | 8516 | 883 | 96.96 | 96.96 | 96.44 | 96.95 | 0.81 | 0.79 | 2.25 | 0.00 |
| 2009 | 5218.51 | 6119 | 883 | 69.87 | 69.87 | 67.47 | 69.85 | 1.54 | 1.09 | 29.04 | 0.00 |
| 2010 | 7391.68 | 8456 | 883 | 96.54 | 96.54 | 95.56 | 96.53 | 0.00 | 0.00 | 3.46 | 0.00 |
| 2011 | 6052.02 | 7405 | 883 | 84.57 | 84.57 | 78.24 | 84.53 | 0.74 | 0.63 | 14.80 | 0.00 |
| 2012 | 7581.41 | 8634 | 883 | 98.30 | 98.30 | 97.75 | 98.29 | 0.00 | 0.00 | 1.70 | 0.00 |
| 2013 | 6767.29 | 7728 | 883 | 88.22 | 88.22 | 87.48 | 88.21 | 0.00 | 0.00 | 11.78 | 0.00 |
| 2014 | 7693.19 | 8760 | 883 | 100.00 | 100.00 | 99.46 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 6926.72 | 7950 | 883 | 90.75 | 90.75 | 89.55 | 90.75 | 0.00 | 0.00 | 9.25 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2016 | 7656.23 | 8657 | 883 | 98.55 | 98.55 | 98.71 | 98.55 | 0.00 | 0.00 | 1.45 | 0.00 |
| 2017 | 7212.21 | 8254 | 883 | 94.22 | 94.22 | 93.24 | 94.22 | 0.00 | 0.00 | 5.78 | 0.00 |
| 2018 | 7393.99 | 8562 | 883 | 97.74 | 97.74 | 95.59 | 97.74 | 2.26 | 2.26 | 0.00 | 0.00 |
| 2019 | 6358.89 | 7386 | 883 | 84.33 | 84.33 | 82.21 | 84.32 | 3.75 | 3.28 | 12.39 | 0.00 |
| 2020 | 7557.67 | 8590 | 883 | 97.80 | 97.80 | 97.44 | 97.79 | 0.00 | 0.00 | 2.20 | 0.00 |
| 2021 | 6981.87 | 8023 | 883 | 91.58 | 91.58 | 90.26 | 91.59 | 0.44 | 0.40 | 8.01 | 0.00 |
| 2022 | 7557.77 | 8605 | 883 | 98.23 | 98.23 | 97.71 | 98.23 | 0.00 | 0.00 | 1.77 | 0.00 |
| 2023 | 6833.54 | 7811 | 883 | 91.76 | 91.76 | 88.34 | 89.17 | 0.30 | 0.27 | 7.96 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1979 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 174 | |
| B. Refuelling without maintenance | | | | 16 | | |
| C. Inspection, maintenance or repair combined with refuelling | 760 | | | 898 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 128 | | |
| E. Testing of plant systems or components | | | | 11 | 61 | |
| L. Human factor related | | | | | 30 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 0 | | |
| Z. Other | | | | | 28 | |
| Subtotal | 760 | 24 | | 1053 | 293 | |
| Total | | 784 | | | 1346 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1979 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 24 | 24 |
| 12. Reactor I&C Systems | | 15 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 4 |
| 15. Reactor Cooling Systems | | 93 |
| 31. Turbine and auxiliaries | | 26 |
| 32. Feedwater and Main Steam System | | 33 |
| 33. Circulating Water System | | 3 |
| 34. Miscellaneous Systems | | 5 |
| 41. Main Generator Systems | | 20 |
| 42. Electrical Power Supply Systems | | 11 |
| Total | 24 | 244 |

2023 Operating Experience

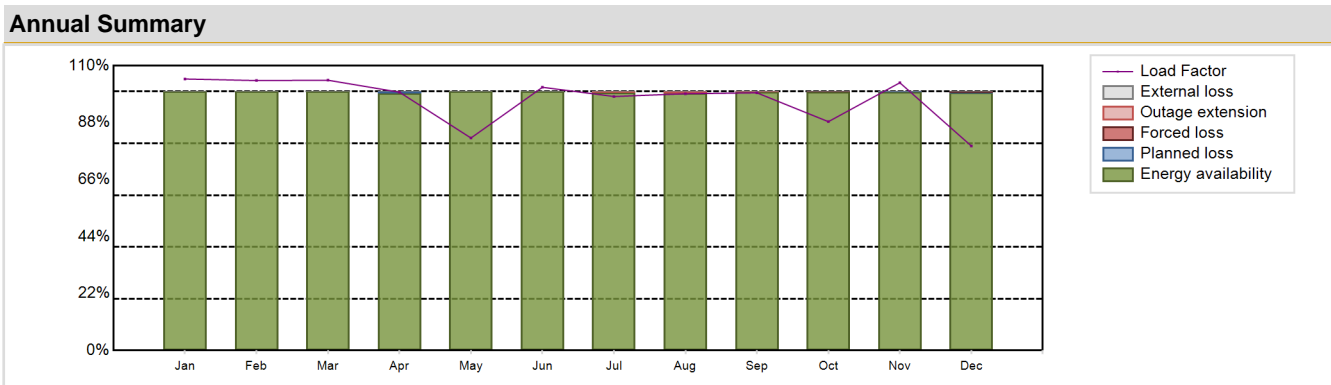
US-354 **HOPE CREEK-1** **UNITED STATES OF AMERICA**

Status at end of year : **Operational**
 Operator : PSEG (PSEG Nuclear, LLC)
 Owner : PSEGPOWER (PSEG Power, Inc.)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)

| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 1) | Construction Date | : 1976-03-01 |
| Thermal power | : 3840 MWth | Grid Date | : 1986-08-01 |
| Gross electrical power | : 1240 MWe | Commercial Date | : 1986-12-20 |
| Reference unit power (net) | : 1172 MWe | Age at end of year | : 37 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.17 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 287 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.42 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 30000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.8 | HP cylinder inlet steam pressure [MPa] | : 6.56 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 764 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 17.52 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 9953.82 GW(e).h | Forced Loss Rate (FLR) | : 0.04 % |
| Energy Availability Factor (EAF) | : 99.8 % | Unplanned Capability Loss Factor (UCL) | : 0.13 % |
| Unit Capability Factor (UCF) | : 99.8 % | Planned Unavailability Factor (PUF) | : 0.07 % |
| Load Factor (LF) | : 96.95 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 96.38 % | Total off-line time | : 317 hours |

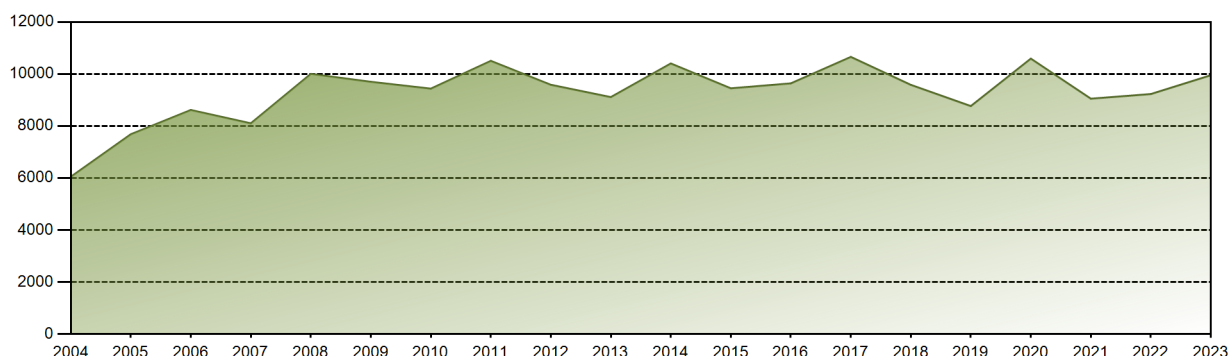


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 914.38 | 821.27 | 909.08 | 841.90 | 715.74 | 857.88 | 855.47 | 864.79 | 839.86 | 770.73 | 873.89 | 688.84 | 9953.82 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 99.33 | 100.00 | 100.00 | 99.61 | 99.35 | 99.90 | 99.90 | 99.90 | 99.65 | 99.80 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 99.33 | 100.00 | 100.00 | 99.61 | 99.35 | 99.90 | 99.90 | 99.90 | 99.65 | 99.80 |
| LF [%] | 104.86 | 104.28 | 104.40 | 99.77 | 82.08 | 101.66 | 98.11 | 99.18 | 99.53 | 88.39 | 103.42 | 79.00 | 96.95 |
| OF [%] | 100.00 | 100.00 | 100.00 | 98.47 | 82.26 | 100.00 | 100.00 | 100.00 | 100.00 | 90.05 | 100.00 | 86.56 | 96.38 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.32 | 0.04 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | 0.65 | 0.10 | 0.10 | 0.00 | 0.32 | 0.13 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.03 | 0.07 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 314089.9 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.33 % |
| Cumulative Energy Availability Factor (EAF) | : 88.99 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.13 % |
| Cumulative Unit Capability Factor (UCF) | : 88.99 % | Cumulative Planned Unavailability Factor (PUF) | : 8.89 % |
| Cumulative Load Factor (LF) | : 88.06 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 88.22 % | | |

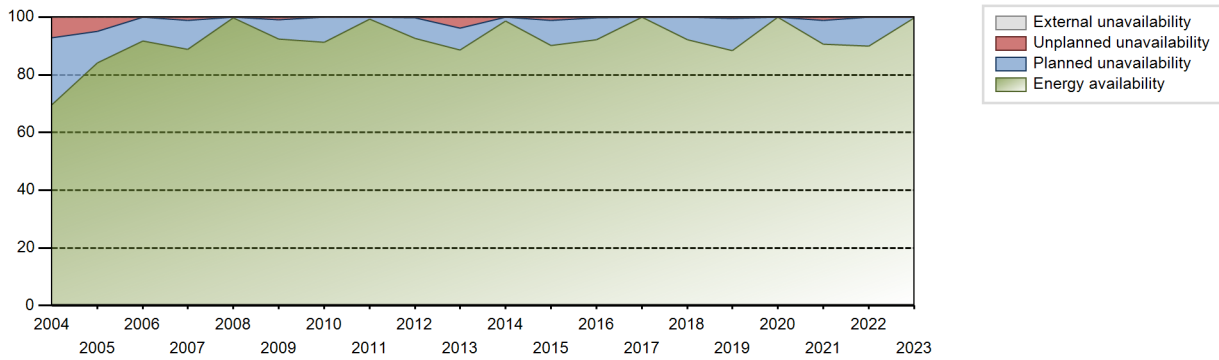
Electricity Production (net) [GWh]



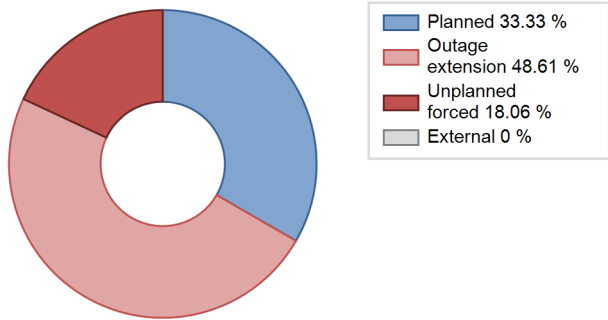
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | | | | Data not provided | | | | | | | |
| 1987 | 7308.74 | 7457 | 1067 | 92.67 | 92.67 | 78.19 | 85.13 | 4.09 | 3.95 | 3.38 | 0.00 |
| 1988 | 6470.87 | 6369 | 1061 | 79.03 | 79.03 | 69.43 | 72.51 | 5.32 | 4.44 | 16.53 | 0.00 |
| 1989 | 6614.33 | 6717 | 1031 | 76.72 | 76.72 | 73.24 | 76.68 | 1.41 | 1.10 | 22.18 | 0.00 |
| 1990 | 8100.14 | 7940 | 1031 | 90.66 | 90.66 | 89.69 | 90.64 | 6.26 | 6.05 | 3.29 | 0.00 |
| 1991 | 7402.71 | 7280 | 1031 | 83.07 | 83.07 | 81.96 | 83.11 | 4.06 | 3.52 | 13.41 | 0.00 |
| 1992 | 7059.11 | 6930 | 1031 | 78.92 | 78.92 | 77.95 | 78.89 | 2.57 | 2.08 | 19.00 | 0.00 |
| 1993 | 8825.34 | 8526 | 1031 | 97.35 | 97.35 | 97.72 | 97.33 | 2.65 | 2.65 | 0.00 | 0.00 |
| 1994 | 7125.64 | 6969 | 1031 | 79.60 | 79.60 | 78.90 | 79.55 | 6.85 | 5.86 | 14.54 | 0.00 |
| 1995 | 7072.28 | 6937 | 1031 | 79.21 | 79.21 | 78.31 | 79.19 | 7.95 | 6.84 | 13.95 | 0.00 |
| 1996 | 6770.72 | 6618 | 1031 | 75.36 | 75.36 | 74.76 | 75.34 | 0.00 | 0.00 | 24.64 | 0.00 |
| 1997 | 6417.76 | 6511 | 1031 | 74.32 | 74.32 | 71.06 | 74.33 | 0.93 | 0.70 | 24.99 | 0.00 |
| 1998 | 8700.37 | 8539 | 1031 | 97.48 | 97.48 | 96.33 | 97.48 | 2.52 | 2.52 | 0.00 | 0.00 |
| 1999 | 7701.08 | 7538 | 1031 | 86.05 | 86.05 | 85.27 | 86.05 | 0.00 | 0.00 | 13.95 | 0.00 |
| 2000 | 7271.74 | 7259 | 1031 | 82.57 | 82.57 | 80.29 | 82.64 | 8.12 | 7.30 | 10.13 | 0.00 |
| 2001 | 8065.27 | 7859 | 1049 | 89.79 | 89.79 | 88.65 | 89.71 | 3.66 | 3.41 | 6.80 | 0.00 |
| 2002 | 8843.08 | 8555 | 1049 | 97.66 | 97.66 | 96.23 | 97.66 | 1.33 | 1.31 | 1.03 | 0.00 |
| 2003 | 7260.58 | 7137 | 1049 | 81.47 | 81.47 | 79.01 | 81.47 | 9.64 | 8.69 | 9.84 | 0.00 |
| 2004 | 6048.87 | 6123 | 1049 | 69.71 | 69.71 | 65.65 | 69.71 | 9.29 | 7.14 | 23.16 | 0.00 |
| 2005 | 7684.77 | 7379 | 1049 | 84.24 | 84.24 | 83.62 | 84.23 | 5.55 | 4.95 | 10.81 | 0.00 |
| 2006 | 8617.78 | 8042 | 1059 | 91.82 | 91.82 | 92.90 | 91.80 | 0.08 | 0.07 | 8.10 | 0.00 |
| 2007 | 8104.54 | 7774 | 1061 | 88.78 | 88.78 | 87.20 | 88.74 | 1.27 | 1.14 | 10.08 | 0.00 |
| 2008 | 10006.26 | 8756 | 1186 | 99.67 | 99.67 | 100.44 | 99.68 | 0.00 | 0.00 | 0.33 | 0.00 |
| 2009 | 9700.30 | 8104 | 1161 | 92.37 | 92.37 | 95.38 | 92.51 | 1.09 | 1.01 | 6.61 | 0.00 |
| 2010 | 9438.54 | 8001 | 1191 | 91.37 | 91.37 | 92.60 | 91.34 | 0.00 | 0.00 | 8.63 | 0.00 |
| 2011 | 10505.93 | 8690 | 1191 | 99.20 | 99.20 | 100.70 | 99.20 | 0.00 | 0.00 | 0.80 | 0.00 |
| 2012 | 9586.25 | 8141 | 1172 | 92.70 | 92.70 | 93.12 | 92.68 | 0.20 | 0.18 | 7.12 | 0.00 |
| 2013 | 9112.68 | 7751 | 1172 | 88.49 | 88.49 | 88.75 | 88.47 | 4.20 | 3.88 | 7.63 | 0.00 |
| 2014 | 10406.06 | 8636 | 1172 | 98.58 | 98.58 | 101.36 | 98.58 | 0.00 | 0.00 | 1.42 | 0.00 |
| 2015 | 9450.74 | 7895 | 1172 | 90.13 | 90.13 | 92.05 | 90.13 | 1.16 | 1.06 | 8.81 | 0.00 |
| 2016 | 9639.69 | 8087 | 1172 | 92.07 | 92.07 | 93.64 | 92.07 | 0.25 | 0.23 | 7.70 | 0.00 |
| 2017 | 10657.91 | 8760 | 1172 | 100.00 | 100.00 | 103.81 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 9583.40 | 8071 | 1172 | 92.14 | 92.14 | 93.34 | 92.13 | 0.00 | 0.00 | 7.86 | 0.00 |
| 2019 | 8767.20 | 7746 | 1172 | 88.44 | 88.44 | 85.39 | 88.42 | 0.57 | 0.51 | 11.05 | 0.00 |
| 2020 | 10592.70 | 8783 | 1172 | 100.00 | 100.00 | 102.89 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 9051.91 | 7942 | 1172 | 90.65 | 90.65 | 88.17 | 90.66 | 1.16 | 1.07 | 8.28 | 0.00 |
| 2022 | 9229.60 | 7882 | 1172 | 89.98 | 89.98 | 89.90 | 89.98 | 0.06 | 0.05 | 9.97 | 0.00 |

2023 9953.82 8443 1172 99.80 99.80 96.95 96.38 0.04 0.13 0.07 0.00

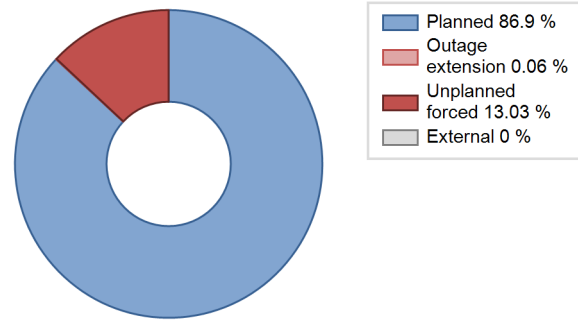
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 158 | |
| B. Refuelling without maintenance | | | | 36 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 669 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 91 | | |
| E. Testing of plant systems or components | | | | 0 | | |
| H. Nuclear regulatory requirements | | | | | 0 | |
| L. Human factor related | | | | | 14 | |
| P. Fire | | | | | 1 | |
| Z. Other | | | | | 5 | |
| Subtotal | | | | 796 | 178 | |
| Total | | 0 | | | 974 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 12 |
| 12. Reactor I&C Systems | | 6 |
| 13. Reactor Auxiliary Systems | | 20 |
| 15. Reactor Cooling Systems | | 24 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 28 |
| 32. Feedwater and Main Steam System | | 23 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 14 |
| 42. Electrical Power Supply Systems | | 22 |
| Total | | 160 |

2023 Operating Experience

US-373

LASALLE-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : BWR / BWR-5 (Mark 2)
 Thermal power : 3546 MWth
 Gross electrical power : 1207 MWe
 Reference unit power (net) : 1137 MWe

Key Dates

Construction Date : 1973-09-10
 Grid Date : 1982-09-04
 Commercial Date : 1984-01-01
 Age at end of year : 41 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 40
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 4.88
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 764
 Fuel linear heat generation rate [kW/m] : 44
 Number of control rod assemblies : 185
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.1
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : 0.41

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.65
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Pond (closed-cycle)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

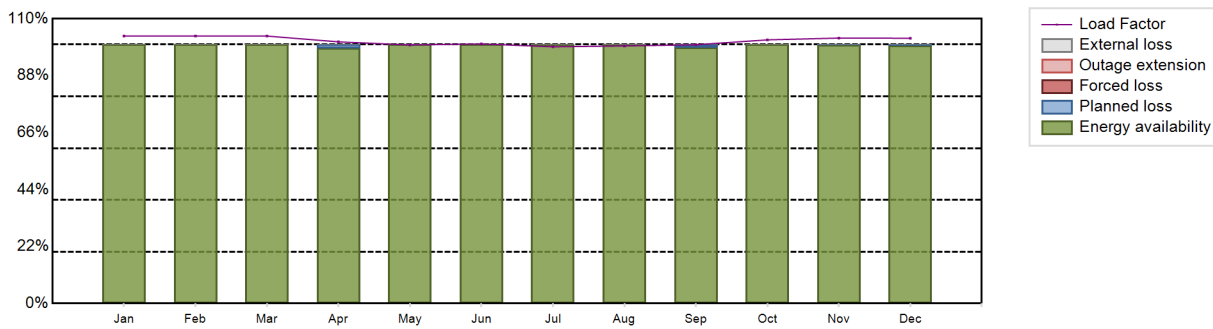
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 10095.55 GW(e).h
 Energy Availability Factor (EAF) : 99.77 %
 Unit Capability Factor (UCF) : 99.77 %
 Load Factor (LF) : 101.36 %
 Operating Factor (OF) : 100 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.23 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

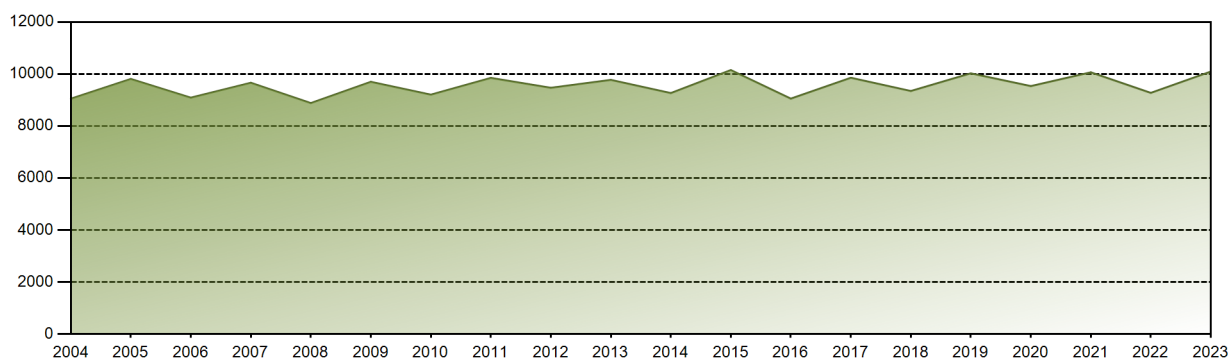


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 873.74 | 789.26 | 872.69 | 827.39 | 844.73 | 820.75 | 838.75 | 841.50 | 818.20 | 861.37 | 840.45 | 866.72 | 10095.55 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 98.73 | 100.00 | 100.00 | 100.00 | 100.00 | 98.86 | 100.00 | 99.93 | 99.68 | 99.77 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 98.73 | 100.00 | 100.00 | 100.00 | 100.00 | 98.86 | 100.00 | 99.93 | 99.68 | 99.77 |
| LF [%] | 103.29 | 103.30 | 103.30 | 101.07 | 99.86 | 100.26 | 99.15 | 99.48 | 99.95 | 101.83 | 102.52 | 102.46 | 101.36 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 1.27 | 0.00 | 0.00 | 0.00 | 0.00 | 1.14 | 0.00 | 0.07 | 0.32 | 0.23 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 314469.24 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.23 % |
| Cumulative Energy Availability Factor (EAF) | : 83.32 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.6 % |
| Cumulative Unit Capability Factor (UCF) | : 83.33 % | Cumulative Planned Unavailability Factor (PUF) | : 12.07 % |
| Cumulative Load Factor (LF) | : 82.17 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 82.66 % | | |

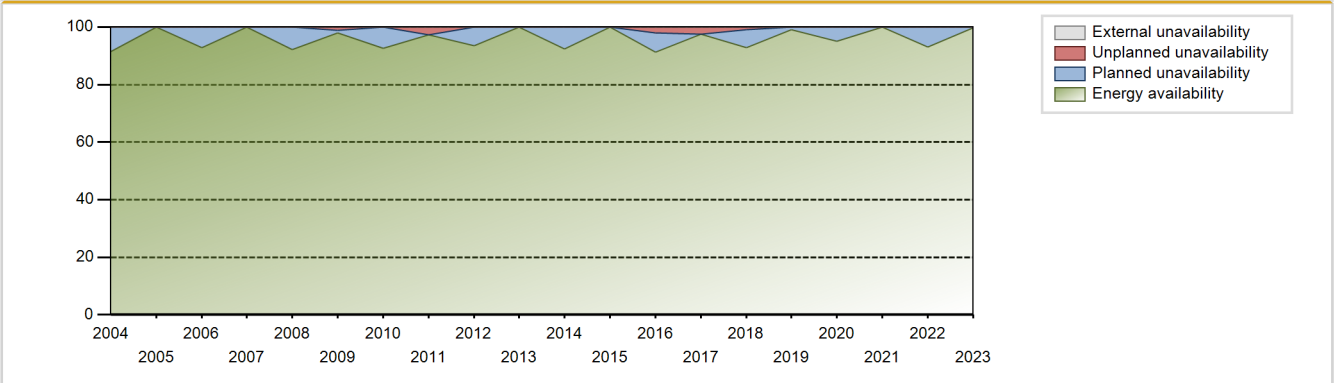
Electricity Production (net) [GWh]



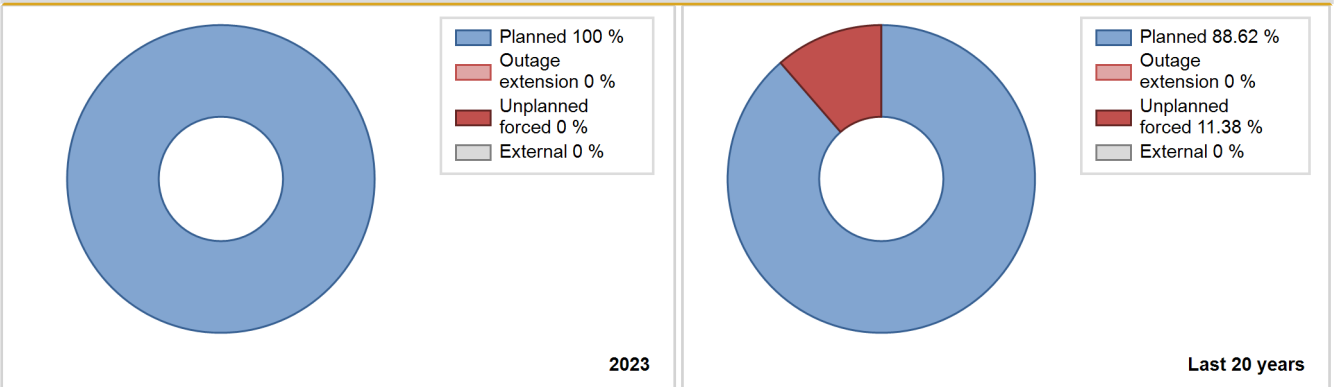
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 5206.21 | 6052 | 1078 | 69.43 | 69.43 | 54.99 | 68.91 | 16.31 | 13.53 | 17.04 | 0.00 |
| 1985 | 4827.46 | 5581 | 1036 | 63.69 | 64.26 | 53.19 | 63.71 | 19.25 | 15.32 | 20.42 | 0.57 |
| 1986 | 2100.75 | 2331 | 1036 | 25.78 | 25.78 | 23.15 | 26.61 | 2.65 | 0.70 | 73.52 | 0.00 |
| 1987 | 4108.12 | 5455 | 1036 | 61.89 | 61.89 | 45.27 | 62.27 | 38.11 | 38.11 | 0.00 | 0.00 |
| 1988 | 5453.67 | 5818 | 1036 | 65.86 | 65.86 | 59.93 | 66.23 | 2.49 | 1.68 | 32.45 | 0.00 |
| 1989 | 6180.58 | 6103 | 1036 | 69.67 | 69.67 | 68.10 | 69.67 | 1.37 | 0.97 | 29.36 | 0.00 |
| 1990 | 8637.38 | 8329 | 1036 | 95.02 | 95.02 | 95.17 | 95.08 | 1.85 | 1.79 | 3.19 | 0.00 |
| 1991 | 6841.44 | 6627 | 1036 | 75.39 | 75.39 | 75.38 | 75.65 | 2.23 | 1.72 | 22.89 | 0.00 |
| 1992 | 6469.28 | 6528 | 1036 | 74.04 | 74.04 | 71.09 | 74.32 | 1.44 | 1.08 | 24.87 | 0.00 |
| 1993 | 7207.51 | 7102 | 1036 | 80.97 | 80.97 | 79.42 | 81.07 | 11.79 | 10.82 | 8.21 | 0.00 |
| 1994 | 4945.32 | 5095 | 1036 | 57.78 | 57.78 | 54.49 | 58.16 | 16.78 | 11.65 | 30.57 | 0.00 |
| 1995 | 8239.56 | 8226 | 1036 | 93.88 | 93.88 | 90.79 | 93.90 | 6.12 | 6.12 | 0.00 | 0.00 |
| 1996 | 3300.36 | 3349 | 1036 | 37.48 | 37.48 | 36.27 | 38.13 | 30.53 | 16.47 | 46.05 | 0.00 |
| 1997 | 0.00 | 0 | 1036 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1998 | 3336.67 | 3174 | 1036 | 36.27 | 36.27 | 36.77 | 36.23 | 63.06 | 61.91 | 1.82 | 0.00 |
| 1999 | 8013.68 | 7963 | 1036 | 90.81 | 90.81 | 88.30 | 90.90 | 0.75 | 0.69 | 8.50 | 0.00 |
| 2000 | 9745.39 | 8784 | 1114 | 100.00 | 100.00 | 102.81 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 9850.36 | 8708 | 1111 | 99.42 | 99.42 | 101.01 | 99.41 | 0.58 | 0.58 | 0.00 | 0.00 |
| 2002 | 8927.60 | 7945 | 1111 | 90.57 | 90.57 | 91.73 | 90.70 | 0.00 | 0.00 | 9.43 | 0.00 |
| 2003 | 9739.03 | 8716 | 1111 | 99.50 | 99.50 | 100.07 | 99.50 | 0.00 | 0.00 | 0.50 | 0.00 |
| 2004 | 9051.53 | 8059 | 1111 | 91.50 | 91.50 | 92.75 | 91.75 | 0.00 | 0.00 | 8.50 | 0.00 |
| 2005 | 9811.96 | 8760 | 1146 | 100.00 | 100.00 | 97.73 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2006 | 9092.07 | 8129 | 1118 | 92.81 | 92.81 | 92.84 | 92.80 | 0.00 | 0.00 | 7.19 | 0.00 |
| 2007 | 9664.63 | 8760 | 1118 | 100.00 | 100.00 | 98.68 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 8883.77 | 8103 | 1118 | 92.26 | 92.26 | 90.46 | 92.25 | 0.00 | 0.00 | 7.74 | 0.00 |
| 2009 | 9700.71 | 8580 | 1118 | 97.95 | 97.95 | 99.05 | 97.95 | 1.10 | 1.09 | 0.96 | 0.00 |
| 2010 | 9207.03 | 8119 | 1118 | 92.69 | 92.69 | 94.01 | 92.68 | 0.00 | 0.00 | 7.31 | 0.00 |
| 2011 | 9851.68 | 8529 | 1118 | 97.37 | 97.37 | 100.59 | 97.36 | 2.63 | 2.63 | 0.00 | 0.00 |
| 2012 | 9471.23 | 8213 | 1137 | 93.60 | 93.60 | 95.09 | 93.50 | 0.00 | 0.00 | 6.40 | 0.00 |
| 2013 | 9774.52 | 8465 | 1137 | 100.00 | 100.00 | 98.13 | 96.62 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 9267.74 | 8092 | 1137 | 92.37 | 92.37 | 93.05 | 92.37 | 0.00 | 0.00 | 7.63 | 0.00 |
| 2015 | 10153.40 | 8760 | 1137 | 100.00 | 100.00 | 101.94 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 9054.09 | 8019 | 1137 | 91.29 | 91.29 | 90.66 | 91.29 | 2.29 | 2.14 | 6.56 | 0.00 |
| 2017 | 9856.32 | 8541 | 1137 | 97.51 | 97.51 | 98.96 | 97.50 | 2.49 | 2.49 | 0.00 | 0.00 |
| 2018 | 9347.13 | 8117 | 1137 | 92.83 | 92.83 | 93.85 | 92.66 | 0.88 | 0.83 | 6.34 | 0.00 |
| 2019 | 10026.81 | 8680 | 1137 | 99.10 | 99.10 | 100.67 | 99.09 | 0.00 | 0.00 | 0.90 | 0.00 |
| 2020 | 9535.89 | 8342 | 1137 | 94.98 | 94.98 | 95.48 | 94.97 | 0.00 | 0.00 | 5.02 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|--------|--------|--------|--------|------|------|------|------|
| 2021 | 10066.17 | 8760 | 1137 | 100.00 | 100.00 | 101.06 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 9275.00 | 8160 | 1137 | 93.15 | 93.15 | 93.12 | 93.15 | 0.00 | 0.00 | 6.85 | 0.00 |
| 2023 | 10095.55 | 8760 | 1137 | 99.77 | 99.77 | 101.36 | 100.00 | 0.00 | 0.00 | 0.23 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 324 | |
| B. Refuelling without maintenance | | | | 26 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 771 | | |
| D. Inspection, maintenance or repair without refuelling | 24 | | | 290 | | |
| E. Testing of plant systems or components | | | | 39 | 3 | |
| H. Nuclear regulatory requirements | | | | | 134 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 9 |
| L. Human factor related | | | | | 24 | |
| Z. Other | | | | | 4 | |
| Subtotal | 24 | | | 1126 | 489 | 9 |
| Total | | 24 | | | 1624 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 27 |
| 12. Reactor I&C Systems | | 23 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 32 |
| 15. Reactor Cooling Systems | | 93 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 70 |
| 32. Feedwater and Main Steam System | | 13 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | | 10 |
| 35. All other I&C Systems | | 3 |
| 41. Main Generator Systems | | 11 |
| 42. Electrical Power Supply Systems | | 30 |
| Total | | 329 |

2023 Operating Experience

US-374

LASALLE-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : BWR / BWR-5 (Mark 2)
 Thermal power : 3546 MWth
 Gross electrical power : 1207 MWe
 Reference unit power (net) : 1140 MWe

Key Dates

Construction Date : 1973-09-10
 Grid Date : 1984-04-20
 Commercial Date : 1984-10-19
 Age at end of year : 39 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 40
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 4.88
 Active core height/length [m] : 3.81
 Number of fissile fuel assemblies/bundles : 764
 Fuel linear heat generation rate [kW/m] : 44
 Number of control rod assemblies : 185
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.1
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : 0.41

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.65
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Pond (closed-cycle)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

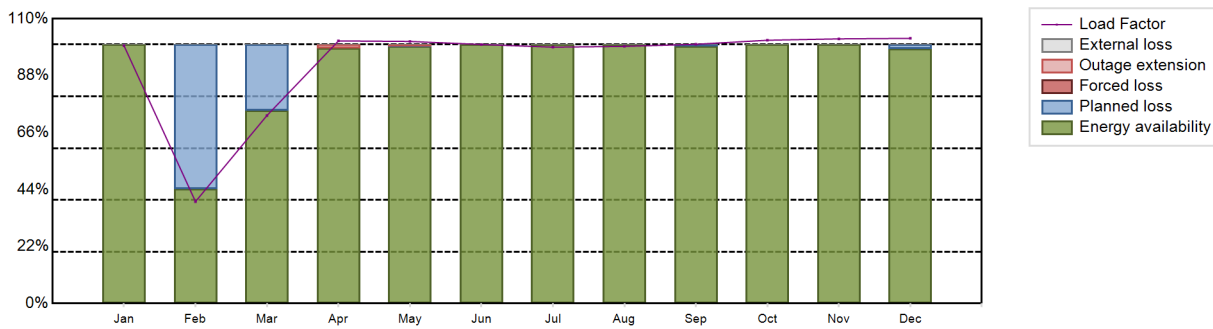
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9348.5 GW(e).h
 Energy Availability Factor (EAF) : 93.21 %
 Unit Capability Factor (UCF) : 93.21 %
 Load Factor (LF) : 93.61 %
 Operating Factor (OF) : 93.39 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0.17 %
 Planned Unavailability Factor (PUF) : 6.62 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 579 hours

Annual Summary

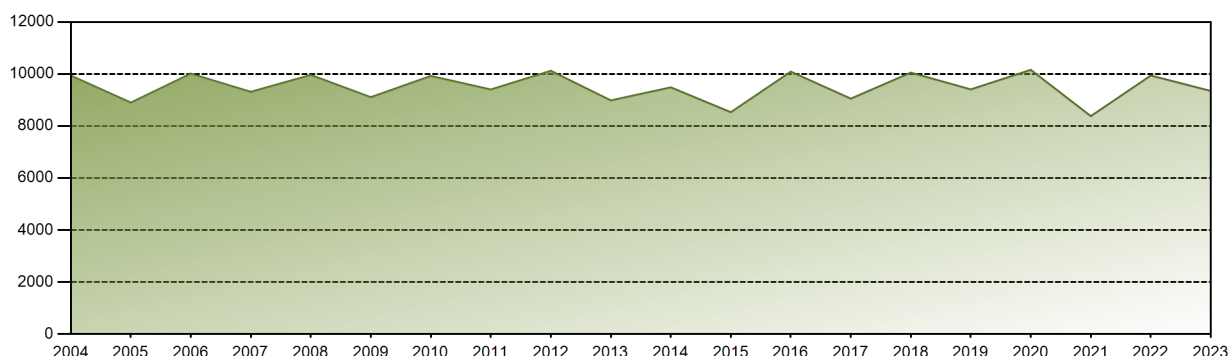


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 844.54 | 301.58 | 615.06 | 832.50 | 858.48 | 821.17 | 839.83 | 842.28 | 821.74 | 862.47 | 840.17 | 868.68 | 9348.51 |
| EAF [%] | 100.00 | 44.31 | 74.46 | 98.57 | 99.28 | 100.00 | 100.00 | 100.00 | 99.45 | 100.00 | 100.00 | 98.49 | 93.21 |
| UCF [%] | 100.00 | 44.31 | 74.46 | 98.57 | 99.28 | 100.00 | 100.00 | 100.00 | 99.45 | 100.00 | 100.00 | 98.49 | 93.21 |
| LF [%] | 99.57 | 39.37 | 72.61 | 101.43 | 101.22 | 100.04 | 99.02 | 99.31 | 100.11 | 101.69 | 102.22 | 102.42 | 93.61 |
| OF [%] | 100.00 | 42.86 | 73.76 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.39 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 1.43 | 0.63 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 |
| PUF [%] | 0.00 | 55.69 | 25.54 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.55 | 0.00 | 0.00 | 1.51 | 6.62 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 307119.23 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.2 % |
| Cumulative Energy Availability Factor (EAF) | : 82.52 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.46 % |
| Cumulative Unit Capability Factor (UCF) | : 82.53 % | Cumulative Planned Unavailability Factor (PUF) | : 12.02 % |
| Cumulative Load Factor (LF) | : 81.81 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 81.87 % | | |

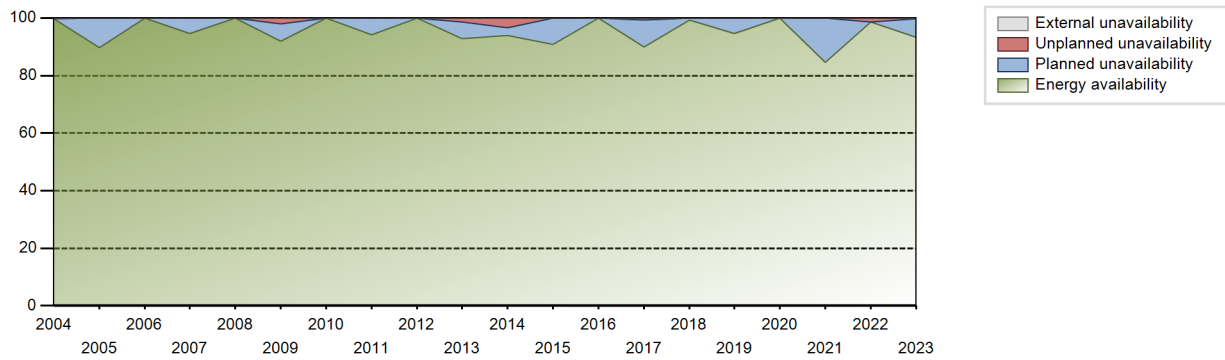
Electricity Production (net) [GWh]



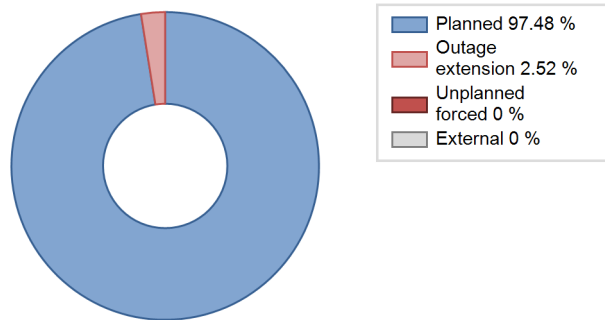
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|--------|--------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 2735.73 | 4058 | 1039 | 86.57 | 86.57 | 77.10 | 86.68 | 13.43 | 13.43 | 0.00 | 0.00 |
| 1985 | 3476.96 | 3698 | 1036 | 41.81 | 41.81 | 38.31 | 42.21 | 30.40 | 18.26 | 39.93 | 0.00 |
| 1986 | 5727.77 | 6533 | 1036 | 74.58 | 75.00 | 63.11 | 74.58 | 24.61 | 24.49 | 0.51 | 0.43 |
| 1987 | 4573.28 | 4699 | 1036 | 53.13 | 53.13 | 50.39 | 53.64 | 1.67 | 0.90 | 45.97 | 0.00 |
| 1988 | 5662.76 | 6593 | 1036 | 75.07 | 75.07 | 62.23 | 75.06 | 4.26 | 3.34 | 21.59 | 0.00 |
| 1989 | 6506.76 | 6591 | 1036 | 75.13 | 75.13 | 71.70 | 75.24 | 0.00 | 0.00 | 24.87 | 0.00 |
| 1990 | 6216.77 | 6162 | 1036 | 70.01 | 70.01 | 68.50 | 70.34 | 7.34 | 5.55 | 24.45 | 0.00 |
| 1991 | 8712.41 | 8357 | 1036 | 95.35 | 95.35 | 96.00 | 95.40 | 4.65 | 4.65 | 0.00 | 0.00 |
| 1992 | 5797.87 | 5850 | 1036 | 66.28 | 66.28 | 63.71 | 66.60 | 8.49 | 6.15 | 27.57 | 0.00 |
| 1993 | 5859.19 | 5825 | 1036 | 66.12 | 66.12 | 64.56 | 66.50 | 0.00 | 0.00 | 33.88 | 0.00 |
| 1994 | 8428.87 | 8101 | 1036 | 92.44 | 92.44 | 92.88 | 92.48 | 4.45 | 4.31 | 3.26 | 0.00 |
| 1995 | 5905.70 | 5855 | 1036 | 66.49 | 66.49 | 65.07 | 66.84 | 3.18 | 2.18 | 31.33 | 0.00 |
| 1996 | 5642.33 | 5649 | 1036 | 64.50 | 64.50 | 62.00 | 64.31 | 10.53 | 7.59 | 27.92 | 0.00 |
| 1997 | 0.00 | 0 | 1036 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1998 | 0.00 | 0 | 1036 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1999 | 6632.33 | 6231 | 1036 | 71.11 | 71.11 | 73.08 | 71.13 | 28.89 | 28.89 | 0.00 | 0.00 |
| 2000 | 9040.45 | 8229 | 1114 | 93.08 | 93.08 | 95.97 | 93.68 | 0.81 | 0.76 | 6.17 | 0.00 |
| 2001 | 9683.43 | 8515 | 1111 | 97.18 | 97.18 | 99.30 | 97.20 | 2.82 | 2.82 | 0.00 | 0.00 |
| 2002 | 8995.59 | 8078 | 1111 | 92.09 | 92.09 | 92.43 | 92.21 | 0.00 | 0.00 | 7.91 | 0.00 |
| 2003 | 8709.05 | 7762 | 1111 | 88.43 | 88.43 | 89.49 | 88.61 | 3.07 | 2.80 | 8.77 | 0.00 |
| 2004 | 9940.43 | 8764 | 1111 | 99.77 | 99.77 | 101.86 | 99.77 | 0.23 | 0.23 | 0.00 | 0.00 |
| 2005 | 8901.22 | 7857 | 1147 | 89.71 | 89.71 | 88.58 | 89.68 | 0.00 | 0.00 | 10.29 | 0.00 |
| 2006 | 10015.75 | 8760 | 1120 | 100.00 | 100.00 | 102.08 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 9315.51 | 8287 | 1120 | 94.61 | 94.61 | 94.95 | 94.60 | 0.00 | 0.00 | 5.39 | 0.00 |
| 2008 | 9964.59 | 8784 | 1120 | 100.00 | 100.00 | 101.29 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 9108.04 | 8058 | 1120 | 92.01 | 92.01 | 92.83 | 91.99 | 2.07 | 1.95 | 6.04 | 0.00 |
| 2010 | 9925.54 | 8760 | 1120 | 100.00 | 100.00 | 101.17 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 9404.75 | 8238 | 1140 | 94.14 | 94.14 | 94.44 | 94.04 | 0.00 | 0.00 | 5.86 | 0.00 |
| 2012 | 10123.73 | 8784 | 1140 | 100.00 | 100.00 | 101.10 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 8985.77 | 7962 | 1140 | 92.90 | 92.90 | 89.97 | 90.88 | 1.43 | 1.34 | 5.76 | 0.00 |
| 2014 | 9487.27 | 8228 | 1140 | 93.93 | 93.93 | 95.00 | 93.93 | 3.52 | 3.43 | 2.64 | 0.00 |
| 2015 | 8530.63 | 7955 | 1140 | 90.81 | 90.81 | 85.42 | 90.81 | 0.00 | 0.00 | 9.19 | 0.00 |
| 2016 | 10090.77 | 8784 | 1140 | 100.00 | 100.00 | 100.77 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 9052.14 | 7877 | 1140 | 89.92 | 89.92 | 90.64 | 89.92 | 0.77 | 0.70 | 9.38 | 0.00 |
| 2018 | 10053.26 | 8687 | 1140 | 99.19 | 99.19 | 100.67 | 99.17 | 0.00 | 0.00 | 0.81 | 0.00 |
| 2019 | 9408.48 | 8290 | 1140 | 94.64 | 94.64 | 94.21 | 94.63 | 0.00 | 0.00 | 5.36 | 0.00 |
| 2020 | 10159.80 | 8783 | 1140 | 100.00 | 100.00 | 101.46 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2021 | 8380.54 | 7402 | 1140 | 84.50 | 84.50 | 83.92 | 84.50 | 0.00 | 0.00 | 15.50 | 0.00 |
| 2022 | 9941.96 | 8641 | 1140 | 98.63 | 98.63 | 99.56 | 98.64 | 1.37 | 1.37 | 0.00 | 0.00 |
| 2023 | 9348.50 | 8181 | 1140 | 93.21 | 93.21 | 93.61 | 93.39 | 0.00 | 0.17 | 6.62 | 0.00 |

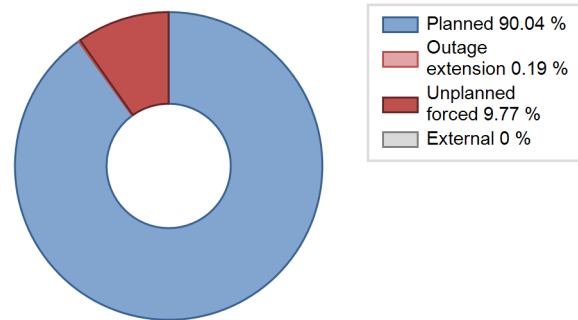
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 193 | |
| B. Refuelling without maintenance | | | | 35 | | |
| C. Inspection, maintenance or repair combined with refuelling | 578 | | | 883 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 134 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 288 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 5 |
| L. Human factor related | | | | | 5 | |
| Z. Other | | | | | 45 | |
| Subtotal | 578 | | | 1053 | 531 | 5 |
| Total | | 578 | | | 1589 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 46 |
| 12. Reactor I&C Systems | | 42 |
| 15. Reactor Cooling Systems | | 19 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 36 |
| 32. Feedwater and Main Steam System | | 9 |
| 34. Miscellaneous Systems | | 14 |
| 35. All other I&C Systems | | 8 |
| 41. Main Generator Systems | | 5 |
| 42. Electrical Power Supply Systems | | 16 |
| Total | | 196 |

2023 Operating Experience

US-352 **LIMERICK-1** **UNITED STATES OF AMERICA**

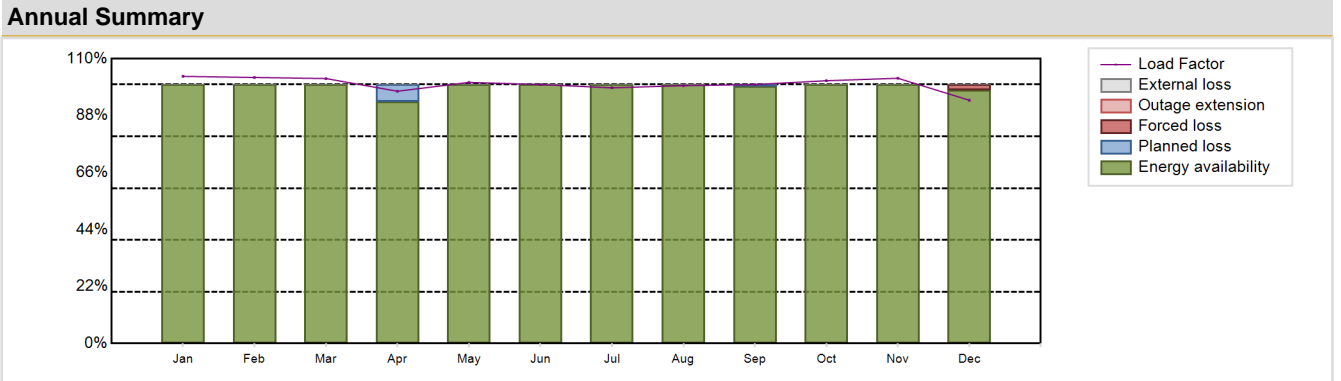
Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 2) | Construction Date | : 1974-06-19 |
| Thermal power | : 3515 MWth | Grid Date | : 1985-04-13 |
| Gross electrical power | : 1194 MWe | Commercial Date | : 1986-02-01 |
| Reference unit power (net) | : 1134 MWe | Age at end of year | : 38 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.1 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 282 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.38 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 40 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 45000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.57 | HP cylinder inlet steam pressure [MPa] | : 6.65 |
| Active core height/length [m] | : 3.71 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 764 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 16.4 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|------------|
| Net Energy Production | : 9955.71 GW(e).h | Forced Loss Rate (FLR) | : 0.19 % |
| Energy Availability Factor (EAF) | : 99.23 % | Unplanned Capability Loss Factor (UCL) | : 0.19 % |
| Unit Capability Factor (UCF) | : 99.23 % | Planned Unavailability Factor (PUF) | : 0.59 % |
| Load Factor (LF) | : 100.22 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 99.5 % | Total off-line time | : 44 hours |

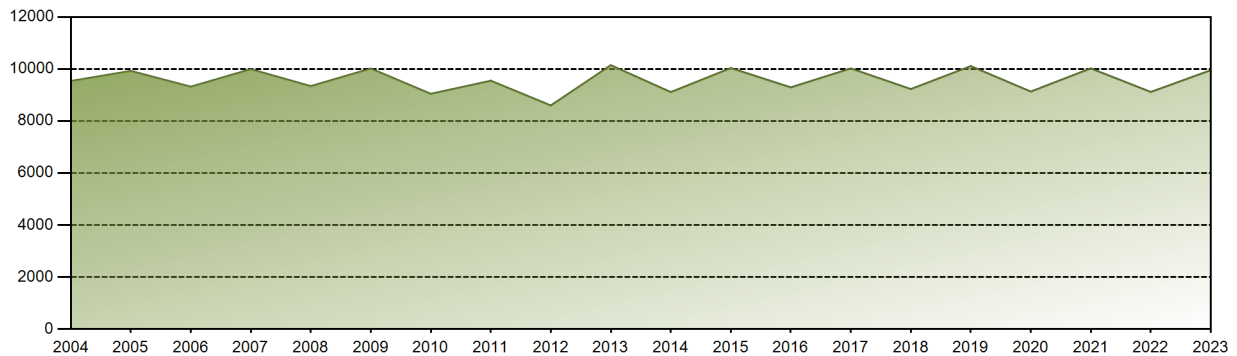


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 870.45 | 783.09 | 862.24 | 795.46 | 850.87 | 816.72 | 833.19 | 840.26 | 816.73 | 856.31 | 837.64 | 792.74 | 9955.71 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 93.51 | 100.00 | 100.00 | 100.00 | 100.00 | 99.35 | 100.00 | 100.00 | 97.81 | 99.23 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 93.51 | 100.00 | 100.00 | 100.00 | 100.00 | 99.35 | 100.00 | 100.00 | 97.81 | 99.23 |
| LF [%] | 103.17 | 102.76 | 102.34 | 97.43 | 100.85 | 100.03 | 98.75 | 99.59 | 100.03 | 101.50 | 102.45 | 93.96 | 100.22 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.09 | 99.50 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.19 | 0.19 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.19 | 0.19 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 6.49 | 0.00 | 0.00 | 0.00 | 0.00 | 0.65 | 0.00 | 0.00 | 0.00 | 0.59 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | | | |
|---|---|------------------|---|---|--------|
| Lifetime energy generation | : | 333451.2 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 1.61 % |
| Cumulative Energy Availability Factor (EAF) | : | 92.1 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 1.51 % |
| Cumulative Unit Capability Factor (UCF) | : | 92.1 % | Cumulative Planned Unavailability Factor (PUF) | : | 6.39 % |
| Cumulative Load Factor (LF) | : | 90.42 % | Cumulative Externally cause unavailability (XUF) | : | 0 % |
| Cumulative Operating Factor (OF) | : | 91.74 % | | | |

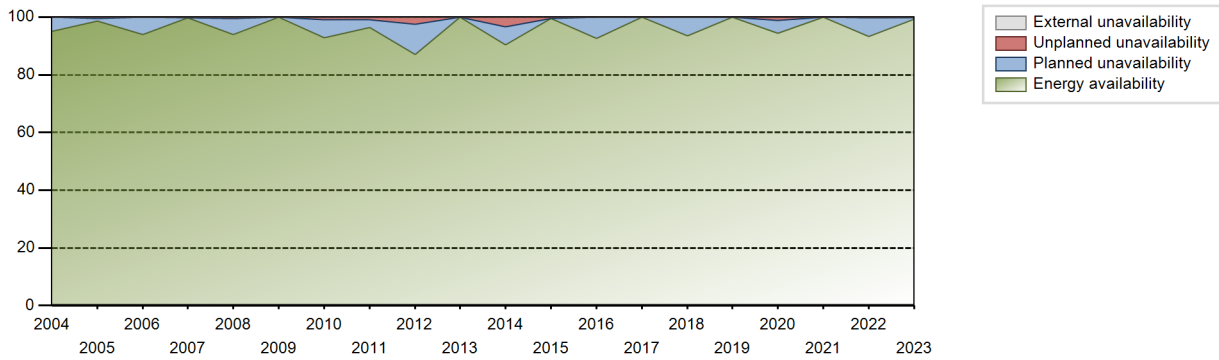
Electricity Production (net) [GWh]



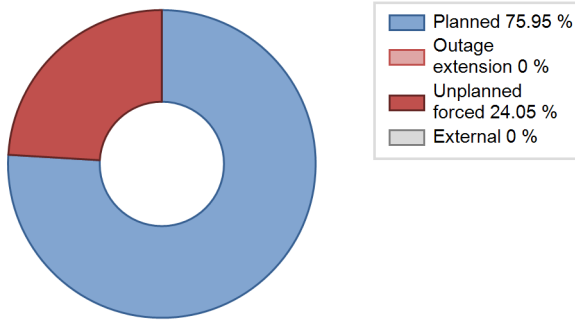
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 7210.57 | 7022 | 1055 | 82.79 | 82.79 | 80.99 | 82.76 | 3.46 | 2.97 | 14.25 | 0.00 |
| 1987 | 5341.32 | 5924 | 1055 | 67.66 | 67.66 | 57.80 | 67.63 | 4.11 | 2.90 | 29.44 | 0.00 |
| 1988 | 6674.75 | 8470 | 1055 | 96.43 | 96.43 | 72.03 | 96.43 | 3.57 | 3.57 | 0.00 | 0.00 |
| 1989 | 5244.25 | 5638 | 1055 | 69.36 | 69.36 | 56.74 | 64.36 | 0.00 | 0.00 | 30.64 | 0.00 |
| 1990 | 5633.12 | 5724 | 1055 | 65.34 | 65.34 | 60.95 | 65.34 | 6.61 | 4.62 | 30.03 | 0.00 |
| 1991 | 8133.85 | 8043 | 1055 | 91.83 | 91.83 | 88.01 | 91.82 | 8.17 | 8.17 | 0.00 | 0.00 |
| 1992 | 6239.64 | 6115 | 1055 | 69.63 | 69.63 | 67.33 | 69.62 | 0.10 | 0.07 | 30.31 | 0.00 |
| 1993 | 8745.47 | 8626 | 1055 | 98.48 | 98.48 | 94.63 | 98.47 | 1.52 | 1.52 | 0.00 | 0.00 |
| 1994 | 7858.02 | 7840 | 1055 | 89.52 | 89.52 | 85.03 | 89.50 | 0.86 | 0.78 | 9.70 | 0.00 |
| 1995 | 8147.47 | 7973 | 1055 | 91.06 | 91.06 | 88.16 | 91.02 | 7.90 | 7.81 | 1.13 | 0.00 |
| 1996 | 8141.62 | 7758 | 1096 | 88.83 | 88.83 | 84.51 | 88.32 | 3.15 | 2.89 | 8.28 | 0.00 |
| 1997 | 9227.48 | 8534 | 1105 | 97.54 | 97.54 | 95.33 | 97.42 | 0.00 | 0.00 | 2.46 | 0.00 |
| 1998 | 7449.12 | 7061 | 1112 | 81.62 | 81.62 | 76.45 | 80.61 | 8.24 | 7.33 | 11.04 | 0.00 |
| 1999 | 9744.01 | 8588 | 1134 | 98.05 | 98.05 | 98.09 | 98.04 | 1.95 | 1.95 | 0.00 | 0.00 |
| 2000 | 8988.10 | 7982 | 1143 | 90.94 | 90.94 | 89.82 | 90.87 | 1.04 | 0.96 | 8.10 | 0.00 |
| 2001 | 10133.10 | 8735 | 1143 | 99.73 | 99.73 | 101.20 | 99.71 | 0.00 | 0.00 | 0.27 | 0.00 |
| 2002 | 9286.82 | 8244 | 1134 | 94.07 | 94.07 | 93.49 | 94.11 | 1.20 | 1.14 | 4.78 | 0.00 |
| 2003 | 10057.46 | 8672 | 1134 | 99.00 | 99.00 | 101.24 | 99.00 | 1.00 | 1.00 | 0.00 | 0.00 |
| 2004 | 9539.06 | 8345 | 1134 | 95.01 | 95.01 | 95.76 | 95.00 | 0.00 | 0.00 | 4.99 | 0.00 |
| 2005 | 9926.94 | 8642 | 1134 | 98.67 | 98.67 | 99.92 | 98.64 | 0.45 | 0.45 | 0.89 | 0.00 |
| 2006 | 9320.36 | 8224 | 1134 | 93.90 | 93.90 | 93.82 | 93.88 | 0.00 | 0.00 | 6.10 | 0.00 |
| 2007 | 9994.36 | 8744 | 1134 | 99.82 | 99.82 | 100.61 | 99.82 | 0.18 | 0.18 | 0.00 | 0.00 |
| 2008 | 9342.51 | 8251 | 1134 | 93.94 | 93.94 | 93.79 | 93.93 | 0.63 | 0.59 | 5.47 | 0.00 |
| 2009 | 10019.44 | 8760 | 1130 | 100.00 | 100.00 | 101.22 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 9046.94 | 8129 | 1130 | 92.81 | 92.81 | 91.39 | 92.80 | 1.02 | 0.96 | 6.23 | 0.00 |
| 2011 | 9550.19 | 8435 | 1130 | 96.29 | 96.29 | 96.48 | 96.29 | 0.88 | 0.85 | 2.86 | 0.00 |
| 2012 | 8599.50 | 7637 | 1130 | 86.99 | 86.99 | 86.64 | 86.94 | 2.80 | 2.51 | 10.50 | 0.00 |
| 2013 | 10147.12 | 8760 | 1130 | 100.00 | 100.00 | 102.50 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 9112.31 | 7926 | 1130 | 90.48 | 90.48 | 92.05 | 90.48 | 3.50 | 3.28 | 6.24 | 0.00 |
| 2015 | 10037.82 | 8718 | 1130 | 99.52 | 99.52 | 101.40 | 99.52 | 0.48 | 0.48 | 0.00 | 0.00 |
| 2016 | 9294.59 | 8132 | 1130 | 92.58 | 92.58 | 93.64 | 92.58 | 0.00 | 0.00 | 7.42 | 0.00 |
| 2017 | 10023.55 | 8760 | 1130 | 100.00 | 100.00 | 101.26 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 9228.95 | 8197 | 1099 | 93.57 | 93.57 | 95.86 | 93.57 | 0.00 | 0.00 | 6.43 | 0.00 |
| 2019 | 10112.18 | 8760 | 1134 | 100.00 | 100.00 | 101.80 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 9133.19 | 8283 | 1134 | 94.30 | 94.30 | 91.69 | 94.30 | 1.29 | 1.24 | 4.47 | 0.00 |
| 2021 | 10024.41 | 8760 | 1134 | 100.00 | 100.00 | 100.91 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 9117.79 | 8167 | 1134 | 93.23 | 93.23 | 91.79 | 93.23 | 0.33 | 0.31 | 6.46 | 0.00 |

2023 9955.71 8716 1134 99.23 99.23 100.22 99.50 0.19 0.19 0.59 0.00

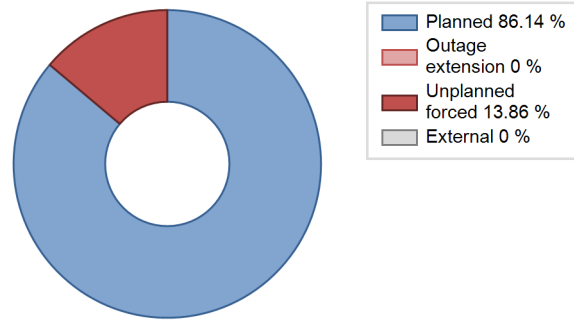
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 121 | |
| B. Refuelling without maintenance | | | | 33 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 531 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 166 | | |
| E. Testing of plant systems or components | | | | 8 | 8 | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| Z. Other | | | | 69 | 27 | |
| Subtotal | | | | 807 | 157 | |
| Total | | 0 | | | 964 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1986 to 2023 | |
|-------------------------------------|------------|--|-------------------------------------|------------|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | | | 8 |
| 12. Reactor I&C Systems | | | | 1 |
| 13. Reactor Auxiliary Systems | | | | 5 |
| 14. Safety Systems | | | | 9 |
| 15. Reactor Cooling Systems | | | | 25 |
| 31. Turbine and auxiliaries | | | | 43 |
| 32. Feedwater and Main Steam System | | | | 8 |
| 34. Miscellaneous Systems | | | | 9 |
| 41. Main Generator Systems | | | | 8 |
| 42. Electrical Power Supply Systems | | | | 18 |
| Total | | | | 134 |

2023 Operating Experience

US-353 **LIMERICK-2** **UNITED STATES OF AMERICA**

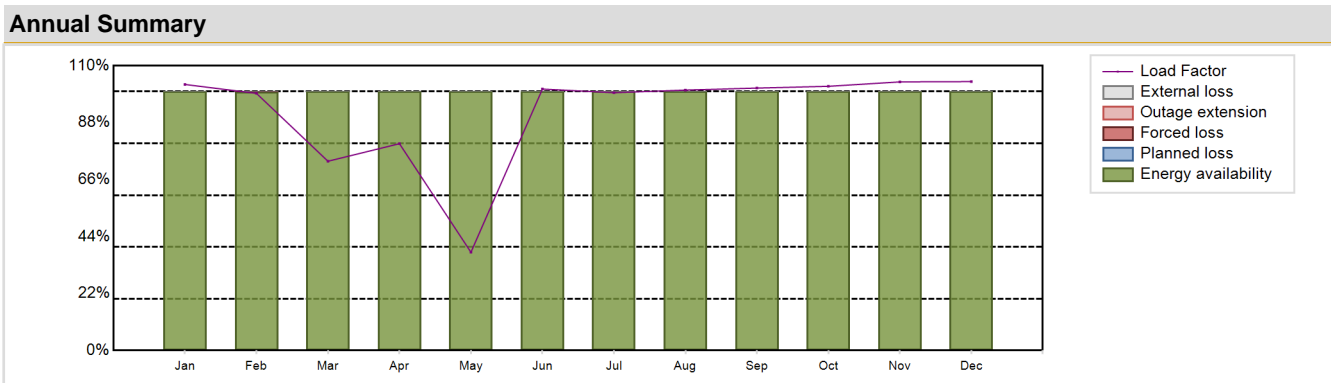
Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXELCORP (Exelon Corporation)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 2) | Construction Date | : 1974-06-19 |
| Thermal power | : 3515 MWth | Grid Date | : 1989-09-01 |
| Gross electrical power | : 1194 MWe | Commercial Date | : 1990-01-08 |
| Reference unit power (net) | : 1134 MWe | Age at end of year | : 34 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.1 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 282 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.38 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 40 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 45000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.57 | HP cylinder inlet steam pressure [MPa] | : 6.65 |
| Active core height/length [m] | : 3.71 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 764 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 16.4 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 9138.37 GW(e).h | Forced Loss Rate (FLR) | : 0.01 % |
| Energy Availability Factor (EAF) | : 99.99 % | Unplanned Capability Loss Factor (UCL) | : 0.01 % |
| Unit Capability Factor (UCF) | : 99.99 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 91.99 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 93.6 % | Total off-line time | : 561 hours |

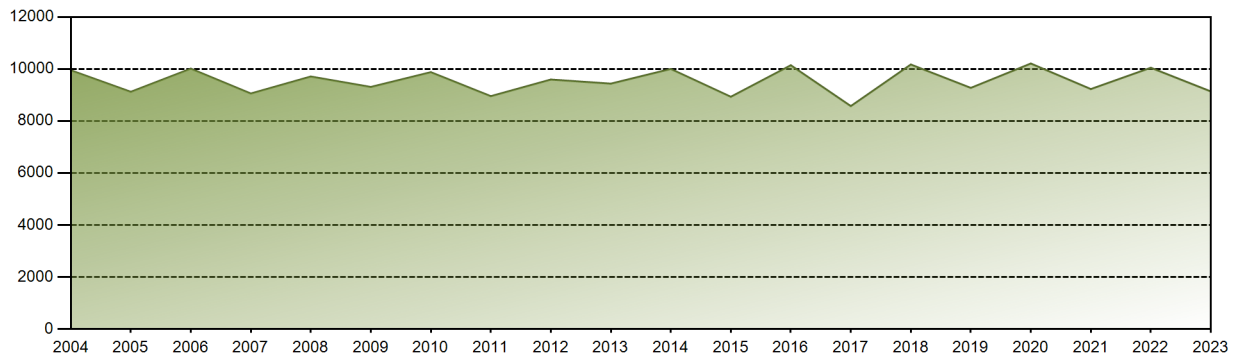


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 866.95 | 756.78 | 615.91 | 652.28 | 320.25 | 824.48 | 840.04 | 848.63 | 827.55 | 860.97 | 848.29 | 876.23 | 9138.37 |
| EAF [%] | 100.00 | 99.93 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| UCF [%] | 100.00 | 99.93 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| LF [%] | 102.76 | 99.31 | 73.10 | 79.89 | 37.96 | 100.98 | 99.57 | 100.59 | 101.36 | 102.05 | 103.75 | 103.86 | 91.99 |
| OF [%] | 100.00 | 100.00 | 83.58 | 100.00 | 40.99 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.60 |
| FLR [%] | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| UCL [%] | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

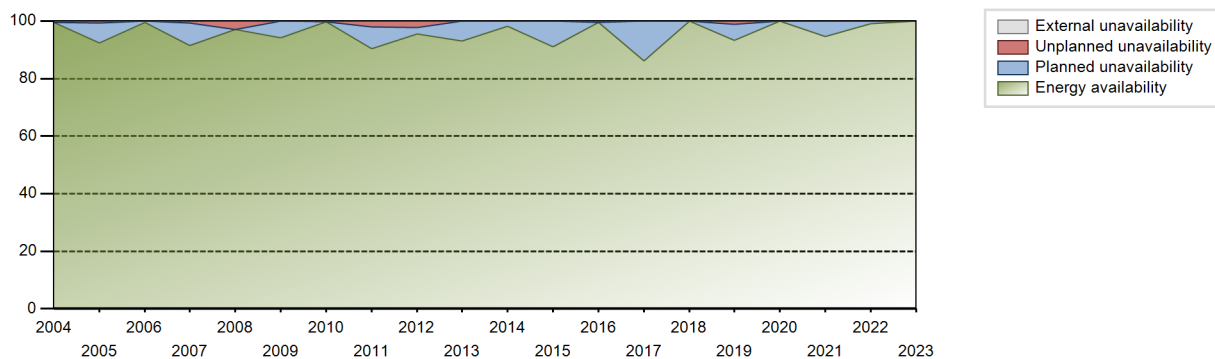
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 311858.26 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.27 % |
| Cumulative Energy Availability Factor (EAF) | : 94.12 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.21 % |
| Cumulative Unit Capability Factor (UCF) | : 94.14 % | Cumulative Planned Unavailability Factor (PUF) | : 4.65 % |
| Cumulative Load Factor (LF) | : 93.4 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 93.96 % | | |

Electricity Production (net) [GWh]

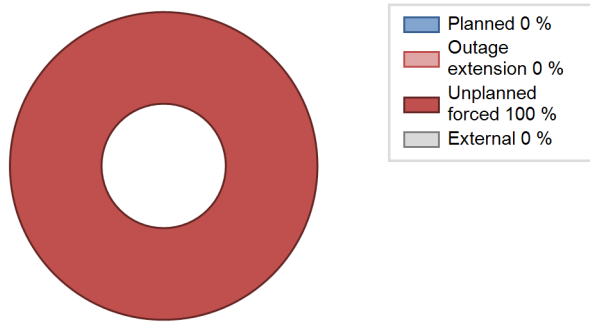


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1990 | 7232.60 | 7174 | 1055 | 81.81 | 81.81 | 79.79 | 83.50 | 13.12 | 12.35 | 5.84 | 0.00 |
| 1991 | 7146.91 | 6919 | 1055 | 77.82 | 77.82 | 77.33 | 78.98 | 0.55 | 0.43 | 21.74 | 0.00 |
| 1992 | 8489.18 | 8557 | 1055 | 97.42 | 97.42 | 91.61 | 97.42 | 2.58 | 2.58 | 0.00 | 0.00 |
| 1993 | 7468.72 | 7289 | 1055 | 82.26 | 82.26 | 80.81 | 83.21 | 2.60 | 2.20 | 15.54 | 0.00 |
| 1994 | 8571.51 | 8657 | 1055 | 98.78 | 98.78 | 92.75 | 98.82 | 1.22 | 1.22 | 0.00 | 0.00 |
| 1995 | 8401.43 | 7984 | 1110 | 91.17 | 91.17 | 86.41 | 91.14 | 2.66 | 2.49 | 6.34 | 0.00 |
| 1996 | 9001.10 | 8346 | 1115 | 95.08 | 95.72 | 91.90 | 95.01 | 4.28 | 4.28 | 0.00 | 0.64 |
| 1997 | 8307.46 | 7840 | 1115 | 89.33 | 89.33 | 85.05 | 89.50 | 0.00 | 0.00 | 10.67 | 0.00 |
| 1998 | 9257.88 | 8346 | 1115 | 95.30 | 95.30 | 94.78 | 95.27 | 0.00 | 0.00 | 4.70 | 0.00 |
| 1999 | 8560.96 | 7726 | 1135 | 88.42 | 88.42 | 86.06 | 88.20 | 1.25 | 1.12 | 10.46 | 0.00 |
| 2000 | 9940.73 | 8661 | 1145 | 98.64 | 98.64 | 98.76 | 98.60 | 1.36 | 1.36 | 0.00 | 0.00 |
| 2001 | 9243.35 | 8230 | 1143 | 93.93 | 93.93 | 92.32 | 93.95 | 1.60 | 1.53 | 4.55 | 0.00 |
| 2002 | 10009.52 | 8672 | 1134 | 98.99 | 98.99 | 100.76 | 99.00 | 1.01 | 1.01 | 0.00 | 0.00 |
| 2003 | 9387.12 | 8252 | 1134 | 94.21 | 94.21 | 94.50 | 94.20 | 0.37 | 0.35 | 5.44 | 0.00 |
| 2004 | 9952.00 | 8734 | 1134 | 99.43 | 99.43 | 99.91 | 99.43 | 0.57 | 0.57 | 0.00 | 0.00 |
| 2005 | 9124.68 | 8085 | 1134 | 92.31 | 92.31 | 91.85 | 92.29 | 0.77 | 0.71 | 6.98 | 0.00 |
| 2006 | 10015.11 | 8710 | 1134 | 99.43 | 99.43 | 100.82 | 99.43 | 0.00 | 0.00 | 0.57 | 0.00 |
| 2007 | 9059.17 | 8007 | 1134 | 91.42 | 91.42 | 91.20 | 91.40 | 0.77 | 0.71 | 7.87 | 0.00 |
| 2008 | 9712.13 | 8517 | 1134 | 96.97 | 96.97 | 97.50 | 96.96 | 3.03 | 3.03 | 0.00 | 0.00 |
| 2009 | 9311.40 | 8241 | 1134 | 94.09 | 94.09 | 93.73 | 94.08 | 0.00 | 0.00 | 5.91 | 0.00 |
| 2010 | 9879.13 | 8727 | 1134 | 99.63 | 99.63 | 99.45 | 99.62 | 0.37 | 0.37 | 0.00 | 0.00 |
| 2011 | 8956.99 | 7917 | 1134 | 90.40 | 90.40 | 90.17 | 90.38 | 2.29 | 2.12 | 7.48 | 0.00 |
| 2012 | 9595.26 | 8392 | 1134 | 95.55 | 95.55 | 96.33 | 95.54 | 2.23 | 2.18 | 2.26 | 0.00 |
| 2013 | 9437.56 | 8143 | 1134 | 92.96 | 92.96 | 94.99 | 92.95 | 0.00 | 0.00 | 7.04 | 0.00 |
| 2014 | 10003.11 | 8607 | 1134 | 98.25 | 98.25 | 100.70 | 98.25 | 0.00 | 0.00 | 1.75 | 0.00 |
| 2015 | 8933.00 | 7982 | 1134 | 91.11 | 91.11 | 89.92 | 91.12 | 0.00 | 0.00 | 8.89 | 0.00 |
| 2016 | 10144.92 | 8744 | 1134 | 99.55 | 99.55 | 101.85 | 99.54 | 0.45 | 0.45 | 0.00 | 0.00 |
| 2017 | 8574.81 | 7552 | 1134 | 86.21 | 86.21 | 86.32 | 86.21 | 0.00 | 0.00 | 13.79 | 0.00 |
| 2018 | 10173.71 | 8760 | 1134 | 100.00 | 100.00 | 102.41 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 9274.51 | 8170 | 1134 | 93.29 | 93.29 | 93.36 | 93.26 | 1.16 | 1.10 | 5.62 | 0.00 |
| 2020 | 10211.57 | 8783 | 1134 | 100.00 | 100.00 | 102.51 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 9229.49 | 8281 | 1134 | 94.54 | 94.54 | 92.91 | 94.53 | 0.00 | 0.00 | 5.46 | 0.00 |
| 2022 | 10049.36 | 8681 | 1134 | 99.10 | 99.10 | 101.16 | 99.10 | 0.00 | 0.00 | 0.90 | 0.00 |
| 2023 | 9138.37 | 8199 | 1134 | 99.99 | 99.99 | 91.99 | 93.60 | 0.01 | 0.01 | 0.00 | 0.00 |

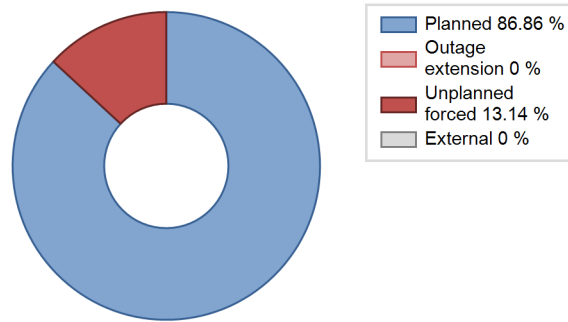
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1990 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 93 | |
| B. Refuelling without maintenance | | | | 14 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 324 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 67 | | |
| E. Testing of plant systems or components | | | | 0 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 8 | |
| Z. Other | | | | | 5 | |
| Subtotal | | | | 405 | 106 | 2 |
| Total | | 0 | | | 513 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1990 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 4 |
| 12. Reactor I&C Systems | | 3 |
| 13. Reactor Auxiliary Systems | | 2 |
| 15. Reactor Cooling Systems | | 11 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 31. Turbine and auxiliaries | | 48 |
| 32. Feedwater and Main Steam System | | 5 |
| 34. Miscellaneous Systems | | 2 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 9 |
| 42. Electrical Power Supply Systems | | 10 |
| Total | | 102 |

2023 Operating Experience

US-369

MCGUIRE-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : DUKEENER (Duke Energy Corp.)
 Owner : DUKEENER (Duke Energy Corp.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (ICECND)
 Thermal power : 3411 MWth
 Gross electrical power : 1215 MWe
 Reference unit power (net) : 1158 MWe

Key Dates

Construction Date : 1971-04-01
 Grid Date : 1981-09-12
 Commercial Date : 1981-12-01
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 37
 Average discharge burnup [MWd/t] : 40200
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 18.3
 Number of control rod assemblies : 25
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 325
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 0.204

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.83
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

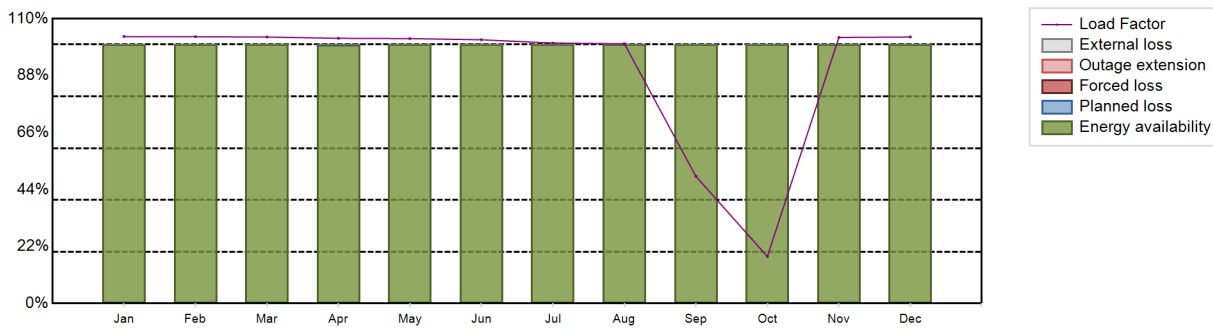
Non-electrical applications

Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9202.1 GW(e).h
 Energy Availability Factor (EAF) : 99.99 %
 Unit Capability Factor (UCF) : 99.99 %
 Load Factor (LF) : 90.71 %
 Operating Factor (OF) : 89.34 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.01 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 934 hours

Annual Summary

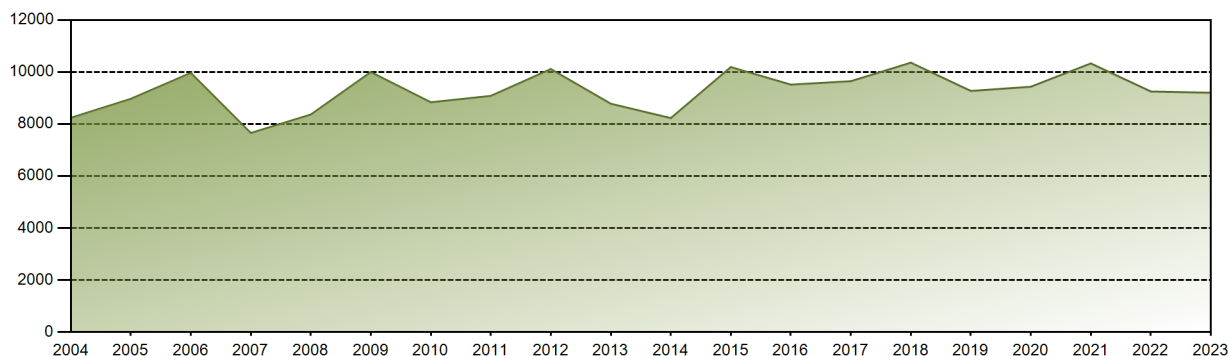


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 888.24 | 801.82 | 885.49 | 854.02 | 881.60 | 849.26 | 866.65 | 864.20 | 409.68 | 156.48 | 857.86 | 886.81 | 9202.10 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 99.93 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 99.93 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| LF [%] | 103.10 | 103.04 | 102.92 | 102.43 | 102.33 | 101.86 | 100.59 | 100.31 | 49.14 | 18.16 | 102.75 | 102.93 | 90.71 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 50.56 | 22.31 | 100.00 | 100.00 | 89.34 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 346250.41 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.91 % |
| Cumulative Energy Availability Factor (EAF) | : 84.76 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.41 % |
| Cumulative Unit Capability Factor (UCF) | : 84.98 % | Cumulative Planned Unavailability Factor (PUF) | : 10.62 % |
| Cumulative Load Factor (LF) | : 82.84 % | Cumulative Externally cause unavailability (XUF) | : 0.22 % |
| Cumulative Operating Factor (OF) | : 84.33 % | | |

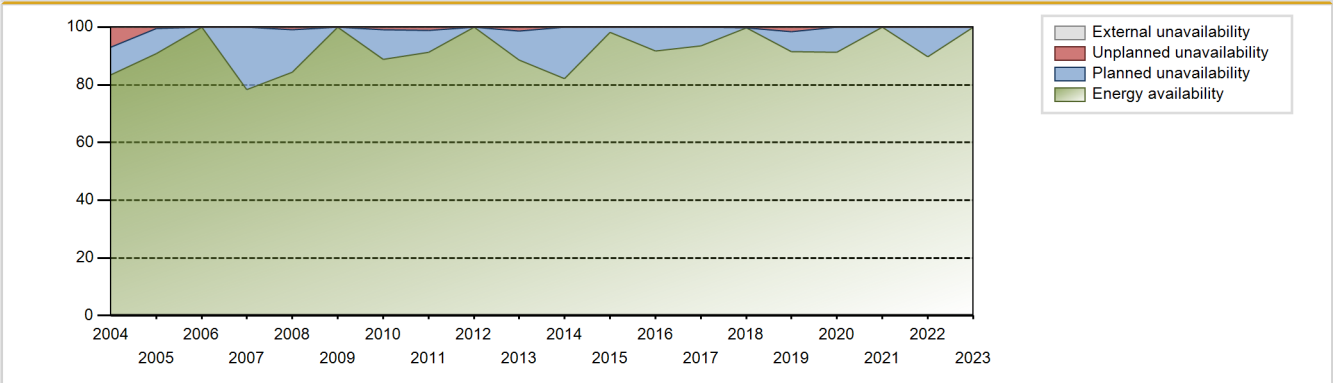
Electricity Production (net) [GWh]



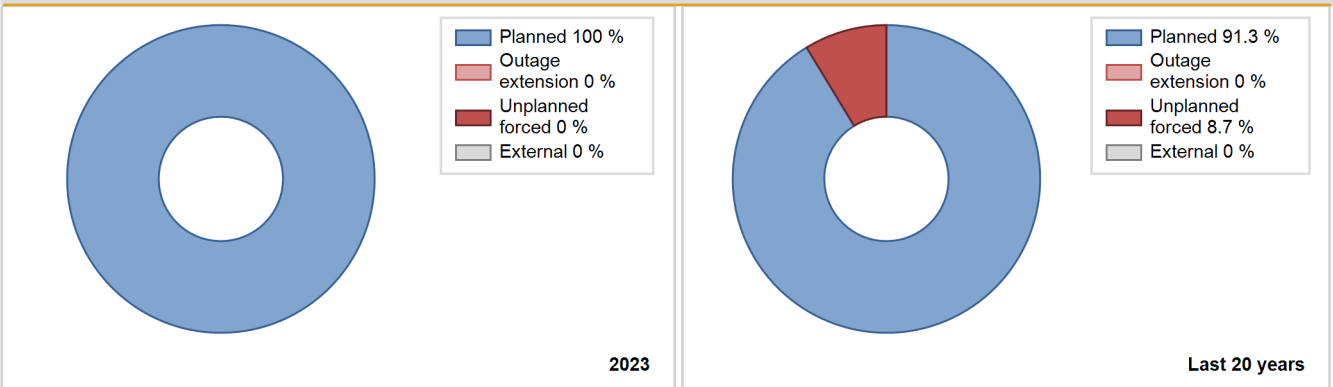
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 19.10 | 45 | 1146 | 10.20 | 10.20 | 2.18 | 6.05 | 89.80 | 89.80 | 0.00 | 0.00 |
| 1982 | 4302.30 | 7043 | 1180 | 81.62 | 81.62 | 41.62 | 80.40 | 14.80 | 14.18 | 4.20 | 0.00 |
| 1983 | 4650.00 | 4852 | 1180 | 57.26 | 57.26 | 44.98 | 55.39 | 16.60 | 11.39 | 31.34 | 0.00 |
| 1984 | 6434.27 | 6011 | 1180 | 69.33 | 78.14 | 62.08 | 68.43 | 4.14 | 3.38 | 18.48 | 8.81 |
| 1985 | 6780.08 | 6747 | 1180 | 77.10 | 77.10 | 65.59 | 77.02 | 8.75 | 7.39 | 15.51 | 0.00 |
| 1986 | 5181.08 | 4912 | 1150 | 56.16 | 56.16 | 51.43 | 56.07 | 27.72 | 21.54 | 22.29 | 0.00 |
| 1987 | 7352.88 | 6713 | 1150 | 76.70 | 76.70 | 72.99 | 76.63 | 4.75 | 3.82 | 19.48 | 0.00 |
| 1988 | 7406.41 | 6763 | 1129 | 77.04 | 77.04 | 74.68 | 76.99 | 1.35 | 1.06 | 21.90 | 0.00 |
| 1989 | 7807.23 | 7187 | 1129 | 84.49 | 84.49 | 78.94 | 82.04 | 15.49 | 15.48 | 0.03 | 0.00 |
| 1990 | 4755.31 | 4718 | 1129 | 56.90 | 56.90 | 48.08 | 53.86 | 13.38 | 8.79 | 34.30 | 0.00 |
| 1991 | 6851.08 | 6259 | 1129 | 71.45 | 71.45 | 69.27 | 71.45 | 9.09 | 7.15 | 21.40 | 0.00 |
| 1992 | 7485.28 | 6839 | 1129 | 77.89 | 77.89 | 75.48 | 77.86 | 22.11 | 22.11 | 0.00 | 0.00 |
| 1993 | 5537.09 | 5095 | 1129 | 58.18 | 58.18 | 55.99 | 58.16 | 23.34 | 17.72 | 24.10 | 0.00 |
| 1994 | 6877.25 | 6291 | 1129 | 71.86 | 71.86 | 69.54 | 71.82 | 16.20 | 13.89 | 14.25 | 0.00 |
| 1995 | 8860.20 | 8017 | 1129 | 91.58 | 91.58 | 89.59 | 91.52 | 3.72 | 3.54 | 4.89 | 0.00 |
| 1996 | 8558.29 | 7858 | 1129 | 89.50 | 89.50 | 86.30 | 89.46 | 3.79 | 3.53 | 6.97 | 0.00 |
| 1997 | 7011.25 | 6361 | 1129 | 72.68 | 72.68 | 70.89 | 72.61 | 1.83 | 1.36 | 25.96 | 0.00 |
| 1998 | 8822.61 | 7889 | 1119 | 89.99 | 89.99 | 89.98 | 90.06 | 0.73 | 0.66 | 9.35 | 0.00 |
| 1999 | 8593.31 | 7584 | 1100 | 86.58 | 86.58 | 89.18 | 86.58 | 2.15 | 1.91 | 11.51 | 0.00 |
| 2000 | 9995.02 | 8741 | 1100 | 99.52 | 99.52 | 103.44 | 99.51 | 0.48 | 0.48 | 0.00 | 0.00 |
| 2001 | 8684.94 | 7708 | 1100 | 88.00 | 88.00 | 90.13 | 87.99 | 1.70 | 1.53 | 10.47 | 0.00 |
| 2002 | 9100.83 | 8042 | 1100 | 91.83 | 91.83 | 94.45 | 91.80 | 1.04 | 1.87 | 6.30 | 0.00 |
| 2003 | 9912.47 | 8760 | 1100 | 100.00 | 100.00 | 102.87 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 8238.51 | 7321 | 1100 | 83.37 | 83.37 | 85.26 | 83.34 | 7.74 | 6.99 | 9.63 | 0.00 |
| 2005 | 8968.59 | 7963 | 1100 | 90.91 | 90.91 | 93.07 | 90.90 | 0.51 | 0.47 | 8.62 | 0.00 |
| 2006 | 9967.23 | 8760 | 1100 | 100.00 | 100.00 | 103.44 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 7656.08 | 6852 | 1100 | 78.24 | 78.24 | 79.45 | 78.22 | 0.00 | 0.00 | 21.76 | 0.00 |
| 2008 | 8364.40 | 7412 | 1100 | 84.38 | 84.38 | 86.57 | 84.38 | 1.09 | 0.93 | 14.68 | 0.00 |
| 2009 | 9999.08 | 8760 | 1100 | 100.00 | 100.00 | 103.77 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 8835.73 | 7778 | 1100 | 88.81 | 88.81 | 91.70 | 88.79 | 1.01 | 0.91 | 10.29 | 0.00 |
| 2011 | 9081.86 | 7979 | 1129 | 91.17 | 91.17 | 93.63 | 91.08 | 1.28 | 1.19 | 7.64 | 0.00 |
| 2012 | 10114.04 | 8784 | 1129 | 100.00 | 100.00 | 101.99 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 8780.45 | 7740 | 1158 | 88.65 | 88.65 | 86.55 | 88.35 | 1.46 | 1.31 | 10.04 | 0.00 |
| 2014 | 8227.61 | 7194 | 1158 | 82.13 | 82.13 | 81.11 | 82.12 | 0.00 | 0.00 | 17.87 | 0.00 |
| 2015 | 10188.92 | 8603 | 1160 | 98.21 | 98.21 | 100.27 | 98.21 | 0.00 | 0.00 | 1.79 | 0.00 |
| 2016 | 9515.88 | 8085 | 1160 | 91.77 | 91.77 | 93.39 | 92.04 | 0.00 | 0.00 | 8.23 | 0.00 |
| 2017 | 9646.27 | 8196 | 1158 | 93.55 | 93.55 | 95.09 | 93.56 | 0.00 | 0.00 | 6.45 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|--------|--------|--------|--------|------|------|-------|------|
| 2018 | 10359.25 | 8730 | 1158 | 99.66 | 99.66 | 102.12 | 99.66 | 0.34 | 0.34 | 0.00 | 0.00 |
| 2019 | 9271.86 | 8022 | 1158 | 91.59 | 91.59 | 91.40 | 91.58 | 1.75 | 1.63 | 6.78 | 0.00 |
| 2020 | 9434.12 | 8013 | 1158 | 91.23 | 91.23 | 92.75 | 91.22 | 0.00 | 0.00 | 8.77 | 0.00 |
| 2021 | 10329.64 | 8760 | 1158 | 100.00 | 100.00 | 101.83 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 9252.30 | 7867 | 1158 | 89.81 | 89.81 | 91.21 | 89.81 | 0.00 | 0.00 | 10.19 | 0.00 |
| 2023 | 9202.10 | 7826 | 1158 | 99.99 | 99.99 | 90.71 | 89.34 | 0.00 | 0.00 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 372 | |
| B. Refuelling without maintenance | | | | 40 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 770 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 99 | 0 | |
| E. Testing of plant systems or components | | | | 13 | 1 | |
| G. Major backfitting, refurbishment or upgrading activities without refuelling | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 6 | |
| L. Human factor related | | | | | 4 | |
| Z. Other | | | | 9 | 3 | 18 |
| Subtotal | | | | 932 | 386 | 18 |
| Total | | 0 | | | 1336 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 28 |
| 12. Reactor I&C Systems | | 15 |
| 13. Reactor Auxiliary Systems | | 15 |
| 14. Safety Systems | | 20 |
| 15. Reactor Cooling Systems | | 54 |
| 16. Steam generation systems | | 55 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 1 |
| 31. Turbine and auxiliaries | | 36 |
| 32. Feedwater and Main Steam System | | 116 |
| 34. Miscellaneous Systems | | 19 |
| 41. Main Generator Systems | | 4 |
| 42. Electrical Power Supply Systems | | 16 |
| Total | | 380 |

2023 Operating Experience

US-370

MCGUIRE-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : DUKEENER (Duke Energy Corp.)
 Owner : DUKEENER (Duke Energy Corp.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (ICECND)
 Thermal power : 3411 MWth
 Gross electrical power : 1215 MWe
 Reference unit power (net) : 1158 MWe

Key Dates

Construction Date : 1971-04-01
 Grid Date : 1983-05-23
 Commercial Date : 1984-03-01
 Age at end of year : 40 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 39
 Average discharge burnup [MWd/t] : 40600
 Active core diameter [m] : 3.4
 Active core height/length [m] : 3.7
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 18.3
 Number of control rod assemblies : 25
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 325
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 0.2

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.83
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

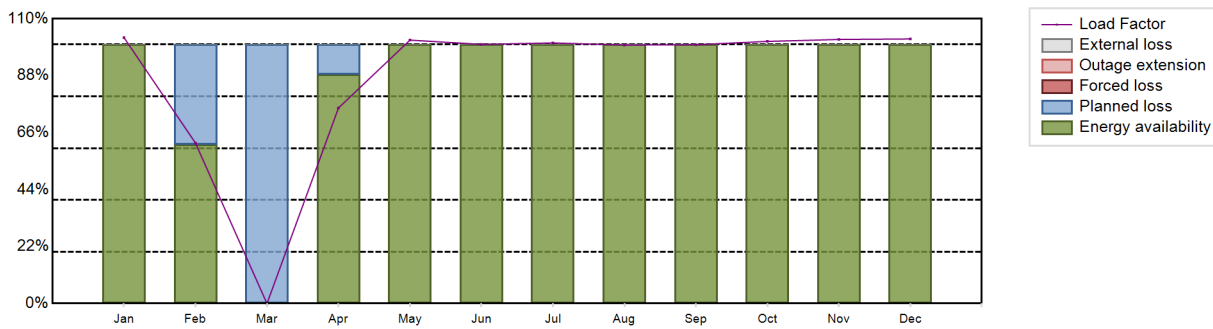
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8872.14 GW(e).h
 Energy Availability Factor (EAF) : 87.61 %
 Unit Capability Factor (UCF) : 87.61 %
 Load Factor (LF) : 87.46 %
 Operating Factor (OF) : 87.61 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 12.39 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1085 hours

Annual Summary

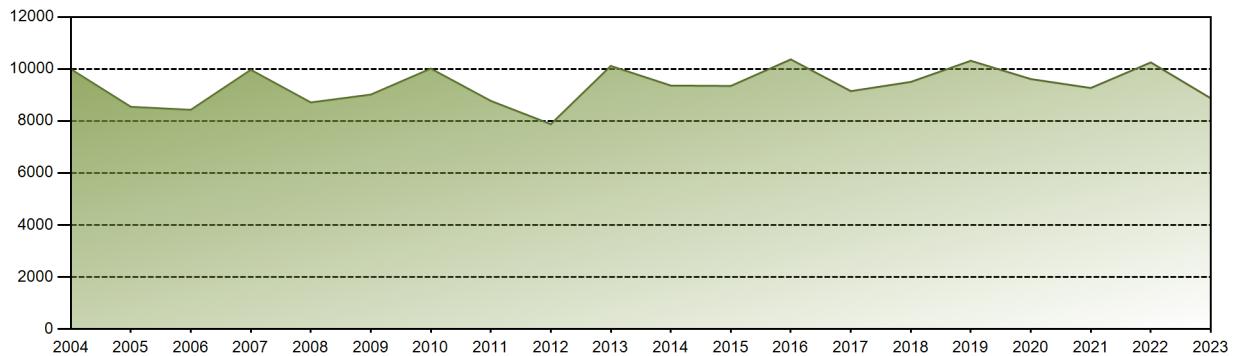


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 884.83 | 482.28 | 0.00 | 629.56 | 876.41 | 834.52 | 866.91 | 860.14 | 833.38 | 872.24 | 851.47 | 880.38 | 8872.14 |
| EAF [%] | 100.00 | 61.31 | 0.00 | 88.55 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.61 |
| UCF [%] | 100.00 | 61.31 | 0.00 | 88.55 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.61 |
| LF [%] | 102.70 | 61.98 | 0.00 | 75.51 | 101.72 | 100.09 | 100.62 | 99.84 | 99.95 | 101.24 | 101.98 | 102.19 | 87.46 |
| OF [%] | 100.00 | 61.31 | 0.00 | 88.61 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.61 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 38.69 | 100.00 | 11.45 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.39 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 344889.62 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.5 % |
| Cumulative Energy Availability Factor (EAF) | : 87.42 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.29 % |
| Cumulative Unit Capability Factor (UCF) | : 87.42 % | Cumulative Planned Unavailability Factor (PUF) | : 10.29 % |
| Cumulative Load Factor (LF) | : 87.34 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 87.29 % | | |

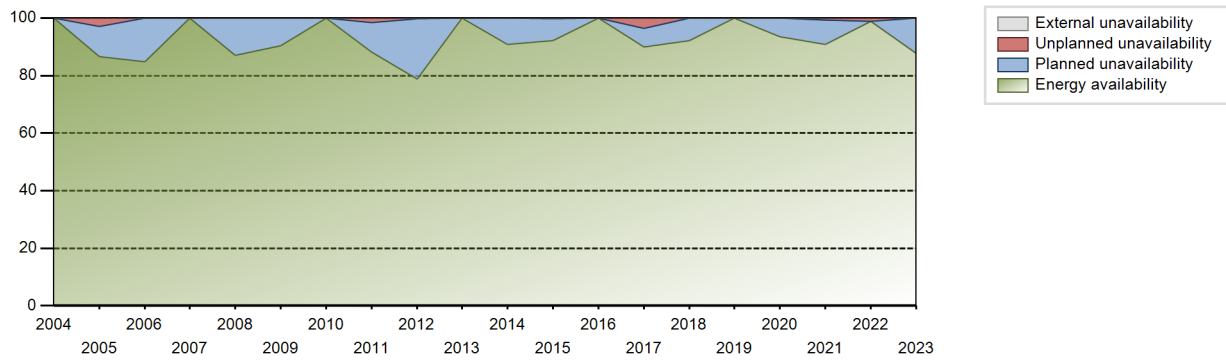
Electricity Production (net) [GWh]



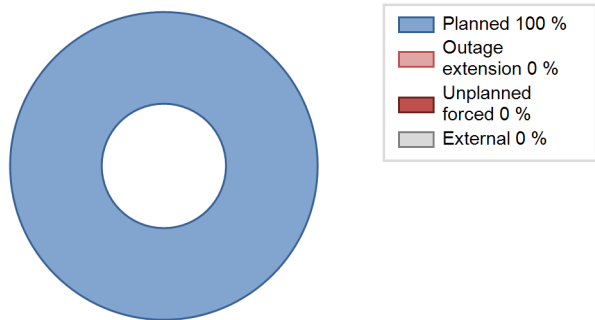
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 6557.80 | 6086 | 1171 | 82.97 | 82.97 | 75.67 | 82.87 | 16.04 | 15.85 | 1.18 | 0.00 |
| 1985 | 5609.29 | 5171 | 1180 | 61.05 | 61.05 | 54.27 | 59.03 | 18.66 | 14.01 | 24.95 | 0.00 |
| 1986 | 6216.62 | 5601 | 1150 | 64.53 | 64.53 | 61.71 | 63.94 | 10.88 | 7.88 | 27.59 | 0.00 |
| 1987 | 7577.35 | 6954 | 1150 | 80.16 | 80.16 | 75.22 | 79.38 | 2.75 | 2.26 | 17.58 | 0.00 |
| 1988 | 8058.02 | 7229 | 1129 | 82.34 | 82.34 | 81.25 | 82.30 | 1.02 | 0.84 | 16.82 | 0.00 |
| 1989 | 7418.33 | 6867 | 1129 | 78.42 | 78.42 | 75.01 | 78.39 | 0.89 | 0.71 | 20.87 | 0.00 |
| 1990 | 6496.16 | 5873 | 1129 | 69.52 | 69.52 | 65.68 | 67.04 | 1.22 | 0.86 | 29.62 | 0.00 |
| 1991 | 9515.97 | 8548 | 1129 | 97.60 | 97.60 | 96.22 | 97.58 | 2.40 | 2.40 | 0.00 | 0.00 |
| 1992 | 6785.04 | 6141 | 1129 | 69.96 | 69.96 | 68.42 | 69.91 | 3.64 | 2.64 | 27.40 | 0.00 |
| 1993 | 6821.09 | 6378 | 1129 | 72.82 | 72.82 | 68.97 | 72.81 | 2.95 | 2.21 | 24.97 | 0.00 |
| 1994 | 8659.96 | 7708 | 1129 | 88.01 | 88.01 | 87.56 | 87.99 | 1.83 | 1.64 | 10.34 | 0.00 |
| 1995 | 9090.01 | 8144 | 1129 | 93.01 | 93.01 | 91.91 | 92.97 | 4.07 | 3.95 | 3.04 | 0.00 |
| 1996 | 7265.11 | 6543 | 1129 | 74.57 | 74.57 | 73.26 | 74.49 | 16.44 | 14.67 | 10.76 | 0.00 |
| 1997 | 6648.44 | 6214 | 1129 | 70.97 | 70.97 | 67.22 | 70.94 | 10.12 | 7.99 | 21.04 | 0.00 |
| 1998 | 9928.27 | 8715 | 1119 | 99.49 | 99.49 | 101.26 | 99.49 | 0.51 | 0.51 | 0.00 | 0.00 |
| 1999 | 8596.72 | 7927 | 1100 | 90.51 | 90.51 | 89.21 | 90.49 | 0.40 | 0.36 | 9.13 | 0.00 |
| 2000 | 8452.37 | 7757 | 1100 | 88.32 | 88.32 | 87.48 | 88.31 | 0.46 | 0.41 | 11.27 | 0.00 |
| 2001 | 9878.04 | 8698 | 1100 | 99.30 | 99.30 | 102.51 | 99.29 | 0.70 | 0.70 | 0.00 | 0.00 |
| 2002 | 8913.51 | 7940 | 1100 | 90.65 | 90.65 | 92.50 | 90.64 | 0.54 | 1.94 | 7.41 | 0.00 |
| 2003 | 9027.81 | 8024 | 1100 | 91.61 | 91.61 | 93.69 | 91.60 | 0.00 | 0.52 | 7.86 | 0.00 |
| 2004 | 9994.02 | 8784 | 1100 | 100.00 | 100.00 | 103.43 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 8545.57 | 7589 | 1100 | 86.66 | 86.66 | 88.67 | 86.62 | 3.20 | 2.87 | 10.47 | 0.00 |
| 2006 | 8430.33 | 7418 | 1100 | 84.70 | 84.70 | 87.49 | 84.68 | 0.00 | 0.00 | 15.30 | 0.00 |
| 2007 | 9967.57 | 8760 | 1100 | 100.00 | 100.00 | 103.44 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 8713.27 | 7651 | 1100 | 87.11 | 87.11 | 90.18 | 87.10 | 0.00 | 0.00 | 12.89 | 0.00 |
| 2009 | 9015.67 | 7907 | 1100 | 90.27 | 90.27 | 93.56 | 90.26 | 0.00 | 0.00 | 9.73 | 0.00 |
| 2010 | 10014.70 | 8760 | 1100 | 100.00 | 100.00 | 103.93 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 8773.24 | 7705 | 1129 | 88.22 | 88.22 | 89.27 | 87.96 | 1.75 | 1.57 | 10.21 | 0.00 |
| 2012 | 7878.65 | 6923 | 1129 | 78.83 | 78.83 | 79.44 | 78.81 | 0.34 | 0.27 | 20.90 | 0.00 |
| 2013 | 10117.09 | 8760 | 1158 | 100.00 | 100.00 | 99.72 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 9362.49 | 7956 | 1158 | 90.82 | 90.82 | 92.30 | 90.82 | 0.00 | 0.00 | 9.18 | 0.00 |
| 2015 | 9347.08 | 8079 | 1158 | 92.22 | 92.22 | 92.14 | 92.23 | 0.19 | 0.17 | 7.60 | 0.00 |
| 2016 | 10368.41 | 8784 | 1158 | 100.00 | 100.00 | 101.93 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 9149.27 | 7878 | 1158 | 89.94 | 89.94 | 90.19 | 89.93 | 3.79 | 3.55 | 6.52 | 0.00 |
| 2018 | 9502.82 | 8076 | 1158 | 92.20 | 92.20 | 93.68 | 92.19 | 0.00 | 0.00 | 7.80 | 0.00 |
| 2019 | 10316.39 | 8760 | 1158 | 100.00 | 100.00 | 101.70 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 9612.83 | 8221 | 1158 | 93.60 | 93.60 | 94.50 | 93.59 | 0.00 | 0.00 | 6.40 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|-------|-------|--------|-------|------|------|-------|------|
| 2021 | 9269.56 | 7963 | 1158 | 90.90 | 90.90 | 91.38 | 90.90 | 0.88 | 0.81 | 8.29 | 0.00 |
| 2022 | 10252.47 | 8664 | 1158 | 98.90 | 98.90 | 101.07 | 98.90 | 1.10 | 1.10 | 0.00 | 0.00 |
| 2023 | 8872.14 | 7675 | 1158 | 87.61 | 87.61 | 87.46 | 87.61 | 0.00 | 0.00 | 12.39 | 0.00 |

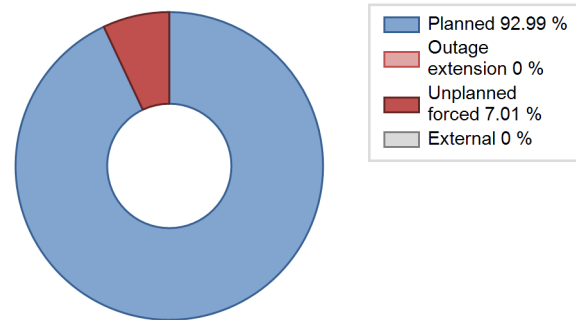
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 184 | |
| B. Refuelling without maintenance | | | | 32 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1296 | | | 814 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 65 | 0 | |
| E. Testing of plant systems or components | | | | 0 | 0 | |
| H. Nuclear regulatory requirements | | | | | 7 | |
| L. Human factor related | | | | | 3 | |
| Z. Other | | | | 0 | 5 | |
| Subtotal | 1296 | | | 911 | 199 | |
| Total | | 1296 | | | 1110 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 16 |
| 13. Reactor Auxiliary Systems | | 14 |
| 14. Safety Systems | | 13 |
| 15. Reactor Cooling Systems | | 56 |
| 16. Steam generation systems | | 9 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 6 |
| 32. Feedwater and Main Steam System | | 28 |
| 34. Miscellaneous Systems | | 1 |
| 41. Main Generator Systems | | 33 |
| 42. Electrical Power Supply Systems | | 14 |
| Total | | 195 |

2023 Operating Experience

US-336 **MILLSTONE-2** **UNITED STATES OF AMERICA**

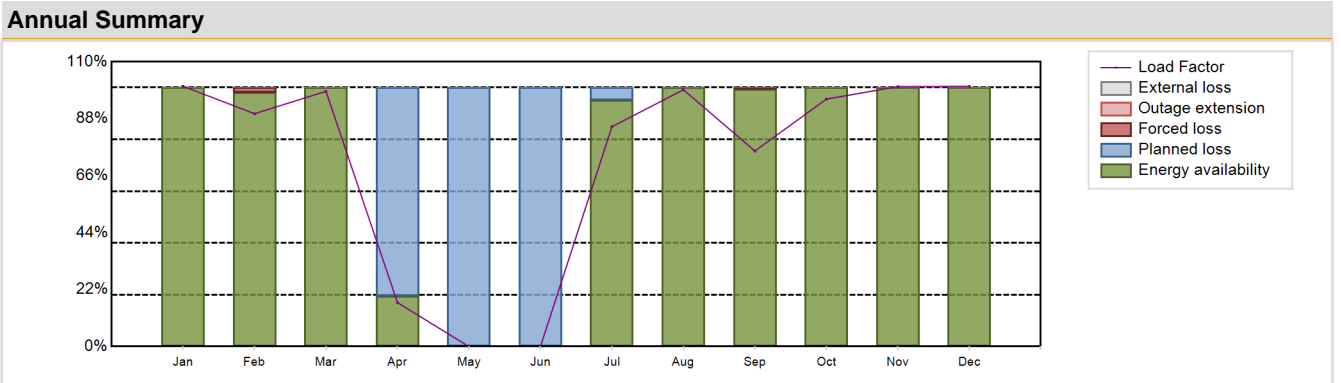
Status at end of year : **Operational**
 Operator : DOMINION (Dominion Energy)
 Owner : DOMINRES (Dominion Resources, Inc.)
 Reactor Supplier : CE (COMBUSTION ENGINEERING CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / CE 2LP (DRYAMB) | Construction Date | : 1969-11-01 |
| Thermal power | : 2700 MWth | Grid Date | : 1975-11-09 |
| Gross electrical power | : 918 MWe | Commercial Date | : 1975-12-26 |
| Reference unit power (net) | : 869 MWe | Age at end of year | : 48 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 312.7 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.483 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.45 | HP cylinder inlet steam pressure [MPa] | : 5.73 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 49 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 5476.38 GW(e).h | Forced Loss Rate (FLR) | : 0.26 % |
| Energy Availability Factor (EAF) | : 76.07 % | Unplanned Capability Loss Factor (UCL) | : 0.2 % |
| Unit Capability Factor (UCF) | : 76.07 % | Planned Unavailability Factor (PUF) | : 23.73 % |
| Load Factor (LF) | : 71.94 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 76.27 % | Total off-line time | : 2079 hours |

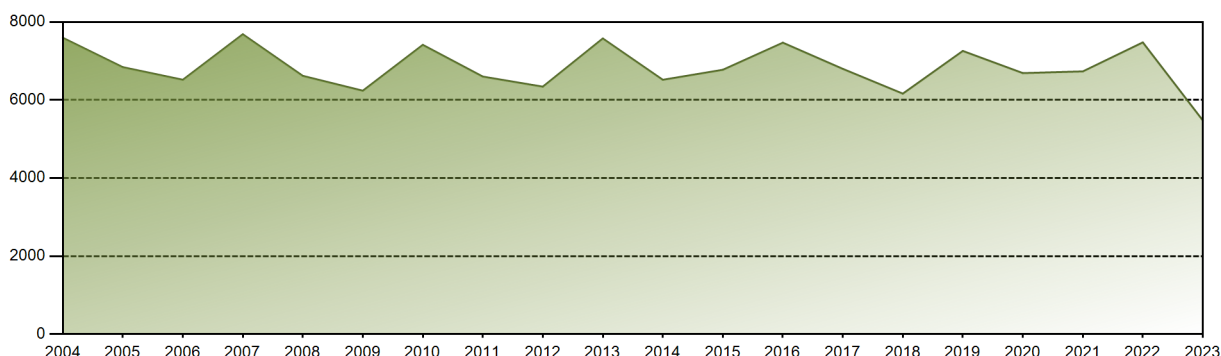


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 649.85 | 525.13 | 636.33 | 106.17 | 0.00 | 0.00 | 548.86 | 641.17 | 472.54 | 617.84 | 628.96 | 649.55 | 5476.38 |
| EAF [%] | 100.00 | 98.03 | 100.00 | 19.54 | 0.00 | 0.00 | 95.23 | 100.00 | 99.40 | 100.00 | 100.00 | 100.00 | 76.07 |
| UCF [%] | 100.00 | 98.03 | 100.00 | 19.54 | 0.00 | 0.00 | 95.23 | 100.00 | 99.40 | 100.00 | 100.00 | 100.00 | 76.07 |
| LF [%] | 100.51 | 89.92 | 98.55 | 16.97 | 0.00 | 0.00 | 84.89 | 99.17 | 75.52 | 95.56 | 100.39 | 100.47 | 71.94 |
| OF [%] | 100.00 | 100.00 | 100.00 | 19.58 | 0.00 | 0.00 | 95.16 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 76.27 |
| FLR [%] | 0.00 | 1.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 | 0.00 | 0.00 | 0.00 | 0.26 |
| UCL [%] | 0.00 | 1.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 | 0.00 | 0.00 | 0.00 | 0.20 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 80.46 | 100.00 | 100.00 | 4.77 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 23.73 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 261735.71 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 14.49 % |
| Cumulative Energy Availability Factor (EAF) | : 73.56 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 12.56 % |
| Cumulative Unit Capability Factor (UCF) | : 74.11 % | Cumulative Planned Unavailability Factor (PUF) | : 13.33 % |
| Cumulative Load Factor (LF) | : 72.12 % | Cumulative Externally cause unavailability (XUF) | : 0.55 % |
| Cumulative Operating Factor (OF) | : 73.82 % | | |

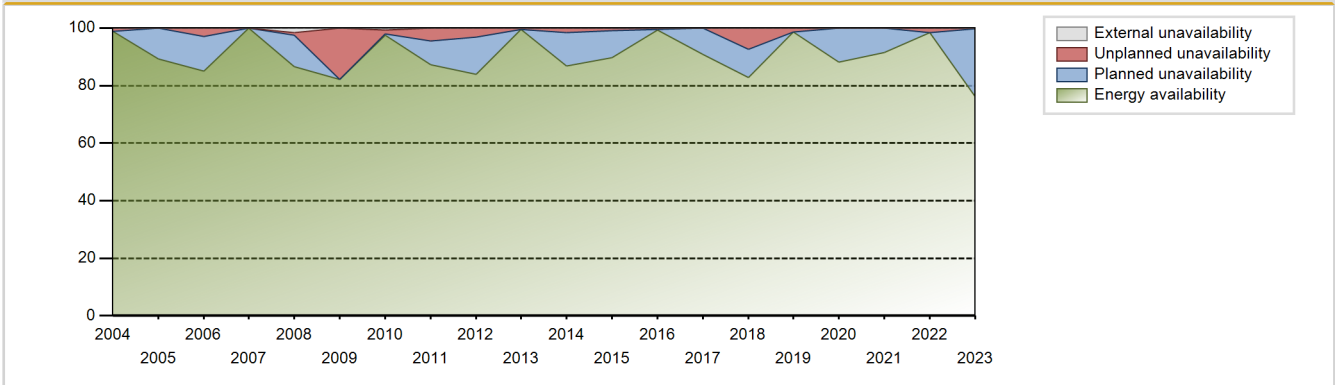
Electricity Production (net) [GWh]



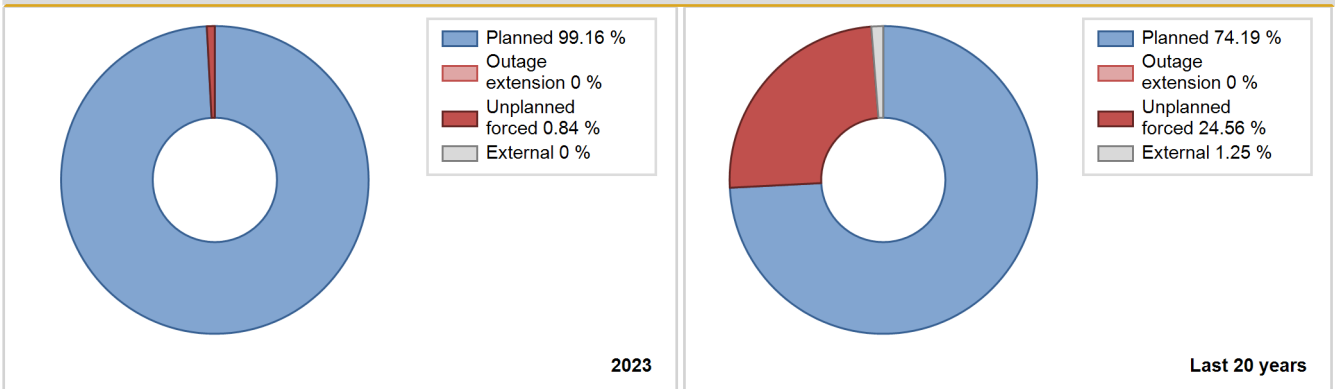
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|--------|--------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1975 | 134.70 | 623 | 851 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1976 | 4543.20 | 6815 | 780 | 66.37 | 66.37 | 66.31 | 77.58 | 31.06 | 29.91 | 3.72 | 0.00 |
| 1977 | 4345.70 | 5756 | 790 | 62.88 | 62.88 | 62.80 | 65.71 | 19.40 | 15.13 | 21.99 | 0.00 |
| 1978 | 4507.20 | 5756 | 802 | 64.12 | 64.12 | 64.15 | 65.71 | 23.99 | 20.24 | 15.64 | 0.00 |
| 1979 | 4370.90 | 5385 | 837 | 59.58 | 59.58 | 59.61 | 61.47 | 23.78 | 18.59 | 21.82 | 0.00 |
| 1980 | 4884.30 | 5947 | 864 | 68.17 | 80.81 | 64.36 | 67.70 | 2.03 | 1.68 | 17.51 | 12.65 |
| 1981 | 6091.70 | 7229 | 864 | 82.71 | 82.71 | 80.49 | 82.52 | 10.74 | 9.95 | 7.33 | 0.00 |
| 1982 | 5015.60 | 6183 | 864 | 70.48 | 70.48 | 66.27 | 70.58 | 11.29 | 8.97 | 20.55 | 0.00 |
| 1983 | 2474.40 | 2993 | 861 | 34.07 | 34.07 | 32.81 | 34.17 | 13.92 | 5.51 | 60.42 | 0.00 |
| 1984 | 6608.34 | 8209 | 860 | 93.40 | 93.40 | 87.48 | 93.45 | 3.79 | 3.68 | 2.92 | 0.00 |
| 1985 | 3515.65 | 4322 | 841 | 47.66 | 59.35 | 47.72 | 49.34 | 2.23 | 1.35 | 39.29 | 11.69 |
| 1986 | 5164.85 | 6352 | 857 | 72.50 | 72.50 | 68.80 | 72.51 | 2.59 | 1.93 | 25.58 | 0.00 |
| 1987 | 6892.53 | 8177 | 857 | 93.29 | 93.29 | 91.81 | 93.34 | 6.47 | 6.45 | 0.26 | 0.00 |
| 1988 | 5735.94 | 6810 | 860 | 77.24 | 77.24 | 75.89 | 77.53 | 3.29 | 2.63 | 20.13 | 0.00 |
| 1989 | 4763.57 | 5705 | 863 | 66.85 | 66.85 | 62.95 | 65.13 | 0.00 | 0.00 | 33.15 | 0.00 |
| 1990 | 5309.94 | 6389 | 863 | 72.84 | 72.84 | 70.24 | 72.93 | 2.54 | 1.90 | 25.26 | 0.00 |
| 1991 | 3948.13 | 4820 | 863 | 55.28 | 55.28 | 52.22 | 55.02 | 44.49 | 44.31 | 0.41 | 0.00 |
| 1992 | 2725.02 | 3187 | 870 | 36.12 | 36.12 | 35.64 | 36.28 | 11.45 | 4.67 | 59.21 | 0.00 |
| 1993 | 6295.91 | 7431 | 873 | 84.79 | 84.79 | 82.33 | 84.83 | 11.85 | 11.39 | 3.81 | 0.00 |
| 1994 | 3676.45 | 4289 | 873 | 49.02 | 49.02 | 48.07 | 48.96 | 34.50 | 25.82 | 25.16 | 0.00 |
| 1995 | 2740.54 | 3273 | 873 | 37.39 | 37.39 | 35.84 | 37.36 | 8.62 | 3.53 | 59.09 | 0.00 |
| 1996 | 1046.48 | 1222 | 871 | 13.73 | 13.73 | 13.68 | 13.91 | 85.90 | 83.63 | 2.65 | 0.00 |
| 1997 | 0.00 | 0 | 871 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1998 | 0.00 | 0 | 871 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1999 | 4433.22 | 5310 | 870 | 60.63 | 60.63 | 58.17 | 60.62 | 39.37 | 39.37 | 0.00 | 0.00 |
| 2000 | 6268.50 | 7353 | 873 | 83.70 | 83.70 | 81.77 | 83.71 | 6.03 | 5.38 | 10.93 | 0.00 |
| 2001 | 7284.02 | 8587 | 869 | 98.04 | 98.04 | 95.44 | 98.03 | 1.96 | 1.96 | 0.00 | 0.00 |
| 2002 | 6209.31 | 7285 | 871 | 83.20 | 83.20 | 81.47 | 83.16 | 4.90 | 4.29 | 12.51 | 0.00 |
| 2003 | 6109.80 | 7083 | 866 | 80.88 | 80.88 | 80.19 | 80.86 | 7.18 | 6.25 | 12.87 | 0.00 |
| 2004 | 7596.04 | 8677 | 877 | 98.81 | 98.81 | 98.71 | 98.78 | 1.19 | 1.19 | 0.00 | 0.00 |
| 2005 | 6843.02 | 7812 | 866 | 89.19 | 89.19 | 90.19 | 89.17 | 0.00 | 0.00 | 10.81 | 0.00 |
| 2006 | 6519.46 | 7453 | 882 | 85.10 | 85.10 | 84.38 | 85.08 | 3.42 | 3.02 | 11.88 | 0.00 |
| 2007 | 7686.76 | 8760 | 877 | 100.00 | 100.00 | 100.06 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 6619.59 | 7596 | 877 | 86.50 | 88.17 | 85.93 | 86.48 | 0.97 | 0.86 | 10.97 | 1.67 |
| 2009 | 6239.17 | 7196 | 877 | 82.18 | 82.18 | 81.21 | 82.15 | 17.82 | 17.82 | 0.00 | 0.00 |
| 2010 | 7414.57 | 8547 | 869 | 97.56 | 98.22 | 97.40 | 97.57 | 1.29 | 1.28 | 0.50 | 0.67 |
| 2011 | 6601.01 | 7620 | 869 | 87.17 | 87.17 | 86.71 | 86.99 | 5.00 | 4.59 | 8.24 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|-------|------|
| 2012 | 6342.84 | 7363 | 869 | 83.85 | 83.85 | 83.09 | 83.82 | 3.66 | 3.18 | 12.97 | 0.00 |
| 2013 | 7578.99 | 8711 | 869 | 99.44 | 99.44 | 99.55 | 99.43 | 0.56 | 0.56 | 0.00 | 0.00 |
| 2014 | 6518.71 | 7534 | 869 | 86.75 | 86.75 | 85.63 | 86.00 | 1.84 | 1.62 | 11.62 | 0.00 |
| 2015 | 6775.63 | 7860 | 869 | 89.72 | 89.72 | 89.01 | 89.73 | 0.94 | 0.85 | 9.43 | 0.00 |
| 2016 | 7469.89 | 8725 | 869 | 99.33 | 99.33 | 97.86 | 99.33 | 0.54 | 0.54 | 0.13 | 0.00 |
| 2017 | 6798.76 | 7953 | 869 | 90.79 | 90.79 | 89.31 | 90.79 | 0.00 | 0.00 | 9.21 | 0.00 |
| 2018 | 6163.60 | 7251 | 869 | 82.77 | 82.77 | 80.97 | 82.77 | 8.14 | 7.34 | 9.89 | 0.00 |
| 2019 | 7257.73 | 8637 | 869 | 98.61 | 98.61 | 95.34 | 98.60 | 1.39 | 1.39 | 0.00 | 0.00 |
| 2020 | 6690.50 | 7748 | 869 | 88.22 | 88.22 | 87.65 | 88.21 | 0.00 | 0.00 | 11.78 | 0.00 |
| 2021 | 6733.75 | 8009 | 869 | 91.42 | 91.42 | 88.46 | 91.43 | 0.00 | 0.00 | 8.58 | 0.00 |
| 2022 | 7477.47 | 8612 | 869 | 98.31 | 98.31 | 98.23 | 98.31 | 1.69 | 1.69 | 0.00 | 0.00 |
| 2023 | 5476.38 | 6681 | 869 | 76.07 | 76.07 | 71.94 | 76.27 | 0.26 | 0.20 | 23.73 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1975 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 451 | |
| B. Refuelling without maintenance | | | | 37 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2043 | | | 1069 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 35 | | |
| E. Testing of plant systems or components | | | | 7 | 152 | |
| H. Nuclear regulatory requirements | | | | | 463 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 20 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 27 |
| Z. Other | | | | 18 | 5 | |
| Subtotal | 2043 | | | 1166 | 1091 | 28 |
| Total | | 2043 | | | 2285 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1975 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 47 |
| 13. Reactor Auxiliary Systems | | 9 |
| 14. Safety Systems | | 12 |
| 15. Reactor Cooling Systems | | 92 |
| 16. Steam generation systems | | 70 |
| 31. Turbine and auxiliaries | | 61 |
| 32. Feedwater and Main Steam System | | 75 |
| 33. Circulating Water System | | 11 |
| 34. Miscellaneous Systems | | 165 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 8 |
| 42. Electrical Power Supply Systems | | 66 |
| Total | | 619 |

2023 Operating Experience

US-423 **MILLSTONE-3** **UNITED STATES OF AMERICA**

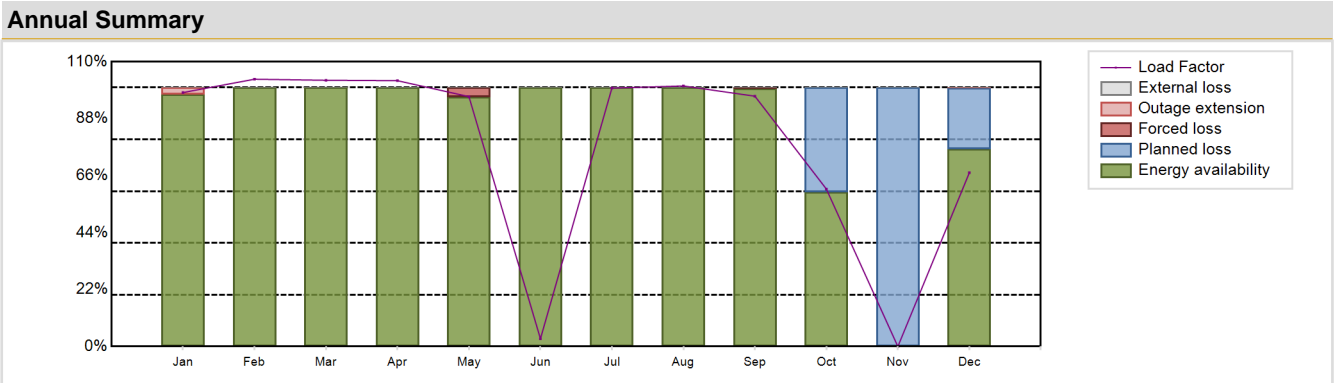
Status at end of year : **Operational**
 Operator : DOMINION (Dominion Energy)
 Owner : DOMINRES (Dominion Resources, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 4LP (DRYSUB) | Construction Date | : 1974-08-09 |
| Thermal power | : 3650 MWth | Grid Date | : 1986-02-12 |
| Gross electrical power | : 1280 MWe | Commercial Date | : 1986-04-23 |
| Reference unit power (net) | : 1210 MWe | Age at end of year | : 37 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.9 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.17 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.4 | HP cylinder inlet steam pressure [MPa] | : 6.7 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 580 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.2 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 24 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 8234.86 GW(e).h | Forced Loss Rate (FLR) | : 0.37 % |
| Energy Availability Factor (EAF) | : 85.79 % | Unplanned Capability Loss Factor (UCL) | : 0.54 % |
| Unit Capability Factor (UCF) | : 85.79 % | Planned Unavailability Factor (PUF) | : 13.67 % |
| Load Factor (LF) | : 77.69 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 77.93 % | Total off-line time | : 1933 hours |

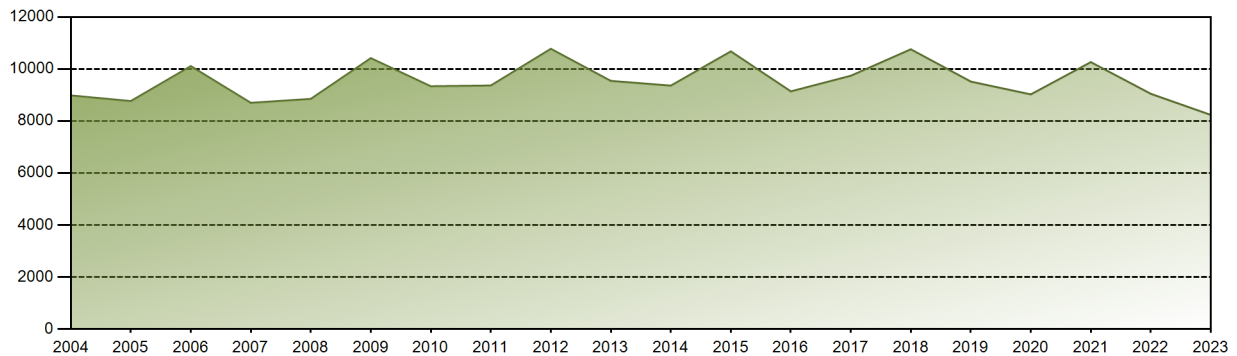


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 883.08 | 839.45 | 924.46 | 894.50 | 868.79 | 26.10 | 898.50 | 905.86 | 842.31 | 547.45 | 0.00 | 604.37 | 8234.86 |
| EAF [%] | 97.49 | 100.00 | 100.00 | 100.00 | 96.48 | 100.00 | 100.00 | 100.00 | 99.73 | 59.57 | 0.00 | 76.34 | 85.79 |
| UCF [%] | 97.49 | 100.00 | 100.00 | 100.00 | 96.48 | 100.00 | 100.00 | 100.00 | 99.73 | 59.57 | 0.00 | 76.34 | 85.79 |
| LF [%] | 98.09 | 103.24 | 102.83 | 102.67 | 96.51 | 3.00 | 99.81 | 100.62 | 96.68 | 60.81 | 0.00 | 67.13 | 77.69 |
| OF [%] | 97.18 | 100.00 | 100.00 | 100.00 | 94.22 | 6.11 | 100.00 | 100.00 | 100.00 | 59.95 | 0.00 | 76.61 | 77.93 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 3.52 | 0.00 | 0.00 | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.37 |
| UCL [%] | 2.51 | 0.00 | 0.00 | 0.00 | 3.52 | 0.00 | 0.00 | 0.00 | 0.27 | 0.00 | 0.00 | 0.02 | 0.54 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 40.43 | 100.00 | 23.64 | 13.67 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 310529.29 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 10.63 % |
| Cumulative Energy Availability Factor (EAF) | : 81.91 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 9.75 % |
| Cumulative Unit Capability Factor (UCF) | : 81.92 % | Cumulative Planned Unavailability Factor (PUF) | : 8.33 % |
| Cumulative Load Factor (LF) | : 80.4 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 81.02 % | | |

Electricity Production (net) [GWh]

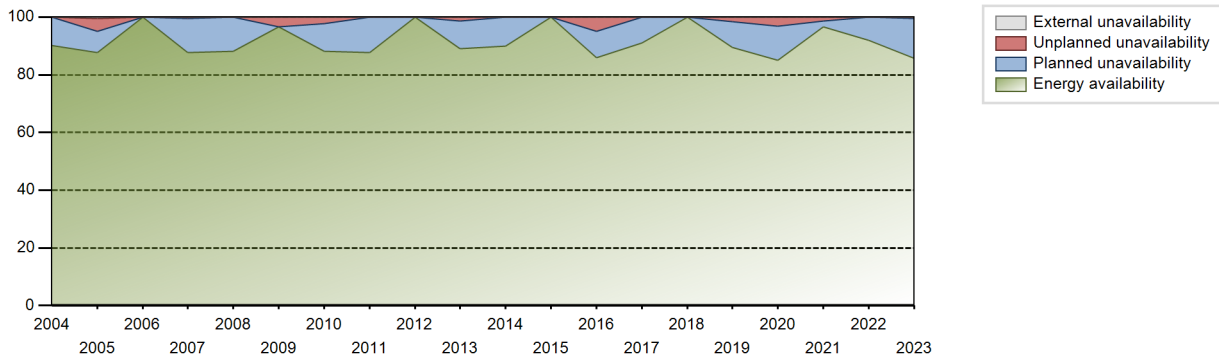


Performance for Years of Commercial Operation

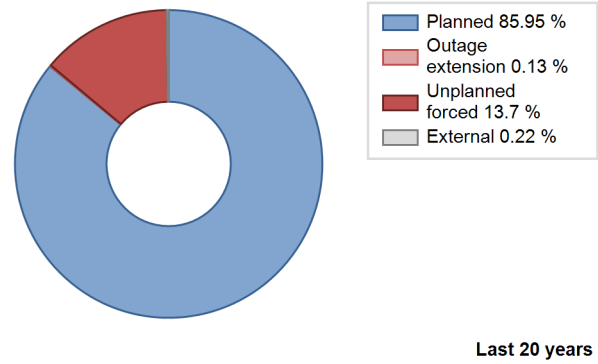
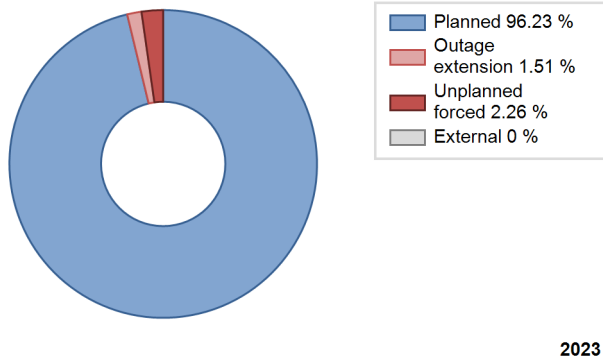
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------------------|--------|--------|--------|--------|--------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | | | | Data not provided | | | | | | | |
| 1987 | 6748.20 | 6235 | 1142 | 71.36 | 71.36 | 67.46 | 71.18 | 5.40 | 4.07 | 24.56 | 0.00 |
| 1988 | 7683.62 | 6954 | 1142 | 79.50 | 79.50 | 76.60 | 79.17 | 11.03 | 9.85 | 10.65 | 0.00 |
| 1989 | 7082.60 | 6636 | 1142 | 75.89 | 75.89 | 70.80 | 75.75 | 9.03 | 7.54 | 16.57 | 0.00 |
| 1990 | 8218.24 | 7798 | 1137 | 89.18 | 89.18 | 82.51 | 89.02 | 10.63 | 10.60 | 0.22 | 0.00 |
| 1991 | 2876.71 | 2850 | 1137 | 33.57 | 33.57 | 28.88 | 32.53 | 58.17 | 46.68 | 19.76 | 0.00 |
| 1992 | 6593.81 | 6311 | 1137 | 72.11 | 72.11 | 66.02 | 71.85 | 23.89 | 22.64 | 5.25 | 0.00 |
| 1993 | 6502.83 | 6106 | 1137 | 70.15 | 70.15 | 65.29 | 69.70 | 4.20 | 3.08 | 26.77 | 0.00 |
| 1994 | 9416.15 | 8426 | 1137 | 96.26 | 96.26 | 94.54 | 96.19 | 3.74 | 3.74 | 0.00 | 0.00 |
| 1995 | 7993.62 | 7083 | 1137 | 81.20 | 81.20 | 80.26 | 80.86 | 0.00 | 0.00 | 18.80 | 0.00 |
| 1996 | 2476.71 | 2156 | 1137 | 25.68 | 25.68 | 24.80 | 24.54 | 74.32 | 74.32 | 0.00 | 0.00 |
| 1997 | 0.00 | 0 | 1137 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1998 | 3392.06 | 3402 | 1137 | 38.87 | 38.87 | 34.06 | 38.84 | 61.01 | 60.83 | 0.30 | 0.00 |
| 1999 | 8307.55 | 7329 | 1139 | 83.67 | 83.67 | 83.21 | 83.66 | 0.00 | 0.00 | 16.33 | 0.00 |
| 2000 | 10125.72 | 8784 | 1151 | 100.00 | 100.00 | 100.09 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 8169.69 | 7392 | 1136 | 84.33 | 84.33 | 81.35 | 84.38 | 0.00 | 0.00 | 15.67 | 0.00 |
| 2002 | 8746.21 | 7803 | 1130 | 88.96 | 88.96 | 88.12 | 89.08 | 2.70 | 2.47 | 8.57 | 0.00 |
| 2003 | 10005.70 | 8729 | 1130 | 99.65 | 99.65 | 101.08 | 99.65 | 0.35 | 0.35 | 0.00 | 0.00 |
| 2004 | 8983.70 | 7905 | 1148 | 90.06 | 90.06 | 89.91 | 89.99 | 0.00 | 0.00 | 9.94 | 0.00 |
| 2005 | 8766.99 | 7677 | 1131 | 87.65 | 88.04 | 88.49 | 87.64 | 4.98 | 4.61 | 7.34 | 0.40 |
| 2006 | 10111.10 | 8760 | 1155 | 100.00 | 100.00 | 99.93 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 8699.38 | 7694 | 1145 | 87.74 | 87.74 | 86.73 | 87.83 | 0.62 | 0.55 | 11.71 | 0.00 |
| 2008 | 8850.30 | 7739 | 1145 | 88.12 | 88.12 | 88.00 | 88.10 | 0.00 | 0.00 | 11.88 | 0.00 |
| 2009 | 10418.22 | 8470 | 1137 | 96.68 | 96.68 | 104.60 | 96.69 | 3.32 | 3.32 | 0.00 | 0.00 |
| 2010 | 9335.74 | 7623 | 1233 | 88.05 | 88.05 | 86.43 | 87.02 | 2.61 | 2.36 | 9.59 | 0.00 |
| 2011 | 9365.73 | 7674 | 1233 | 87.61 | 87.61 | 86.71 | 87.60 | 0.00 | 0.00 | 12.39 | 0.00 |
| 2012 | 10776.49 | 8784 | 1218 | 100.00 | 100.00 | 100.73 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 9542.43 | 7803 | 1210 | 89.01 | 89.01 | 89.92 | 89.07 | 1.41 | 1.28 | 9.71 | 0.00 |
| 2014 | 9360.53 | 7676 | 1218 | 89.99 | 89.99 | 87.73 | 87.63 | 0.00 | 0.00 | 10.01 | 0.00 |
| 2015 | 10677.97 | 8760 | 1229 | 100.00 | 100.00 | 99.18 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 9140.32 | 7539 | 1229 | 85.83 | 85.83 | 84.67 | 85.83 | 5.47 | 4.96 | 9.21 | 0.00 |
| 2017 | 9740.29 | 7972 | 1229 | 91.00 | 91.00 | 90.47 | 91.00 | 0.00 | 0.00 | 9.00 | 0.00 |
| 2018 | 10758.28 | 8760 | 1210 | 100.00 | 100.00 | 101.50 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 9516.62 | 7834 | 1210 | 89.45 | 89.45 | 89.78 | 89.43 | 1.63 | 1.48 | 9.06 | 0.00 |
| 2020 | 9024.35 | 7438 | 1210 | 85.13 | 85.13 | 84.91 | 84.68 | 3.54 | 3.12 | 11.75 | 0.00 |
| 2021 | 10265.20 | 8459 | 1210 | 96.56 | 96.56 | 96.85 | 96.56 | 1.36 | 1.33 | 2.11 | 0.00 |
| 2022 | 9046.54 | 7380 | 1210 | 91.89 | 91.89 | 85.35 | 84.25 | 0.00 | 0.00 | 8.11 | 0.00 |

2023 8234.86 6827 1210 85.79 85.79 77.69 77.93 0.37 0.54 13.67 0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 380 | |
| B. Refuelling without maintenance | | | | 77 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1039 | | | 636 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 42 | | |
| E. Testing of plant systems or components | | | | 2 | | |
| H. Nuclear regulatory requirements | | | | | 237 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 6 |
| L. Human factor related | | | | | 5 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 20 |
| Z. Other | | | | | 238 | |
| Subtotal | 1039 | 24 | | 757 | 860 | 26 |
| Total | | 1063 | | | 1643 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 24 | 1 |
| 12. Reactor I&C Systems | | 11 |
| 13. Reactor Auxiliary Systems | | 15 |
| 14. Safety Systems | | 301 |
| 15. Reactor Cooling Systems | | 39 |
| 16. Steam generation systems | | 24 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 6 |
| 31. Turbine and auxiliaries | | 11 |
| 32. Feedwater and Main Steam System | | 14 |
| 33. Circulating Water System | | 16 |
| 34. Miscellaneous Systems | | 106 |
| 41. Main Generator Systems | | 19 |
| 42. Electrical Power Supply Systems | | 10 |
| Total | 24 | 573 |

2023 Operating Experience

US-263 **MONTICELLO** **UNITED STATES OF AMERICA**

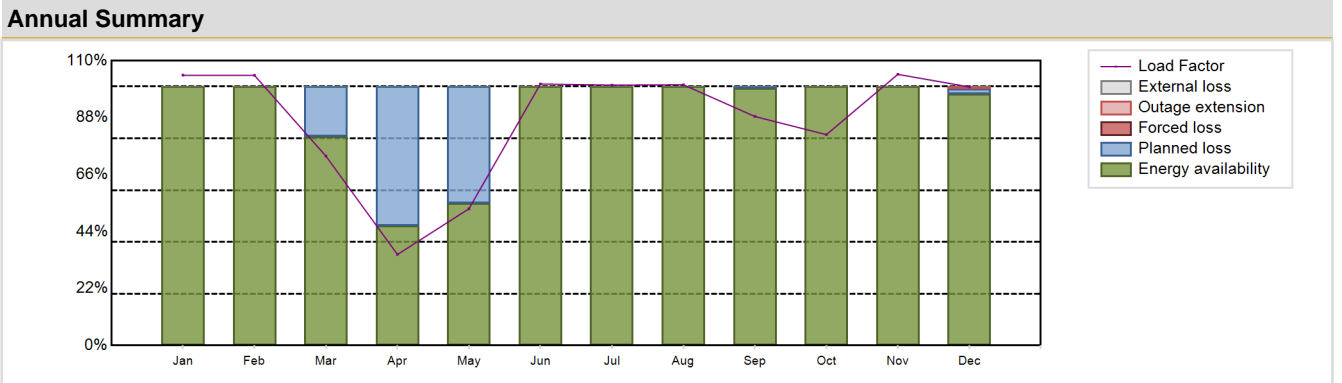
Status at end of year : **Operational**
 Operator : NSP (Northern States Power Co. (subsidiary of Xcel Energy))
 Owner : XCEL (Xcel Energy)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-3 (Mark 1) | Construction Date | : 1967-06-19 |
| Thermal power | : 2004 MWth | Grid Date | : 1971-03-05 |
| Gross electrical power | : 691 MWe | Commercial Date | : 1971-06-30 |
| Reference unit power (net) | : 628 MWe | Age at end of year | : 52 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.17 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 285 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.394 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 75 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 27000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.96 | HP cylinder inlet steam pressure [MPa] | : 6.78 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 484 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 39 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 121 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|------------------|--|--------------|
| Net Energy Production | : 4793.5 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 89.83 % | Unplanned Capability Loss Factor (UCL) | : 0.08 % |
| Unit Capability Factor (UCF) | : 89.83 % | Planned Unavailability Factor (PUF) | : 10.09 % |
| Load Factor (LF) | : 87.13 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 87.47 % | Total off-line time | : 1098 hours |

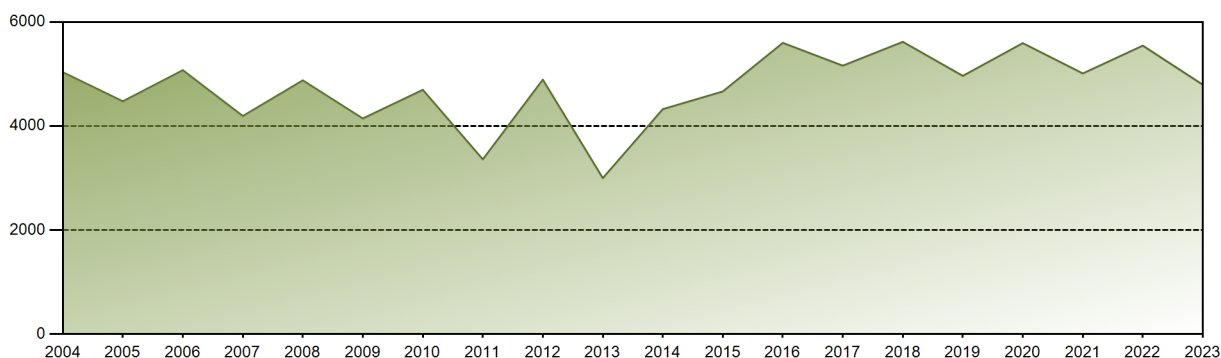


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 487.76 | 440.35 | 341.23 | 158.96 | 246.78 | 456.69 | 469.86 | 470.53 | 399.94 | 380.58 | 474.21 | 466.62 | 4793.50 |
| EAF [%] | 100.00 | 100.00 | 80.76 | 46.23 | 55.07 | 100.00 | 100.00 | 100.00 | 99.33 | 100.00 | 100.00 | 97.06 | 89.83 |
| UCF [%] | 100.00 | 100.00 | 80.76 | 46.23 | 55.07 | 100.00 | 100.00 | 100.00 | 99.33 | 100.00 | 100.00 | 97.06 | 89.83 |
| LF [%] | 104.39 | 104.34 | 73.13 | 35.15 | 52.82 | 101.00 | 100.56 | 100.71 | 88.45 | 81.45 | 104.73 | 99.87 | 87.13 |
| OF [%] | 100.00 | 100.00 | 80.75 | 46.25 | 55.11 | 100.00 | 100.00 | 100.00 | 88.19 | 79.97 | 100.00 | 100.00 | 87.47 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.94 | 0.08 |
| PUF [%] | 0.00 | 0.00 | 19.24 | 53.77 | 44.93 | 0.00 | 0.00 | 0.00 | 0.67 | 0.00 | 0.00 | 2.00 | 10.09 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 215768.17 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.67 % |
| Cumulative Energy Availability Factor (EAF) | : 86.39 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.37 % |
| Cumulative Unit Capability Factor (UCF) | : 86.41 % | Cumulative Planned Unavailability Factor (PUF) | : 11.22 % |
| Cumulative Load Factor (LF) | : 82.62 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 85.31 % | | |

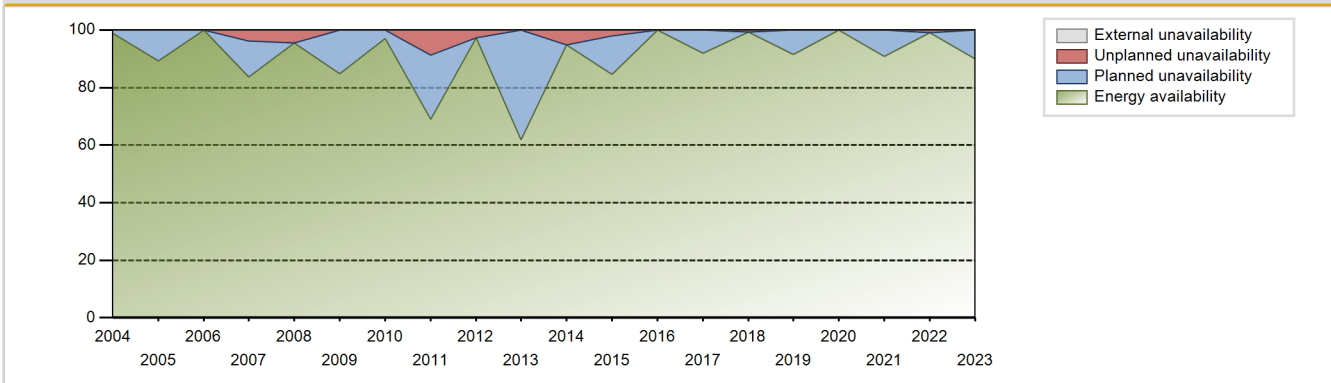
Electricity Production (net) [GWh]



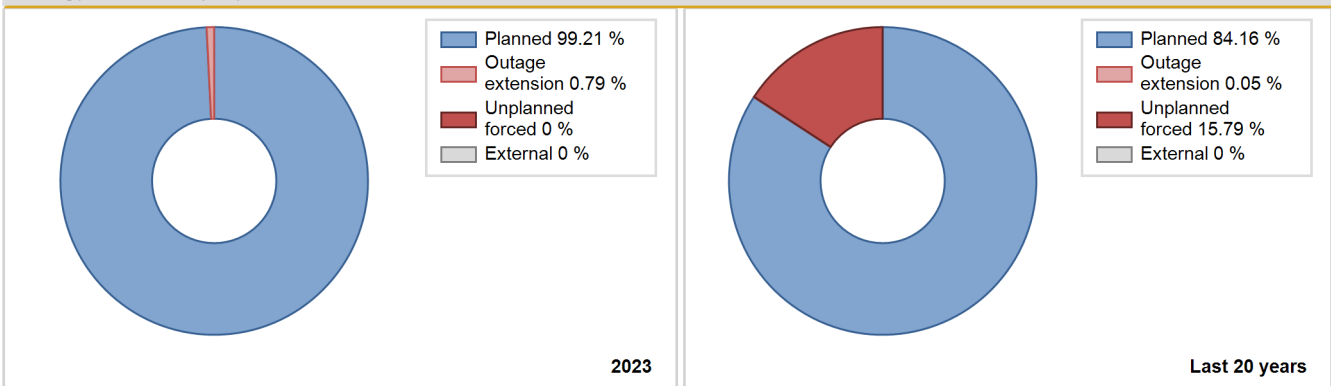
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1971 | 1465.90 | 3357 | 564 | 100.00 | 100.00 | 50.25 | 59.13 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1972 | 3717.90 | 6975 | 580 | 100.00 | 100.00 | 72.98 | 79.41 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | 3271.60 | 6242 | 580 | 100.00 | 100.00 | 64.39 | 71.26 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1974 | 2925.20 | 6567 | 538 | 74.98 | 74.98 | 62.07 | 74.97 | 8.03 | 6.55 | 18.47 | 0.00 |
| 1975 | 2881.40 | 6322 | 538 | 61.05 | 61.05 | 61.14 | 72.17 | 5.95 | 3.86 | 35.09 | 0.00 |
| 1976 | 3986.20 | 8033 | 537 | 84.30 | 84.30 | 84.51 | 91.45 | 2.80 | 2.43 | 13.27 | 0.00 |
| 1977 | 3570.70 | 7001 | 536 | 75.95 | 75.95 | 76.05 | 79.92 | 0.77 | 0.59 | 23.46 | 0.00 |
| 1978 | 3856.20 | 7638 | 536 | 81.70 | 81.70 | 82.13 | 87.19 | 5.75 | 4.98 | 13.32 | 0.00 |
| 1979 | 4399.70 | 8549 | 536 | 93.41 | 93.41 | 93.70 | 97.59 | 3.13 | 3.02 | 3.57 | 0.00 |
| 1980 | 3455.50 | 6876 | 536 | 78.22 | 79.04 | 73.39 | 78.28 | 7.46 | 6.37 | 14.59 | 0.81 |
| 1981 | 3262.30 | 6362 | 536 | 72.34 | 72.34 | 69.48 | 72.63 | 2.11 | 1.56 | 26.11 | 0.00 |
| 1982 | 2425.10 | 5543 | 525 | 62.22 | 62.22 | 52.73 | 63.28 | 1.82 | 1.15 | 36.63 | 0.00 |
| 1983 | 4147.70 | 8438 | 525 | 96.29 | 96.29 | 90.19 | 96.32 | 0.22 | 0.21 | 3.50 | 0.00 |
| 1984 | 279.13 | 808 | 525 | 9.21 | 9.21 | 6.05 | 9.20 | 0.00 | 0.00 | 90.79 | 0.00 |
| 1985 | 4286.99 | 8028 | 536 | 91.63 | 91.63 | 91.30 | 91.64 | 0.58 | 0.54 | 7.84 | 0.00 |
| 1986 | 3379.91 | 6926 | 536 | 78.77 | 78.77 | 71.98 | 79.06 | 0.81 | 0.65 | 20.59 | 0.00 |
| 1987 | 3535.62 | 7051 | 536 | 80.23 | 80.23 | 75.30 | 80.49 | 2.07 | 1.70 | 18.07 | 0.00 |
| 1988 | 4573.58 | 8759 | 536 | 99.71 | 99.71 | 97.14 | 99.72 | 0.29 | 0.29 | 0.00 | 0.00 |
| 1989 | 2650.40 | 6578 | 536 | 74.73 | 74.73 | 56.45 | 75.09 | 1.95 | 1.49 | 23.79 | 0.00 |
| 1990 | 4505.93 | 8414 | 536 | 96.00 | 96.00 | 95.97 | 96.05 | 2.54 | 2.50 | 1.49 | 0.00 |
| 1991 | 3596.53 | 6996 | 536 | 79.56 | 79.56 | 76.60 | 79.86 | 3.15 | 2.58 | 17.85 | 0.00 |
| 1992 | 4453.67 | 8527 | 536 | 97.04 | 97.04 | 94.59 | 97.07 | 1.03 | 1.01 | 1.95 | 0.00 |
| 1993 | 3864.38 | 7322 | 536 | 83.37 | 83.37 | 82.30 | 83.58 | 1.49 | 1.26 | 15.36 | 0.00 |
| 1994 | 3956.18 | 7508 | 536 | 85.55 | 85.55 | 84.26 | 85.71 | 2.88 | 2.54 | 11.91 | 0.00 |
| 1995 | 4756.26 | 8760 | 536 | 100.00 | 100.00 | 101.30 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1996 | 3872.94 | 7443 | 541 | 84.76 | 84.76 | 81.37 | 84.73 | 3.99 | 3.52 | 11.72 | 0.00 |
| 1997 | 3661.60 | 6609 | 544 | 75.23 | 75.23 | 76.84 | 75.45 | 24.77 | 24.77 | 0.00 | 0.00 |
| 1998 | 4118.93 | 7659 | 553 | 87.68 | 87.68 | 84.91 | 87.43 | 2.70 | 2.43 | 9.89 | 0.00 |
| 1999 | 4649.34 | 8092 | 578 | 92.38 | 92.38 | 91.82 | 92.37 | 7.62 | 7.62 | 0.00 | 0.00 |
| 2000 | 4251.42 | 7332 | 578 | 83.49 | 83.49 | 83.74 | 83.47 | 1.85 | 1.57 | 14.94 | 0.00 |
| 2001 | 3880.58 | 6774 | 578 | 76.90 | 76.90 | 76.64 | 77.33 | 12.66 | 11.14 | 11.96 | 0.00 |
| 2002 | 5015.56 | 8620 | 578 | 98.35 | 98.35 | 99.06 | 98.40 | 1.65 | 1.65 | 0.00 | 0.00 |
| 2003 | 4592.46 | 7969 | 578 | 90.70 | 90.70 | 90.70 | 90.97 | 0.00 | 0.00 | 9.30 | 0.00 |
| 2004 | 5034.88 | 8689 | 578 | 98.94 | 98.94 | 99.17 | 98.92 | 0.00 | 0.00 | 1.06 | 0.00 |
| 2005 | 4474.92 | 7826 | 569 | 89.35 | 89.35 | 89.77 | 89.33 | 0.00 | 0.00 | 10.65 | 0.00 |
| 2006 | 5072.59 | 8760 | 572 | 100.00 | 100.00 | 101.23 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 4192.27 | 7327 | 572 | 83.66 | 83.66 | 83.67 | 83.64 | 4.35 | 3.81 | 12.53 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|-------|------|-------|------|
| 2008 | 4878.02 | 8398 | 572 | 95.61 | 95.61 | 97.09 | 95.61 | 4.39 | 4.39 | 0.00 | 0.00 |
| 2009 | 4144.69 | 7421 | 572 | 84.73 | 84.73 | 82.72 | 84.71 | 0.00 | 0.00 | 15.27 | 0.00 |
| 2010 | 4695.11 | 8504 | 572 | 97.08 | 97.08 | 93.70 | 97.08 | 0.00 | 0.00 | 2.92 | 0.00 |
| 2011 | 3358.49 | 6045 | 572 | 69.04 | 69.04 | 67.03 | 69.01 | 11.16 | 8.67 | 22.29 | 0.00 |
| 2012 | 4890.37 | 8552 | 578 | 97.36 | 97.36 | 96.32 | 97.36 | 2.64 | 2.64 | 0.00 | 0.00 |
| 2013 | 2998.28 | 5419 | 578 | 61.87 | 61.87 | 59.21 | 61.85 | 0.00 | 0.00 | 38.13 | 0.00 |
| 2014 | 4323.97 | 8304 | 647 | 94.79 | 94.79 | 76.29 | 94.79 | 5.21 | 5.21 | 0.00 | 0.00 |
| 2015 | 4663.53 | 7407 | 647 | 84.55 | 84.55 | 82.28 | 84.55 | 2.39 | 2.07 | 13.38 | 0.00 |
| 2016 | 5597.76 | 8784 | 647 | 100.00 | 100.00 | 98.50 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 5159.59 | 8051 | 647 | 91.91 | 91.91 | 91.03 | 91.91 | 0.00 | 0.00 | 8.09 | 0.00 |
| 2018 | 5618.02 | 8691 | 628 | 99.21 | 99.21 | 102.12 | 99.21 | 0.79 | 0.79 | 0.00 | 0.00 |
| 2019 | 4964.57 | 8023 | 628 | 91.59 | 91.59 | 90.24 | 91.59 | 0.00 | 0.00 | 8.41 | 0.00 |
| 2020 | 5593.31 | 8783 | 628 | 100.00 | 100.00 | 101.40 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 5011.01 | 7962 | 628 | 90.89 | 90.89 | 91.09 | 90.89 | 0.00 | 0.00 | 9.11 | 0.00 |
| 2022 | 5545.27 | 8683 | 628 | 99.12 | 99.12 | 100.80 | 99.12 | 0.88 | 0.88 | 0.00 | 0.00 |
| 2023 | 4793.50 | 7662 | 628 | 89.83 | 89.83 | 87.13 | 87.47 | 0.00 | 0.08 | 10.09 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1971 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 203 | |
| B. Refuelling without maintenance | | | | 15 | | |
| C. Inspection, maintenance or repair combined with refuelling | 721 | | | 885 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 87 | | |
| E. Testing of plant systems or components | | | | 1 | 21 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 7 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 7 | |
| Z. Other | | | | 1 | 42 | |
| Subtotal | 721 | | | 990 | 280 | 1 |
| Total | | 721 | | | 1271 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1971 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 8 |
| 12. Reactor I&C Systems | | 18 |
| 13. Reactor Auxiliary Systems | | 17 |
| 14. Safety Systems | | 13 |
| 15. Reactor Cooling Systems | | 21 |
| 16. Steam generation systems | | 2 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 31. Turbine and auxiliaries | | 33 |
| 32. Feedwater and Main Steam System | | 42 |
| 33. Circulating Water System | | 0 |
| 34. Miscellaneous Systems | | 35 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 13 |
| 42. Electrical Power Supply Systems | | 24 |
| Total | | 233 |

2023 Operating Experience

US-220 **NINE MILE POINT-1** **UNITED STATES OF AMERICA**

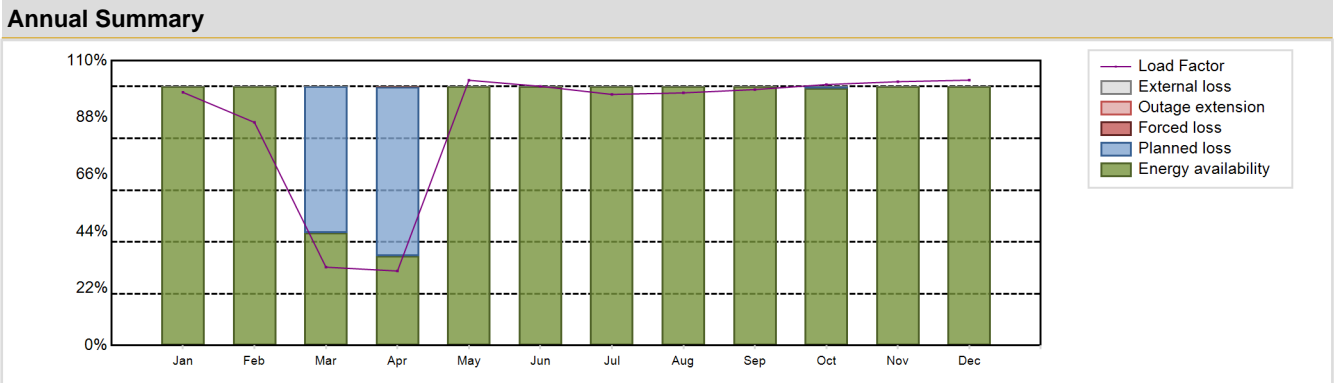
Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXE/EDF (Exelon Nuclear, Électricité de France)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-2 (Mark 1) | Construction Date | : 1965-04-12 |
| Thermal power | : 1850 MWth | Grid Date | : 1969-11-09 |
| Gross electrical power | : 642 MWe | Commercial Date | : 1969-12-01 |
| Reference unit power (net) | : 613 MWe | Age at end of year | : 54 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.13 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 285 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.436 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 34 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 26000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4 | HP cylinder inlet steam pressure [MPa] | : 6.79 |
| Active core height/length [m] | : 3.7 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 532 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 15.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 129 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 5 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 4675.61 GW(e).h | Forced Loss Rate (FLR) | : 0.02 % |
| Energy Availability Factor (EAF) | : 89.78 % | Unplanned Capability Loss Factor (UCL) | : 0.02 % |
| Unit Capability Factor (UCF) | : 89.78 % | Planned Unavailability Factor (PUF) | : 10.2 % |
| Load Factor (LF) | : 87.07 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 88.98 % | Total off-line time | : 965 hours |

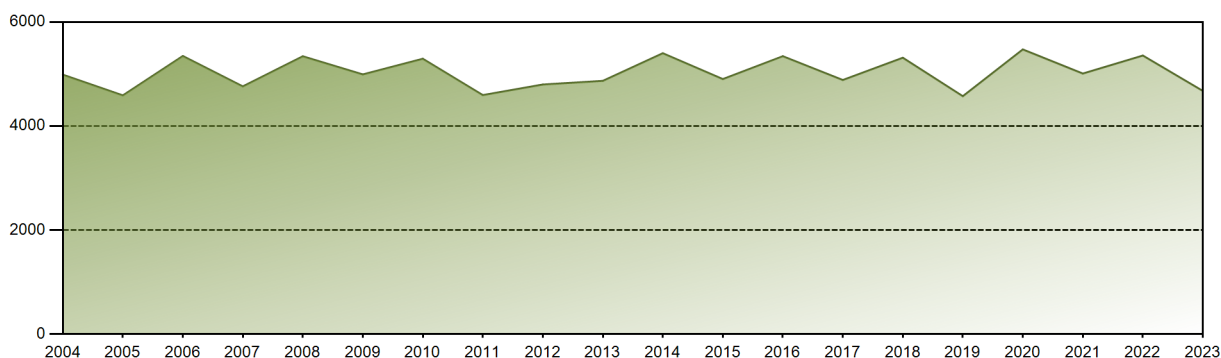


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 445.93 | 354.95 | 137.80 | 126.96 | 467.23 | 441.79 | 442.23 | 445.02 | 436.29 | 459.63 | 450.33 | 467.45 | 4675.61 |
| EAF [%] | 100.00 | 100.00 | 43.44 | 34.67 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.41 | 100.00 | 100.00 | 89.78 |
| UCF [%] | 100.00 | 100.00 | 43.44 | 34.67 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.41 | 100.00 | 100.00 | 89.78 |
| LF [%] | 97.78 | 86.17 | 30.25 | 28.77 | 102.45 | 100.10 | 96.96 | 97.58 | 98.85 | 100.78 | 101.89 | 102.50 | 87.07 |
| OF [%] | 100.00 | 100.00 | 38.63 | 29.31 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 88.98 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| PUF [%] | 0.00 | 0.00 | 56.56 | 65.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.59 | 0.00 | 0.00 | 10.20 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 216768.74 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.78 % |
| Cumulative Energy Availability Factor (EAF) | : 79.8 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.68 % |
| Cumulative Unit Capability Factor (UCF) | : 79.8 % | Cumulative Planned Unavailability Factor (PUF) | : 12.52 % |
| Cumulative Load Factor (LF) | : 75.97 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 78.68 % | | |

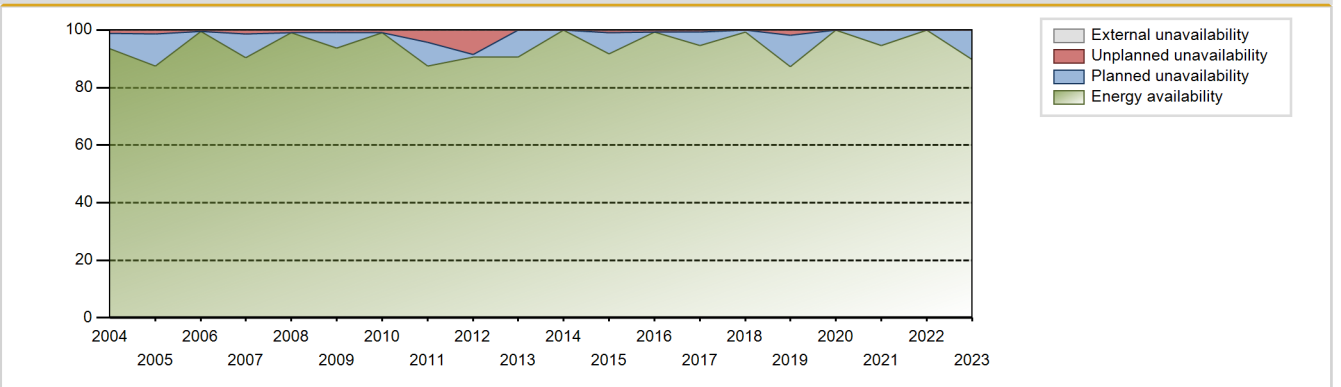
Electricity Production (net) [GWh]



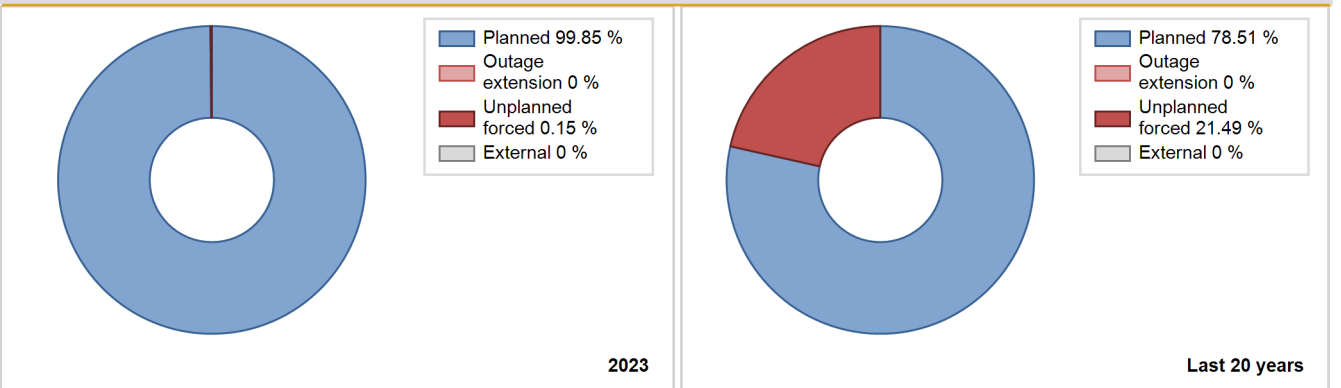
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|-------|--------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1969 | | | | Data not provided | | | | | | | |
| 1970 | 1581.00 | 3443 | 525 | 100.00 | 100.00 | 34.38 | 39.30 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1971 | 3033.10 | 5963 | 592 | 100.00 | 100.00 | 58.49 | 68.07 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1972 | 3344.80 | 6101 | 630 | 100.00 | 100.00 | 60.44 | 69.46 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | 3494.20 | 6682 | 610 | 76.41 | 76.41 | 65.39 | 76.28 | 7.94 | 6.59 | 17.00 | 0.00 |
| 1974 | 3278.70 | 6177 | 610 | 70.50 | 70.50 | 61.36 | 70.51 | 4.91 | 3.64 | 25.86 | 0.00 |
| 1975 | 3044.90 | 6235 | 610 | 57.03 | 57.03 | 56.98 | 71.18 | 17.76 | 12.32 | 30.66 | 0.00 |
| 1976 | 4112.80 | 7724 | 610 | 76.79 | 76.79 | 76.76 | 87.93 | 18.88 | 17.88 | 5.33 | 0.00 |
| 1977 | 2956.80 | 5171 | 610 | 55.39 | 55.39 | 55.33 | 59.03 | 2.16 | 1.22 | 43.39 | 0.00 |
| 1978 | 4467.40 | 8329 | 610 | 83.60 | 83.60 | 83.60 | 95.08 | 4.41 | 3.86 | 12.54 | 0.00 |
| 1979 | 3005.40 | 5785 | 610 | 56.24 | 56.24 | 56.24 | 66.04 | 5.91 | 3.53 | 40.23 | 0.00 |
| 1980 | 4537.30 | 8097 | 610 | 92.16 | 92.16 | 84.68 | 92.18 | 4.77 | 4.61 | 3.22 | 0.00 |
| 1981 | 3270.30 | 5780 | 610 | 65.61 | 65.61 | 61.20 | 65.98 | 1.79 | 1.20 | 33.19 | 0.00 |
| 1982 | 1134.80 | 1872 | 610 | 21.47 | 21.47 | 21.24 | 21.37 | 78.19 | 76.99 | 1.54 | 0.00 |
| 1983 | 2802.00 | 4925 | 610 | 56.21 | 56.21 | 52.44 | 56.22 | 43.79 | 43.79 | 0.00 | 0.00 |
| 1984 | 3635.23 | 6316 | 610 | 71.61 | 71.61 | 67.84 | 71.90 | 3.95 | 2.94 | 25.45 | 0.00 |
| 1985 | 4932.30 | 8441 | 610 | 96.37 | 96.37 | 92.30 | 96.36 | 3.63 | 3.63 | 0.00 | 0.00 |
| 1986 | 3146.88 | 5722 | 610 | 64.95 | 64.95 | 58.89 | 65.32 | 8.55 | 6.07 | 28.98 | 0.00 |
| 1987 | 4615.17 | 8130 | 610 | 92.81 | 92.81 | 86.37 | 92.81 | 7.19 | 7.19 | 0.00 | 0.00 |
| 1988 | 0.00 | 0 | 610 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 5.87 | 94.13 | 0.00 |
| 1989 | 0.00 | 0 | 610 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1990 | 1316.68 | 3043 | 612 | 34.24 | 34.24 | 24.56 | 34.74 | 65.54 | 65.11 | 0.66 | 0.00 |
| 1991 | 3873.51 | 6853 | 615 | 78.22 | 78.22 | 71.90 | 78.23 | 9.02 | 7.75 | 14.03 | 0.00 |
| 1992 | 2930.09 | 5052 | 615 | 57.41 | 57.41 | 54.24 | 57.51 | 42.54 | 42.51 | 0.08 | 0.00 |
| 1993 | 4353.36 | 7370 | 615 | 84.08 | 84.08 | 80.81 | 84.13 | 0.72 | 0.61 | 15.31 | 0.00 |
| 1994 | 4917.95 | 8390 | 565 | 95.42 | 95.42 | 99.36 | 95.78 | 4.58 | 4.58 | 0.00 | 0.00 |
| 1995 | 4127.64 | 7381 | 565 | 82.86 | 82.86 | 83.40 | 84.26 | 1.76 | 1.48 | 15.66 | 0.00 |
| 1996 | 4676.17 | 8133 | 565 | 91.98 | 91.98 | 94.22 | 92.59 | 6.65 | 6.55 | 1.47 | 0.00 |
| 1997 | 2698.57 | 4620 | 565 | 51.77 | 51.77 | 54.52 | 52.74 | 36.61 | 29.90 | 18.33 | 0.00 |
| 1998 | 4845.98 | 8085 | 565 | 92.31 | 92.31 | 97.91 | 92.29 | 7.69 | 7.69 | 0.00 | 0.00 |
| 1999 | 3564.86 | 6162 | 565 | 68.37 | 68.37 | 72.03 | 70.34 | 12.16 | 9.47 | 22.17 | 0.00 |
| 2000 | 4681.85 | 8060 | 565 | 91.00 | 91.00 | 94.34 | 91.76 | 1.53 | 1.41 | 7.58 | 0.00 |
| 2001 | 4378.01 | 7376 | 565 | 83.52 | 83.52 | 88.46 | 84.20 | 2.47 | 2.12 | 14.36 | 0.00 |
| 2002 | 4904.56 | 8194 | 565 | 92.90 | 92.90 | 99.09 | 93.54 | 6.14 | 6.07 | 1.03 | 0.00 |
| 2003 | 4361.37 | 7373 | 565 | 83.61 | 83.61 | 88.12 | 84.17 | 3.65 | 3.17 | 13.22 | 0.00 |
| 2004 | 4988.21 | 8258 | 565 | 93.46 | 93.46 | 100.51 | 94.01 | 1.22 | 1.15 | 5.39 | 0.00 |
| 2005 | 4589.79 | 7667 | 621 | 87.55 | 87.55 | 84.36 | 87.51 | 1.49 | 1.33 | 11.12 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2006 | 5346.94 | 8713 | 621 | 99.47 | 99.47 | 98.29 | 99.46 | 0.53 | 0.53 | 0.00 | 0.00 |
| 2007 | 4762.88 | 7910 | 621 | 90.31 | 90.31 | 87.55 | 90.30 | 1.59 | 1.46 | 8.23 | 0.00 |
| 2008 | 5341.42 | 8707 | 621 | 99.13 | 99.13 | 97.92 | 99.12 | 0.87 | 0.87 | 0.00 | 0.00 |
| 2009 | 4992.58 | 8216 | 621 | 93.81 | 93.81 | 91.78 | 93.79 | 0.87 | 0.82 | 5.37 | 0.00 |
| 2010 | 5294.08 | 8677 | 621 | 99.06 | 99.06 | 97.32 | 99.05 | 0.94 | 0.94 | 0.00 | 0.00 |
| 2011 | 4595.11 | 7671 | 621 | 87.59 | 87.59 | 84.47 | 87.57 | 4.71 | 4.33 | 8.08 | 0.00 |
| 2012 | 4798.45 | 7951 | 621 | 90.57 | 90.57 | 87.97 | 90.52 | 8.49 | 8.40 | 1.02 | 0.00 |
| 2013 | 4868.75 | 7933 | 621 | 90.56 | 90.56 | 89.49 | 90.55 | 0.00 | 0.00 | 9.44 | 0.00 |
| 2014 | 5400.06 | 8760 | 621 | 100.00 | 100.00 | 99.27 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 4903.16 | 8039 | 613 | 91.66 | 91.66 | 91.31 | 91.77 | 1.10 | 1.02 | 7.32 | 0.00 |
| 2016 | 5342.98 | 8721 | 613 | 99.28 | 99.28 | 99.23 | 99.28 | 0.72 | 0.72 | 0.00 | 0.00 |
| 2017 | 4885.28 | 8290 | 613 | 94.64 | 94.64 | 90.98 | 94.63 | 0.70 | 0.67 | 4.69 | 0.00 |
| 2018 | 5313.34 | 8684 | 613 | 99.20 | 99.20 | 98.95 | 99.13 | 0.00 | 0.00 | 0.80 | 0.00 |
| 2019 | 4574.14 | 7646 | 613 | 87.30 | 87.30 | 85.18 | 87.28 | 1.94 | 1.73 | 10.98 | 0.00 |
| 2020 | 5473.00 | 8783 | 613 | 100.00 | 100.00 | 101.64 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 5009.29 | 8280 | 613 | 94.52 | 94.52 | 93.28 | 94.52 | 0.00 | 0.00 | 5.48 | 0.00 |
| 2022 | 5355.41 | 8760 | 613 | 100.00 | 100.00 | 99.73 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 4675.61 | 7795 | 613 | 89.78 | 89.78 | 87.07 | 88.98 | 0.02 | 0.02 | 10.20 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1969 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 554 | |
| B. Refuelling without maintenance | | | | 9 | | |
| C. Inspection, maintenance or repair combined with refuelling | 964 | | | 990 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 105 | | |
| E. Testing of plant systems or components | | | | 2 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 2 | | |
| H. Nuclear regulatory requirements | | | | | 7 | |
| L. Human factor related | | | | | 22 | |
| Z. Other | | | | 4 | 101 | |
| Subtotal | 964 | | | 1112 | 685 | |
| Total | | 964 | | | 1797 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1969 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 16 |
| 12. Reactor I&C Systems | | 27 |
| 13. Reactor Auxiliary Systems | | 22 |
| 14. Safety Systems | | 91 |
| 15. Reactor Cooling Systems | | 242 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 8 |
| 31. Turbine and auxiliaries | | 68 |
| 32. Feedwater and Main Steam System | | 44 |
| 34. Miscellaneous Systems | | 2 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 13 |
| 42. Electrical Power Supply Systems | | 24 |
| Total | | 560 |

2023 Operating Experience

US-410 **NINE MILE POINT-2** **UNITED STATES OF AMERICA**

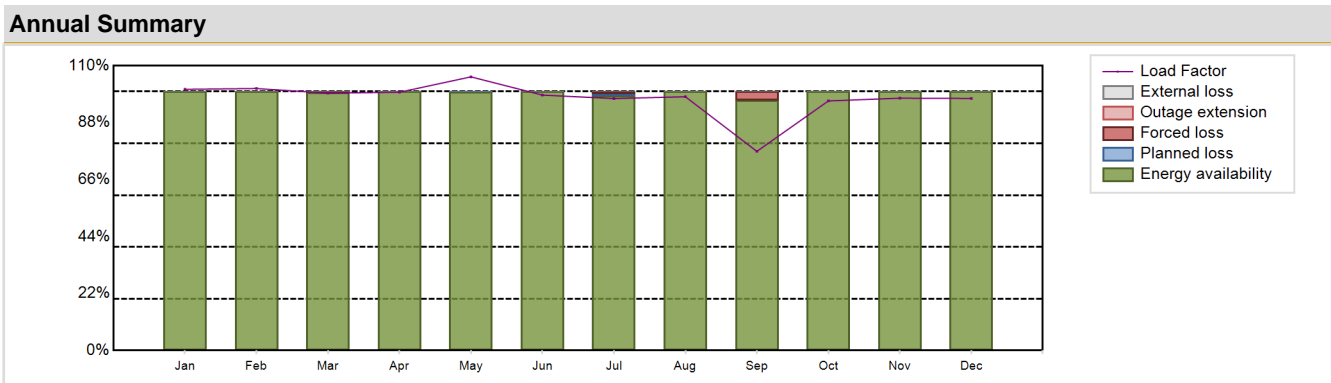
Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXE/EDF (Exelon Nuclear, Électricité de France)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-5 (Mark 2) | Construction Date | : 1975-08-01 |
| Thermal power | : 3988 MWth | Grid Date | : 1987-08-08 |
| Gross electrical power | : 1320 MWe | Commercial Date | : 1988-03-11 |
| Reference unit power (net) | : 1277 MWe | Age at end of year | : 36 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.17 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 287 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.316 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 26 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 32300 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.75 | HP cylinder inlet steam pressure [MPa] | : 6.78 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 764 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 17.68 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|-------------|
| Net Energy Production | : 10899.53 GW(e).h | Forced Loss Rate (FLR) | : 0.39 % |
| Energy Availability Factor (EAF) | : 99.55 % | Unplanned Capability Loss Factor (UCL) | : 0.39 % |
| Unit Capability Factor (UCF) | : 99.55 % | Planned Unavailability Factor (PUF) | : 0.06 % |
| Load Factor (LF) | : 97.43 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 98.54 % | Total off-line time | : 128 hours |

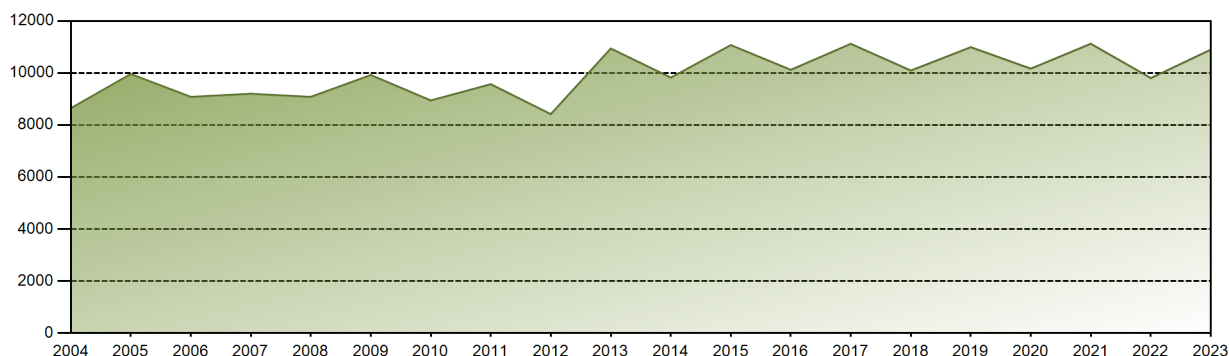


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|---------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 958.52 | 868.32 | 942.99 | 917.19 | 1004.16 | 907.03 | 924.48 | 931.21 | 707.25 | 915.82 | 897.44 | 925.13 | 10899.53 |
| EAF [%] | 100.00 | 100.00 | 99.64 | 100.00 | 99.94 | 100.00 | 98.48 | 100.00 | 96.57 | 100.00 | 100.00 | 100.00 | 99.55 |
| UCF [%] | 100.00 | 100.00 | 99.64 | 100.00 | 99.94 | 100.00 | 98.48 | 100.00 | 96.57 | 100.00 | 100.00 | 100.00 | 99.55 |
| LF [%] | 100.89 | 101.19 | 99.39 | 99.76 | 105.69 | 98.65 | 97.30 | 98.01 | 76.92 | 96.39 | 97.47 | 97.37 | 97.43 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 82.22 | 100.00 | 100.00 | 100.00 | 98.54 |
| FLR [%] | 0.00 | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.91 | 0.00 | 3.43 | 0.00 | 0.00 | 0.00 | 0.39 |
| UCL [%] | 0.00 | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.90 | 0.00 | 3.43 | 0.00 | 0.00 | 0.00 | 0.39 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

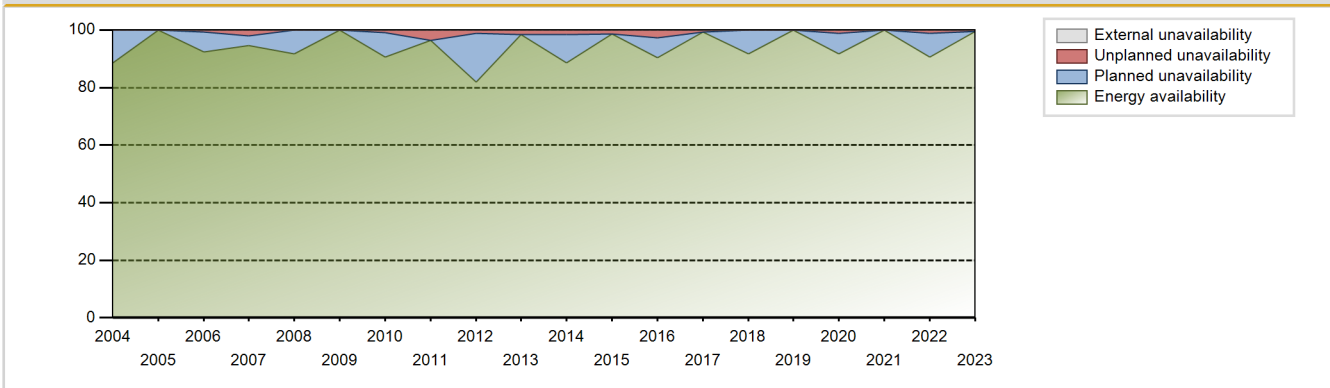
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 313156.39 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.76 % |
| Cumulative Energy Availability Factor (EAF) | : 88.06 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.44 % |
| Cumulative Unit Capability Factor (UCF) | : 88.06 % | Cumulative Planned Unavailability Factor (PUF) | : 8.5 % |
| Cumulative Load Factor (LF) | : 85.99 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 87.03 % | | |

Electricity Production (net) [GWh]

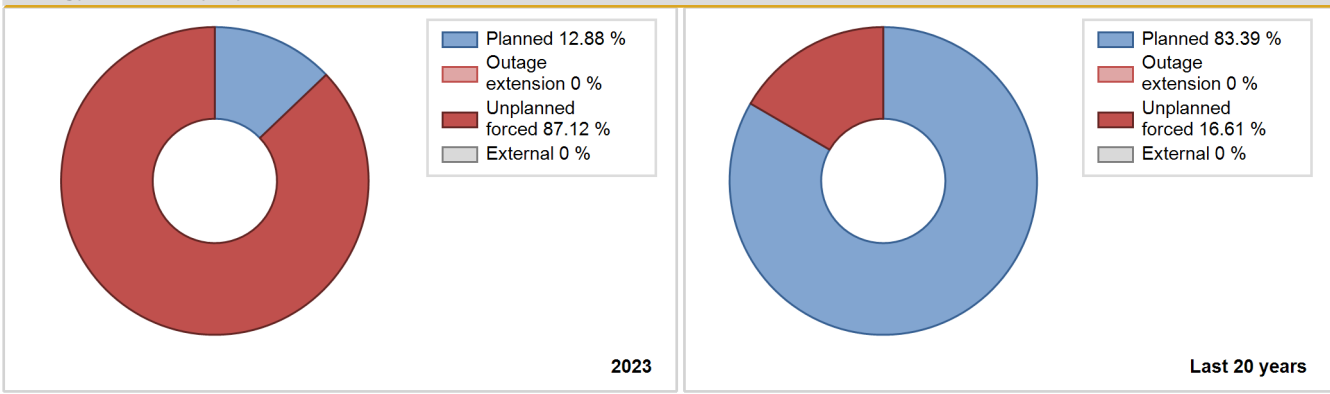


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 2540.56 | 2800 | 1040 | 49.12 | 49.12 | 33.61 | 38.64 | 17.46 | 10.39 | 40.48 | 0.00 |
| 1989 | 4288.28 | 4824 | 1068 | 56.45 | 56.45 | 45.81 | 55.07 | 20.46 | 14.52 | 29.03 | 0.00 |
| 1990 | 4140.41 | 4697 | 1082 | 54.42 | 54.42 | 43.66 | 53.62 | 20.59 | 14.11 | 31.47 | 0.00 |
| 1991 | 6562.93 | 6484 | 1092 | 75.10 | 75.10 | 68.57 | 74.02 | 18.31 | 16.83 | 8.07 | 0.00 |
| 1992 | 5144.97 | 5169 | 1075 | 61.85 | 61.85 | 54.48 | 58.85 | 12.58 | 8.90 | 29.26 | 0.00 |
| 1993 | 7191.09 | 7195 | 1048 | 82.22 | 82.22 | 78.28 | 82.13 | 2.06 | 1.73 | 16.05 | 0.00 |
| 1994 | 8355.90 | 8243 | 994 | 93.93 | 93.93 | 95.96 | 94.10 | 6.07 | 6.07 | 0.00 | 0.00 |
| 1995 | 7253.68 | 6848 | 1061 | 78.91 | 78.91 | 77.99 | 78.17 | 7.60 | 6.49 | 14.59 | 0.00 |
| 1996 | 8698.50 | 7811 | 1106 | 89.75 | 89.75 | 89.50 | 88.92 | 1.23 | 1.12 | 9.13 | 0.00 |
| 1997 | 8877.99 | 8279 | 1105 | 94.93 | 94.93 | 91.72 | 94.51 | 3.22 | 3.16 | 1.91 | 0.00 |
| 1998 | 7307.16 | 7028 | 1105 | 80.84 | 80.84 | 75.49 | 80.23 | 2.37 | 1.96 | 17.20 | 0.00 |
| 1999 | 8782.30 | 7810 | 1128 | 89.06 | 89.06 | 88.86 | 89.16 | 10.94 | 10.94 | 0.00 | 0.00 |
| 2000 | 8001.52 | 7204 | 1123 | 81.73 | 81.73 | 81.11 | 82.01 | 3.35 | 2.83 | 15.43 | 0.00 |
| 2001 | 8858.85 | 7964 | 1119 | 90.66 | 90.66 | 90.37 | 90.91 | 4.01 | 3.78 | 5.56 | 0.00 |
| 2002 | 8417.50 | 7473 | 1119 | 85.14 | 85.14 | 85.87 | 85.31 | 6.47 | 5.89 | 8.97 | 0.00 |
| 2003 | 9566.87 | 8448 | 1119 | 96.40 | 96.40 | 97.60 | 96.44 | 3.60 | 3.60 | 0.00 | 0.00 |
| 2004 | 8643.48 | 7788 | 1119 | 88.52 | 88.52 | 87.94 | 88.66 | 0.00 | 0.00 | 11.48 | 0.00 |
| 2005 | 9961.02 | 8760 | 1135 | 100.00 | 100.00 | 100.17 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2006 | 9081.58 | 8100 | 1135 | 92.48 | 92.48 | 91.34 | 92.47 | 0.69 | 0.64 | 6.88 | 0.00 |
| 2007 | 9201.14 | 8286 | 1140 | 94.60 | 94.60 | 92.14 | 94.59 | 2.00 | 1.93 | 3.46 | 0.00 |
| 2008 | 9082.39 | 8063 | 1140 | 91.81 | 91.81 | 90.70 | 91.79 | 0.00 | 0.00 | 8.19 | 0.00 |
| 2009 | 9921.92 | 8760 | 1142 | 100.00 | 100.00 | 99.18 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 8944.98 | 7934 | 1143 | 90.61 | 90.61 | 89.34 | 90.57 | 0.95 | 0.87 | 8.52 | 0.00 |
| 2011 | 9568.30 | 8450 | 1119 | 96.40 | 96.40 | 97.61 | 96.46 | 3.60 | 3.60 | 0.00 | 0.00 |
| 2012 | 8418.34 | 7119 | 1276 | 81.94 | 81.94 | 80.26 | 81.05 | 1.34 | 1.11 | 16.95 | 0.00 |
| 2013 | 10942.30 | 8622 | 1277 | 98.42 | 98.42 | 97.81 | 98.41 | 1.58 | 1.58 | 0.00 | 0.00 |
| 2014 | 9822.73 | 7755 | 1276 | 88.53 | 88.53 | 87.88 | 88.53 | 1.76 | 1.59 | 9.88 | 0.00 |
| 2015 | 11072.56 | 8647 | 1277 | 98.72 | 98.72 | 98.98 | 98.71 | 1.28 | 1.28 | 0.00 | 0.00 |
| 2016 | 10123.11 | 7935 | 1277 | 90.34 | 90.34 | 90.25 | 90.33 | 3.01 | 2.80 | 6.86 | 0.00 |
| 2017 | 11122.23 | 8695 | 1277 | 99.26 | 99.26 | 99.43 | 99.26 | 0.74 | 0.74 | 0.00 | 0.00 |
| 2018 | 10094.77 | 7988 | 1277 | 91.80 | 91.80 | 90.24 | 91.19 | 0.00 | 0.00 | 8.20 | 0.00 |
| 2019 | 10993.81 | 8760 | 1277 | 100.00 | 100.00 | 98.28 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 10167.61 | 8059 | 1277 | 91.75 | 91.75 | 90.64 | 91.75 | 1.31 | 1.22 | 7.03 | 0.00 |
| 2021 | 11124.49 | 8760 | 1277 | 100.00 | 100.00 | 99.45 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 9804.76 | 7935 | 1277 | 90.59 | 90.59 | 87.65 | 90.58 | 1.24 | 1.13 | 8.28 | 0.00 |
| 2023 | 10899.53 | 8632 | 1277 | 99.55 | 99.55 | 97.43 | 98.54 | 0.39 | 0.39 | 0.06 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 282 | |
| B. Refuelling without maintenance | | | | 31 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 550 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 202 | | |
| E. Testing of plant systems or components | | | | 2 | 3 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| L. Human factor related | | | | | 17 | |
| Z. Other | | | | | 18 | |
| Subtotal | | 24 | | 785 | 320 | 4 |
| Total | | 24 | | | 1109 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1988 to 2023 | |
|--|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 24 | | 8 |
| 12. Reactor I&C Systems | | | | 23 |
| 13. Reactor Auxiliary Systems | | | | 9 |
| 14. Safety Systems | | | | 7 |
| 15. Reactor Cooling Systems | | | | 43 |
| 16. Steam generation systems | | | | 9 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 2 |
| 31. Turbine and auxiliaries | | | | 25 |
| 32. Feedwater and Main Steam System | | | | 43 |
| 33. Circulating Water System | | | | 9 |
| 34. Miscellaneous Systems | | | | 16 |
| 35. All other I&C Systems | | | | 30 |
| 41. Main Generator Systems | | | | 23 |
| 42. Electrical Power Supply Systems | | | | 44 |
| Total | | 24 | | 291 |

2023 Operating Experience

US-338

NORTH ANNA-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : DOMINION (Dominion Energy)
 Owner : VEPCO (Virginia Electric Power Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 3LP (DRYSUB)
 Thermal power : 2940 MWth
 Gross electrical power : 990 MWe
 Reference unit power (net) : 948 MWe

Key Dates

Construction Date : 1971-02-19
 Grid Date : 1978-04-17
 Commercial Date : 1978-06-06
 Age at end of year : 45 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 39000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18.59
 Number of control rod assemblies : 32
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 327
 Number of SG : 3
 Containment type : -
 Containment design pressure [MPa] : 0.316

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.82
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

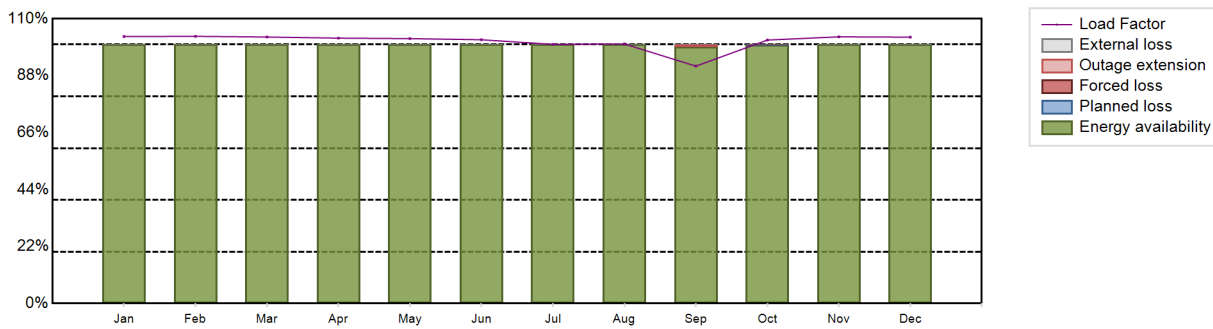
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 8412.1 GW(e).h
 Energy Availability Factor (EAF) : 99.91 %
 Unit Capability Factor (UCF) : 99.91 %
 Load Factor (LF) : 101.3 %
 Operating Factor (OF) : 99.54 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0.08 %
 Planned Unavailability Factor (PUF) : 0.01 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 40 hours

Annual Summary

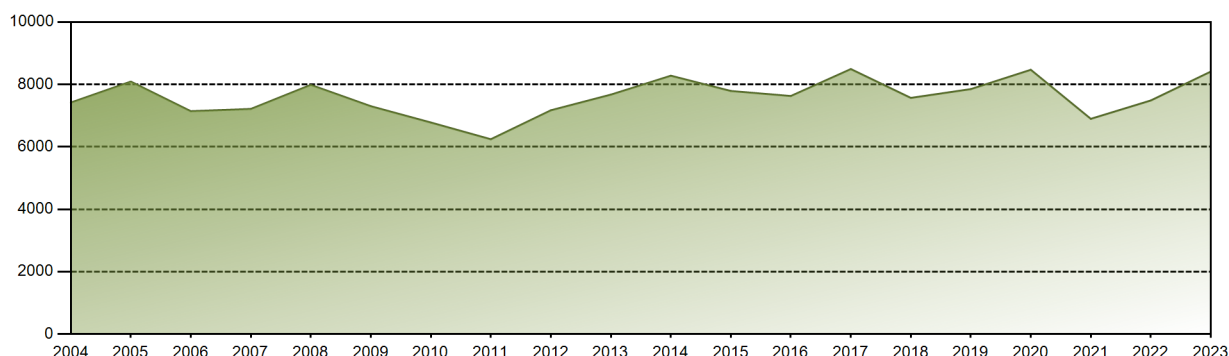


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 727.26 | 657.34 | 724.99 | 699.55 | 721.58 | 695.30 | 705.91 | 707.02 | 625.78 | 717.65 | 704.06 | 725.66 | 8412.10 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.00 | 99.87 | 100.00 | 100.00 | 99.91 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.00 | 99.87 | 100.00 | 100.00 | 99.91 |
| LF [%] | 103.11 | 103.18 | 102.93 | 102.49 | 102.31 | 101.87 | 100.09 | 100.24 | 91.68 | 101.75 | 103.01 | 102.89 | 101.30 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.44 | 100.00 | 100.00 | 100.00 | 99.54 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.03 | 0.00 | 0.00 | 0.08 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 305401.75 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.11 % |
| Cumulative Energy Availability Factor (EAF) | : 85.06 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.67 % |
| Cumulative Unit Capability Factor (UCF) | : 85.56 % | Cumulative Planned Unavailability Factor (PUF) | : 10.77 % |
| Cumulative Load Factor (LF) | : 83.79 % | Cumulative Externally cause unavailability (XUF) | : 0.5 % |
| Cumulative Operating Factor (OF) | : 85.1 % | | |

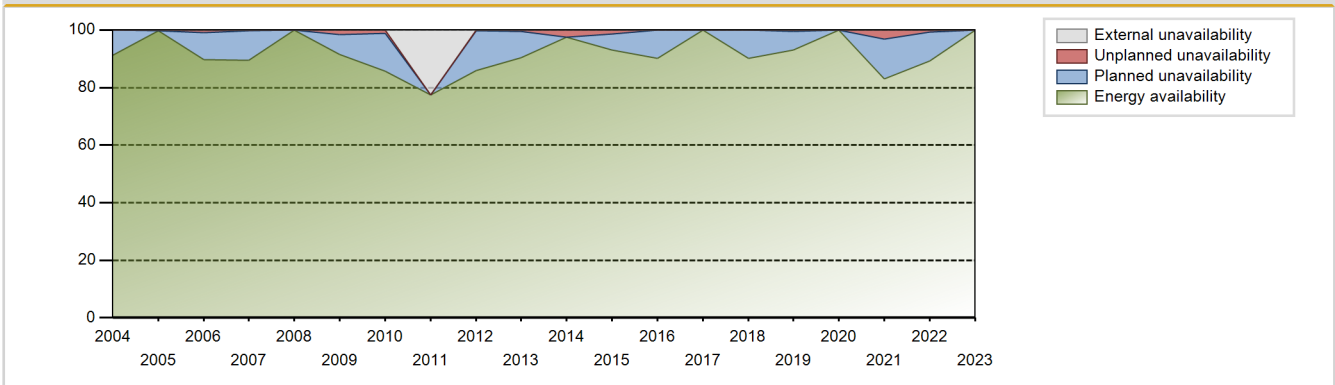
Electricity Production (net) [GWh]



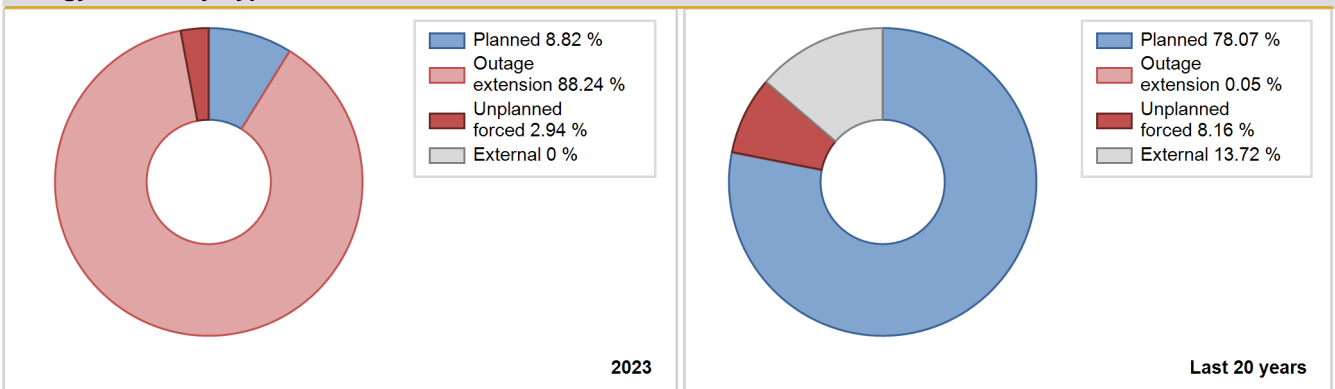
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1978 | 3971.50 | 5420 | 896 | 81.39 | 81.39 | 79.45 | 92.85 | 13.69 | 12.91 | 5.70 | 0.00 |
| 1979 | 4188.70 | 5399 | 898 | 53.25 | 53.25 | 53.25 | 61.63 | 21.68 | 14.74 | 32.02 | 0.00 |
| 1980 | 5631.00 | 7589 | 878 | 87.25 | 87.25 | 73.01 | 86.40 | 6.30 | 5.87 | 6.89 | 0.00 |
| 1981 | 4637.90 | 5703 | 860 | 65.62 | 65.62 | 61.56 | 65.10 | 0.38 | 0.25 | 34.13 | 0.00 |
| 1982 | 2397.90 | 3027 | 865 | 34.73 | 34.73 | 31.65 | 34.55 | 22.49 | 10.08 | 55.19 | 0.00 |
| 1983 | 5310.40 | 6277 | 872 | 71.62 | 71.62 | 69.52 | 71.66 | 23.75 | 22.30 | 6.08 | 0.00 |
| 1984 | 3784.80 | 4425 | 883 | 50.31 | 50.31 | 48.80 | 50.38 | 19.28 | 12.01 | 37.68 | 0.00 |
| 1985 | 5798.93 | 6820 | 892 | 77.88 | 77.88 | 74.21 | 77.85 | 5.14 | 4.22 | 17.90 | 0.00 |
| 1986 | 6310.74 | 7327 | 893 | 83.70 | 83.70 | 80.67 | 83.64 | 16.10 | 16.06 | 0.24 | 0.00 |
| 1987 | 3568.91 | 4523 | 913 | 52.09 | 52.09 | 44.61 | 51.63 | 35.37 | 28.50 | 19.41 | 0.00 |
| 1988 | 6897.30 | 7760 | 915 | 88.61 | 88.61 | 85.82 | 88.34 | 10.25 | 10.12 | 1.26 | 0.00 |
| 1989 | 4303.32 | 4978 | 915 | 57.80 | 57.80 | 53.69 | 56.83 | 9.68 | 6.20 | 36.01 | 0.00 |
| 1990 | 7233.54 | 8726 | 912 | 99.62 | 99.62 | 90.54 | 99.61 | 0.38 | 0.38 | 0.00 | 0.00 |
| 1991 | 5625.82 | 6549 | 911 | 75.16 | 75.16 | 70.50 | 74.76 | 11.49 | 9.75 | 15.08 | 0.00 |
| 1992 | 5358.08 | 7225 | 858 | 81.53 | 81.53 | 71.07 | 82.25 | 3.04 | 2.56 | 15.91 | 0.00 |
| 1993 | 5692.65 | 6444 | 890 | 73.49 | 73.49 | 72.99 | 73.56 | 0.00 | 0.00 | 26.51 | 0.00 |
| 1994 | 6795.70 | 8012 | 900 | 91.55 | 91.55 | 86.20 | 91.46 | 0.00 | 0.00 | 8.45 | 0.00 |
| 1995 | 7839.17 | 8733 | 896 | 99.70 | 99.70 | 99.82 | 99.69 | 0.30 | 0.30 | 0.00 | 0.00 |
| 1996 | 6945.50 | 7985 | 893 | 90.96 | 90.96 | 88.54 | 90.90 | 0.84 | 0.77 | 8.27 | 0.00 |
| 1997 | 7157.53 | 7992 | 893 | 91.26 | 91.26 | 91.50 | 91.23 | 0.00 | 0.00 | 8.74 | 0.00 |
| 1998 | 7217.05 | 8091 | 893 | 92.39 | 92.39 | 92.26 | 92.36 | 0.71 | 0.66 | 6.95 | 0.00 |
| 1999 | 8124.46 | 8760 | 893 | 100.00 | 100.00 | 103.86 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2000 | 7213.08 | 7997 | 893 | 91.06 | 91.06 | 91.96 | 91.04 | 1.45 | 1.34 | 7.59 | 0.00 |
| 2001 | 7120.79 | 8010 | 925 | 91.46 | 91.46 | 87.88 | 91.44 | 0.00 | 0.00 | 8.54 | 0.00 |
| 2002 | 8164.34 | 8760 | 925 | 100.00 | 100.00 | 100.76 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 6519.92 | 7200 | 925 | 82.21 | 82.21 | 80.46 | 82.19 | 3.41 | 2.90 | 14.89 | 0.00 |
| 2004 | 7418.35 | 8023 | 925 | 91.35 | 91.35 | 91.30 | 91.34 | 0.00 | 0.00 | 8.65 | 0.00 |
| 2005 | 8091.86 | 8744 | 925 | 99.82 | 99.82 | 99.85 | 99.81 | 0.18 | 0.18 | 0.00 | 0.00 |
| 2006 | 7142.74 | 7861 | 924 | 89.77 | 89.77 | 88.24 | 89.74 | 1.01 | 0.91 | 9.32 | 0.00 |
| 2007 | 7215.14 | 7854 | 903 | 89.45 | 89.45 | 91.21 | 89.66 | 0.32 | 0.28 | 10.27 | 0.00 |
| 2008 | 7986.83 | 8784 | 903 | 100.00 | 100.00 | 100.69 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 7302.50 | 8017 | 903 | 91.53 | 91.53 | 92.32 | 91.52 | 1.70 | 1.58 | 6.88 | 0.00 |
| 2010 | 6779.93 | 7496 | 903 | 85.60 | 85.60 | 85.71 | 85.57 | 1.40 | 1.21 | 13.18 | 0.00 |
| 2011 | 6243.13 | 6746 | 920 | 77.45 | 100.00 | 77.47 | 77.01 | 0.00 | 0.00 | 0.00 | 22.55 |
| 2012 | 7170.90 | 7531 | 943 | 86.00 | 86.00 | 87.27 | 85.74 | 0.23 | 0.20 | 13.81 | 0.00 |
| 2013 | 7672.82 | 7922 | 943 | 90.44 | 90.44 | 92.87 | 90.42 | 0.65 | 0.59 | 8.97 | 0.00 |
| 2014 | 8279.47 | 8546 | 943 | 97.56 | 97.56 | 100.23 | 97.56 | 2.44 | 2.44 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2015 | 7789.98 | 8141 | 948 | 92.96 | 92.96 | 93.80 | 92.93 | 1.54 | 1.46 | 5.58 | 0.00 |
| 2016 | 7629.40 | 7925 | 948 | 90.22 | 90.22 | 91.62 | 90.22 | 0.00 | 0.00 | 9.78 | 0.00 |
| 2017 | 8492.34 | 8760 | 948 | 100.00 | 100.00 | 102.26 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 7568.38 | 7893 | 948 | 90.10 | 90.10 | 91.14 | 90.10 | 0.00 | 0.00 | 9.90 | 0.00 |
| 2019 | 7850.41 | 8159 | 948 | 93.16 | 93.16 | 94.53 | 93.14 | 0.46 | 0.43 | 6.40 | 0.00 |
| 2020 | 8468.83 | 8783 | 948 | 100.00 | 100.00 | 101.70 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 6896.85 | 7276 | 948 | 83.06 | 83.06 | 83.05 | 83.06 | 3.65 | 3.14 | 13.80 | 0.00 |
| 2022 | 7485.98 | 7812 | 948 | 89.17 | 89.17 | 90.14 | 89.18 | 0.86 | 0.77 | 10.06 | 0.00 |
| 2023 | 8412.10 | 8720 | 948 | 99.91 | 99.91 | 101.30 | 99.54 | 0.00 | 0.08 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1978 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 295 | |
| B. Refuelling without maintenance | | | | 41 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 828 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 79 | | |
| E. Testing of plant systems or components | | | | 6 | 3 | |
| L. Human factor related | | | | | 3 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 44 |
| Z. Other | | | | 0 | 7 | |
| Subtotal | | | | 954 | 308 | 44 |
| Total | | 0 | | | 1306 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1978 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 10 |
| 12. Reactor I&C Systems | | 3 |
| 13. Reactor Auxiliary Systems | | 9 |
| 14. Safety Systems | | 14 |
| 15. Reactor Cooling Systems | | 38 |
| 16. Steam generation systems | | 80 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 38 |
| 32. Feedwater and Main Steam System | | 15 |
| 33. Circulating Water System | | 3 |
| 34. Miscellaneous Systems | | 16 |
| 41. Main Generator Systems | | 10 |
| 42. Electrical Power Supply Systems | | 62 |
| Total | | 299 |

2023 Operating Experience

US-339 **NORTH ANNA-2** **UNITED STATES OF AMERICA**

Status at end of year : **Operational**
 Operator : DOMINION (Dominion Energy)
 Owner : VEPCO (Virginia Electric Power Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)

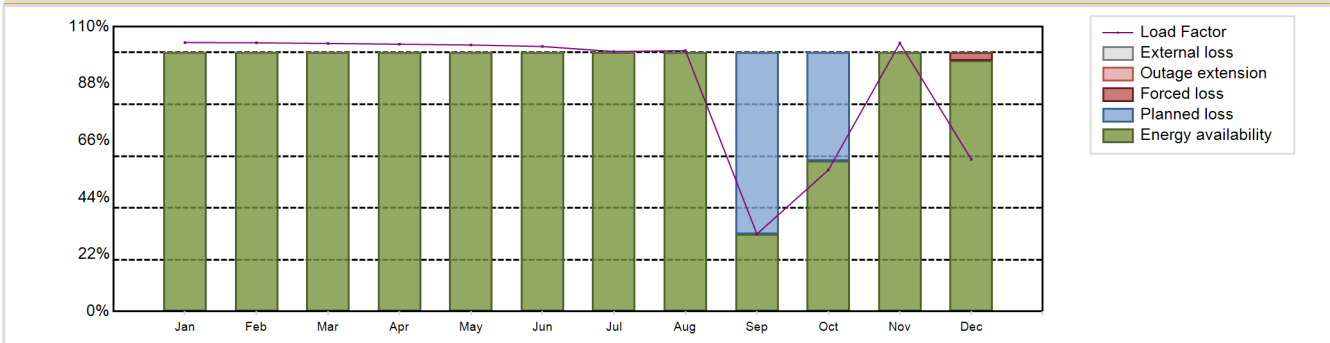


| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP (DRYSUB) | Construction Date | : 1971-02-19 |
| Thermal power | : 2940 MWth | Grid Date | : 1980-08-25 |
| Gross electrical power | : 1011 MWe | Commercial Date | : 1980-12-14 |
| Reference unit power (net) | : 944 MWe | Age at end of year | : 43 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.316 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 39000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.82 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.59 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 32 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 7352.87 GW(e).h | Forced Loss Rate (FLR) | : 0.3 % |
| Energy Availability Factor (EAF) | : 90.41 % | Unplanned Capability Loss Factor (UCL) | : 0.27 % |
| Unit Capability Factor (UCF) | : 90.41 % | Planned Unavailability Factor (PUF) | : 9.32 % |
| Load Factor (LF) | : 88.92 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 89.06 % | Total off-line time | : 958 hours |

Annual Summary

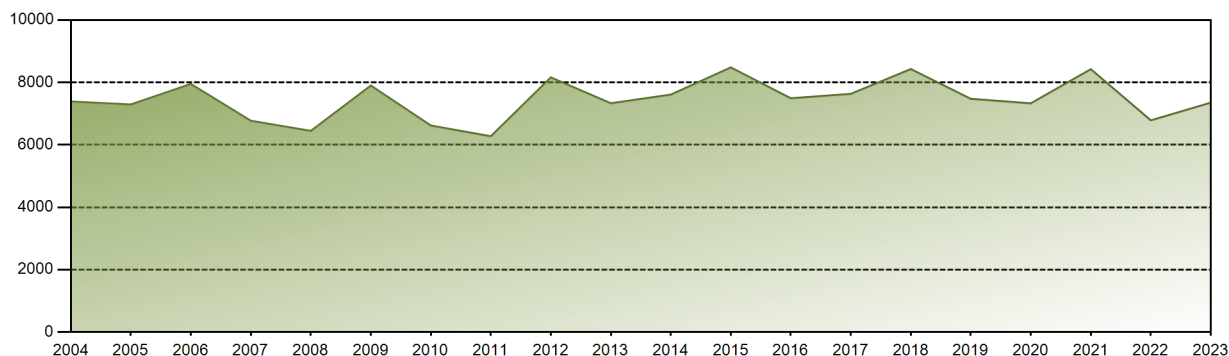


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 729.67 | 658.31 | 726.19 | 701.65 | 723.04 | 695.63 | 705.26 | 707.66 | 203.49 | 383.89 | 705.51 | 412.58 | 7352.87 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 29.95 | 58.05 | 100.00 | 96.77 | 90.41 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 29.95 | 58.05 | 100.00 | 96.77 | 90.41 |
| LF [%] | 103.89 | 103.77 | 103.54 | 103.23 | 102.95 | 102.35 | 100.42 | 100.76 | 29.94 | 54.66 | 103.66 | 58.74 | 88.92 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 30.00 | 58.06 | 100.00 | 80.91 | 89.06 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.23 | 0.30 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.23 | 0.27 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 70.05 | 41.95 | 0.00 | 0.00 | 9.32 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 296717.91 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.36 % |
| Cumulative Energy Availability Factor (EAF) | : 87.13 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.05 % |
| Cumulative Unit Capability Factor (UCF) | : 87.74 % | Cumulative Planned Unavailability Factor (PUF) | : 9.21 % |
| Cumulative Load Factor (LF) | : 85.87 % | Cumulative Externally cause unavailability (XUF) | : 0.62 % |
| Cumulative Operating Factor (OF) | : 86.94 % | | |

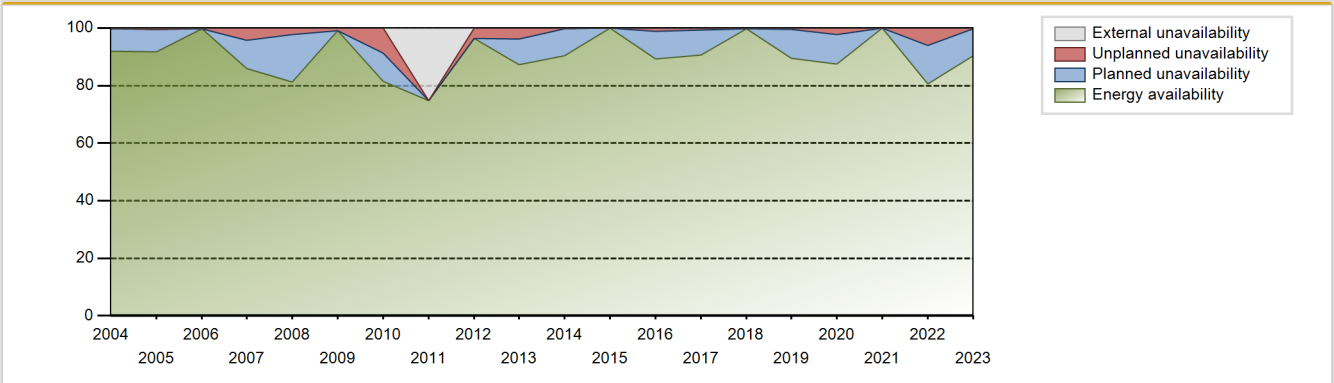
Electricity Production (net) [GWh]



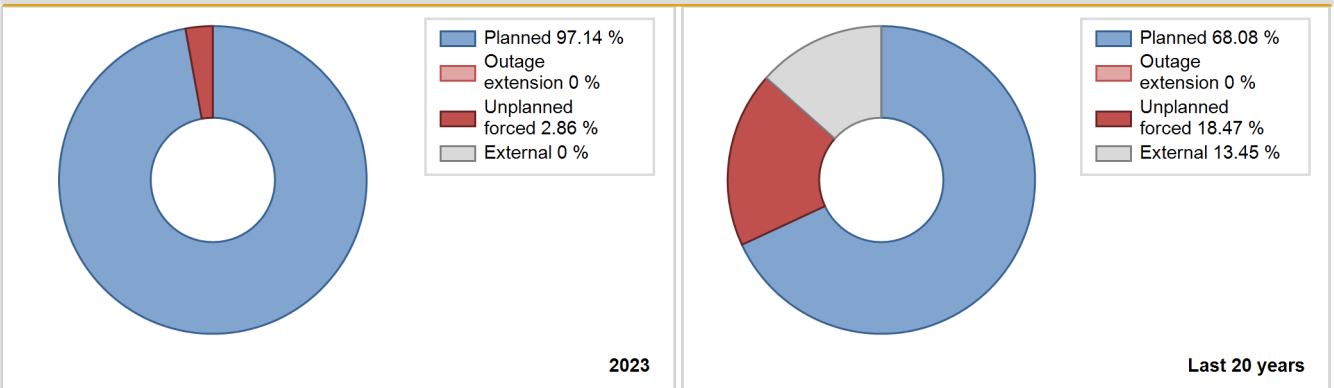
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1980 | 1082.50 | 1701 | 897 | 97.50 | 97.50 | 90.12 | 95.37 | 2.50 | 2.50 | 0.00 | 0.00 |
| 1981 | 5652.70 | 6813 | 883 | 78.35 | 78.35 | 73.08 | 77.77 | 19.06 | 18.46 | 3.19 | 0.00 |
| 1982 | 4047.20 | 4990 | 890 | 57.35 | 57.35 | 51.91 | 56.96 | 22.01 | 16.18 | 26.47 | 0.00 |
| 1983 | 5802.50 | 7052 | 890 | 80.75 | 80.75 | 74.43 | 80.50 | 4.16 | 3.51 | 15.74 | 0.00 |
| 1984 | 4717.19 | 5896 | 890 | 67.14 | 67.14 | 60.34 | 67.12 | 5.29 | 3.75 | 29.11 | 0.00 |
| 1985 | 6813.59 | 8252 | 892 | 94.22 | 94.22 | 87.17 | 94.20 | 5.78 | 5.78 | 0.00 | 0.00 |
| 1986 | 6022.05 | 7208 | 893 | 82.25 | 82.25 | 76.98 | 82.28 | 6.38 | 5.60 | 12.15 | 0.00 |
| 1987 | 5653.45 | 6783 | 905 | 77.42 | 77.42 | 71.24 | 77.43 | 0.00 | 0.00 | 22.58 | 0.00 |
| 1988 | 7883.98 | 8708 | 915 | 99.15 | 99.15 | 98.09 | 99.13 | 0.00 | 0.00 | 0.85 | 0.00 |
| 1989 | 5896.51 | 6887 | 915 | 80.17 | 80.17 | 73.56 | 78.62 | 0.00 | 0.00 | 19.83 | 0.00 |
| 1990 | 5976.65 | 6982 | 910 | 80.01 | 80.01 | 74.93 | 79.70 | 19.96 | 19.95 | 0.03 | 0.00 |
| 1991 | 7684.26 | 8539 | 909 | 97.52 | 97.52 | 96.50 | 97.48 | 2.48 | 2.48 | 0.00 | 0.00 |
| 1992 | 6324.75 | 7237 | 909 | 82.63 | 82.63 | 79.21 | 82.39 | 0.94 | 0.78 | 16.59 | 0.00 |
| 1993 | 6225.22 | 7303 | 909 | 83.60 | 83.60 | 78.18 | 83.37 | 3.16 | 2.73 | 13.68 | 0.00 |
| 1994 | 7490.27 | 8517 | 887 | 97.19 | 97.19 | 96.40 | 97.23 | 2.81 | 2.81 | 0.00 | 0.00 |
| 1995 | 6031.67 | 7086 | 892 | 80.82 | 80.82 | 77.19 | 80.89 | 0.42 | 0.34 | 18.84 | 0.00 |
| 1996 | 6121.54 | 6859 | 897 | 78.13 | 78.13 | 77.69 | 78.09 | 13.48 | 12.17 | 9.70 | 0.00 |
| 1997 | 7834.79 | 8738 | 897 | 99.75 | 99.75 | 99.71 | 99.75 | 0.25 | 0.25 | 0.00 | 0.00 |
| 1998 | 7086.10 | 8049 | 897 | 91.91 | 92.15 | 90.18 | 91.88 | 0.00 | 0.00 | 7.85 | 0.23 |
| 1999 | 7185.14 | 8034 | 897 | 91.73 | 91.73 | 91.44 | 91.71 | 0.49 | 0.45 | 7.82 | 0.00 |
| 2000 | 8018.85 | 8729 | 897 | 99.38 | 99.38 | 101.77 | 99.37 | 0.62 | 0.62 | 0.00 | 0.00 |
| 2001 | 5975.80 | 6776 | 917 | 77.40 | 77.40 | 74.39 | 77.35 | 1.24 | 0.97 | 21.63 | 0.00 |
| 2002 | 5509.69 | 6000 | 917 | 68.48 | 68.48 | 68.59 | 68.49 | 0.00 | 0.00 | 31.52 | 0.00 |
| 2003 | 7262.75 | 7950 | 917 | 90.77 | 90.77 | 90.41 | 90.75 | 0.26 | 0.24 | 9.00 | 0.00 |
| 2004 | 7388.14 | 8077 | 917 | 91.97 | 91.97 | 91.72 | 91.95 | 0.28 | 0.26 | 7.78 | 0.00 |
| 2005 | 7293.54 | 8034 | 917 | 91.72 | 92.14 | 90.80 | 91.71 | 0.00 | 0.00 | 7.86 | 0.42 |
| 2006 | 7950.42 | 8732 | 910 | 99.68 | 99.68 | 99.73 | 99.68 | 0.32 | 0.32 | 0.00 | 0.00 |
| 2007 | 6771.79 | 7524 | 903 | 85.81 | 85.81 | 85.61 | 85.89 | 4.66 | 4.20 | 9.99 | 0.00 |
| 2008 | 6446.59 | 7132 | 903 | 81.21 | 81.21 | 81.27 | 81.19 | 2.84 | 2.37 | 16.42 | 0.00 |
| 2009 | 7900.11 | 8688 | 903 | 99.18 | 99.18 | 99.87 | 99.18 | 0.82 | 0.82 | 0.00 | 0.00 |
| 2010 | 6619.53 | 7093 | 943 | 81.56 | 81.56 | 81.27 | 80.97 | 9.72 | 8.78 | 9.66 | 0.00 |
| 2011 | 6275.39 | 6570 | 943 | 74.77 | 100.00 | 75.97 | 75.00 | 0.00 | 0.00 | 0.00 | 25.23 |
| 2012 | 8162.29 | 8474 | 943 | 96.48 | 96.48 | 98.54 | 96.47 | 3.52 | 3.52 | 0.00 | 0.00 |
| 2013 | 7332.46 | 7642 | 943 | 87.24 | 87.24 | 88.75 | 87.23 | 4.24 | 3.86 | 8.90 | 0.00 |
| 2014 | 7609.18 | 7913 | 943 | 90.33 | 90.33 | 92.11 | 90.33 | 0.41 | 0.37 | 9.31 | 0.00 |
| 2015 | 8480.65 | 8760 | 943 | 100.00 | 100.00 | 102.66 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 7491.97 | 7835 | 943 | 89.18 | 89.18 | 90.45 | 89.20 | 1.30 | 1.18 | 9.64 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2017 | 7633.75 | 7937 | 944 | 90.62 | 90.62 | 92.31 | 90.61 | 0.70 | 0.64 | 8.75 | 0.00 |
| 2018 | 8428.87 | 8732 | 944 | 99.68 | 99.68 | 101.93 | 99.68 | 0.32 | 0.32 | 0.00 | 0.00 |
| 2019 | 7474.13 | 7828 | 944 | 89.38 | 89.38 | 90.38 | 89.36 | 0.46 | 0.41 | 10.21 | 0.00 |
| 2020 | 7331.07 | 7689 | 944 | 87.54 | 87.54 | 88.41 | 87.53 | 2.53 | 2.27 | 10.18 | 0.00 |
| 2021 | 8423.95 | 8760 | 944 | 100.00 | 100.00 | 101.87 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 6784.90 | 7066 | 944 | 80.67 | 80.67 | 82.05 | 80.66 | 6.97 | 6.04 | 13.29 | 0.00 |
| 2023 | 7352.87 | 7802 | 944 | 90.41 | 90.41 | 88.92 | 89.06 | 0.30 | 0.27 | 9.32 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1980 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 208 | |
| B. Refuelling without maintenance | | | | 40 | | |
| C. Inspection, maintenance or repair combined with refuelling | 816 | | | 712 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 58 | | |
| E. Testing of plant systems or components | | | | 2 | | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| L. Human factor related | | | | | 9 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 57 |
| Z. Other | | | | | 46 | |
| Subtotal | 816 | | | 812 | 266 | 57 |
| Total | | 816 | | | 1135 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1980 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 4 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 15 |
| 15. Reactor Cooling Systems | | 24 |
| 16. Steam generation systems | | 67 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 6 |
| 32. Feedwater and Main Steam System | | 18 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 12 |
| 41. Main Generator Systems | | 50 |
| 42. Electrical Power Supply Systems | | 54 |
| Total | | 254 |

2023 Operating Experience

US-269

OCONEE-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : DUKEENER (Duke Energy Corp.)
 Owner : DUKEENER (Duke Energy Corp.)
 Reactor Supplier : B&W (BABCOCK & WILCOX CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / B&W LLP (DRYAMB)
 Thermal power : 2568 MWth
 Gross electrical power : 891 MWe
 Reference unit power (net) : 847 MWe

Key Dates

Construction Date : 1967-11-06
 Grid Date : 1973-05-06
 Commercial Date : 1973-07-15
 Age at end of year : 50 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 34
 Average discharge burnup [MWd/t] : 30000
 Active core diameter [m] : 3.27
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 19
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 318
 Number of SG : 2
 Containment type : -
 Containment design pressure [MPa] : 0.513

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.33
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

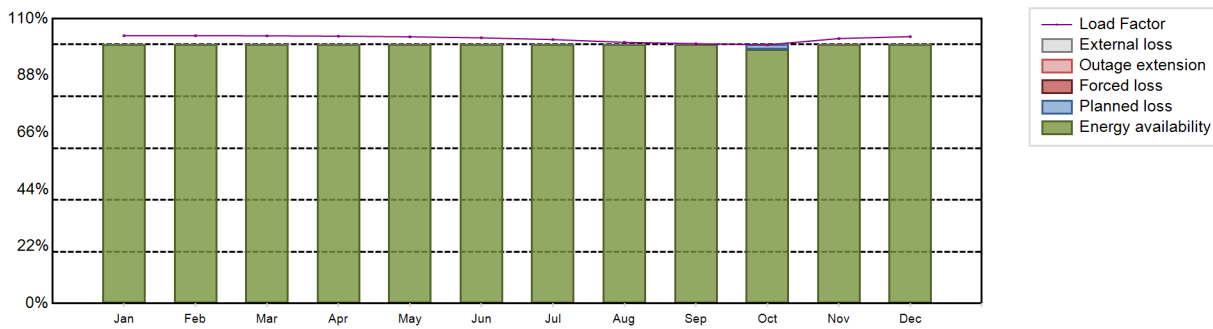
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7589.74 GW(e).h
 Energy Availability Factor (EAF) : 99.84 %
 Unit Capability Factor (UCF) : 99.84 %
 Load Factor (LF) : 102.29 %
 Operating Factor (OF) : 100 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.16 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

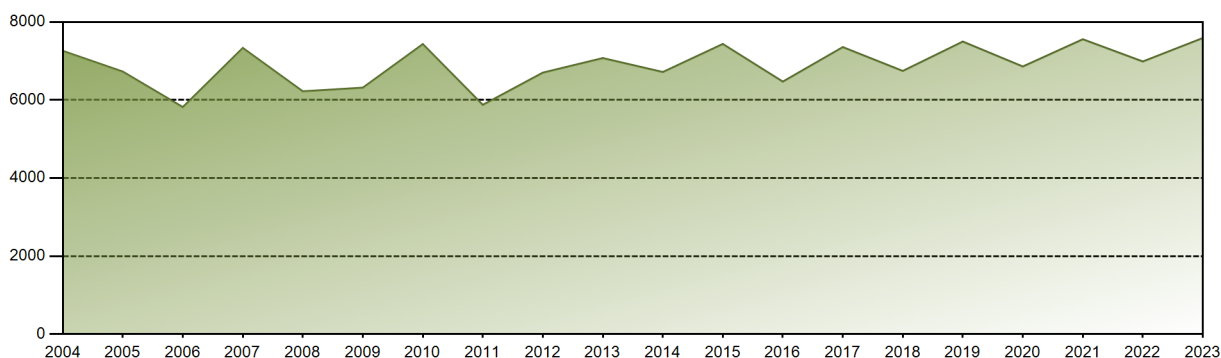


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 651.65 | 588.79 | 650.65 | 629.69 | 649.14 | 625.73 | 642.35 | 635.68 | 611.96 | 629.52 | 624.97 | 649.61 | 7589.74 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.10 | 100.00 | 100.00 | 99.84 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 98.10 | 100.00 | 100.00 | 99.84 |
| LF [%] | 103.41 | 103.44 | 103.39 | 103.26 | 103.01 | 102.61 | 101.93 | 100.88 | 100.35 | 99.90 | 102.34 | 103.09 | 102.29 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.90 | 0.00 | 0.00 | 0.16 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 306113.96 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.89 % |
| Cumulative Energy Availability Factor (EAF) | : 83.53 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.27 % |
| Cumulative Unit Capability Factor (UCF) | : 83.73 % | Cumulative Planned Unavailability Factor (PUF) | : 11 % |
| Cumulative Load Factor (LF) | : 81.47 % | Cumulative Externally cause unavailability (XUF) | : 0.2 % |
| Cumulative Operating Factor (OF) | : 83.2 % | | |

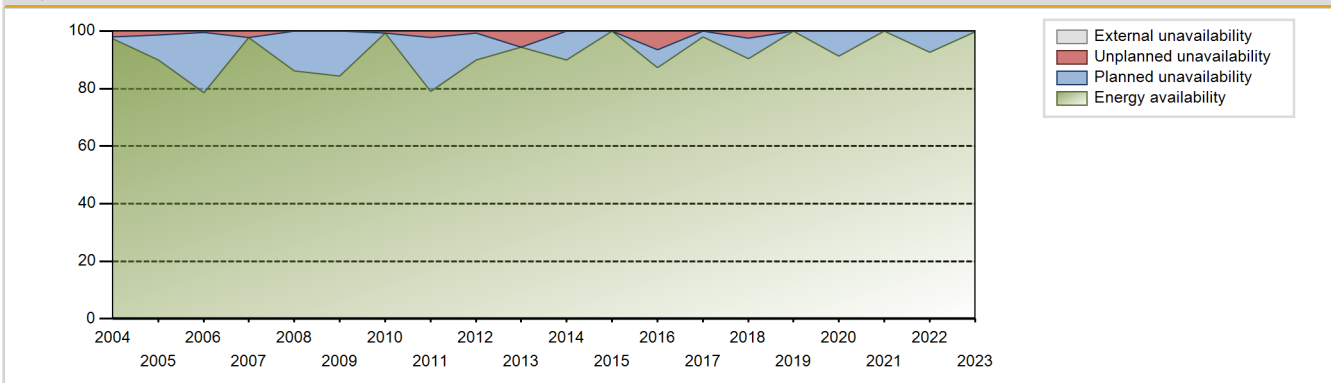
Electricity Production (net) [GWh]



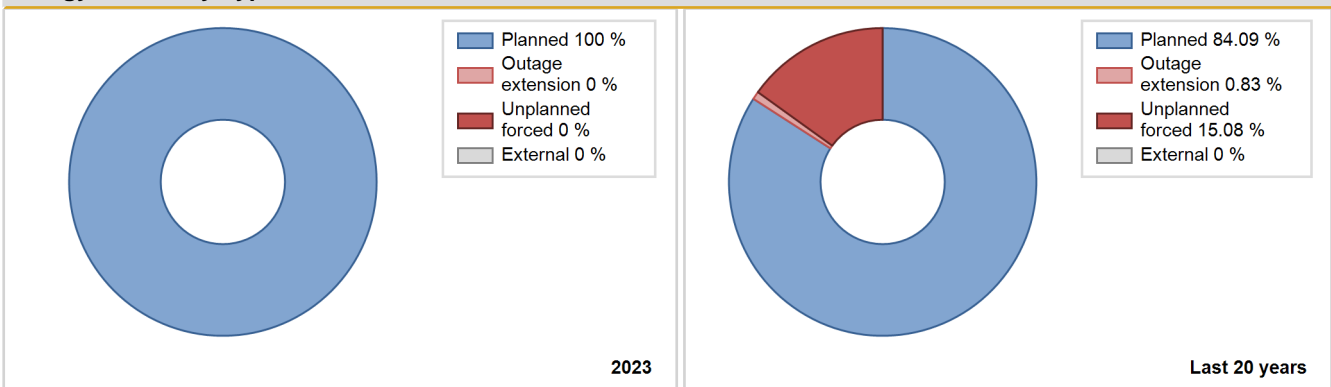
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1973 | 2200.00 | 4226 | 721 | 70.52 | 70.52 | 67.32 | 75.86 | 11.34 | 9.02 | 20.46 | 0.00 |
| 1974 | 4230.30 | 5141 | 920 | 100.00 | 100.00 | 52.49 | 58.69 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1975 | 5299.30 | 6672 | 871 | 69.51 | 69.51 | 69.45 | 76.16 | 27.02 | 25.73 | 4.75 | 0.00 |
| 1976 | 4003.50 | 5029 | 871 | 52.38 | 52.38 | 52.33 | 57.25 | 25.57 | 18.00 | 29.62 | 0.00 |
| 1977 | 3949.00 | 5455 | 860 | 52.47 | 52.47 | 52.42 | 62.27 | 30.19 | 22.69 | 24.84 | 0.00 |
| 1978 | 5054.40 | 6299 | 860 | 67.07 | 67.07 | 67.09 | 71.91 | 20.04 | 16.81 | 16.12 | 0.00 |
| 1979 | 5003.10 | 6220 | 860 | 66.41 | 66.41 | 66.41 | 71.00 | 22.11 | 18.86 | 14.73 | 0.00 |
| 1980 | 5118.30 | 6634 | 860 | 76.23 | 86.33 | 67.75 | 75.52 | 8.70 | 8.22 | 5.45 | 10.10 |
| 1981 | 3023.20 | 3657 | 860 | 42.94 | 42.94 | 40.13 | 41.75 | 13.04 | 6.44 | 50.62 | 0.00 |
| 1982 | 5152.80 | 6335 | 860 | 73.50 | 73.50 | 68.40 | 72.32 | 24.78 | 24.22 | 2.29 | 0.00 |
| 1983 | 5672.00 | 6804 | 860 | 78.43 | 78.43 | 75.29 | 77.67 | 0.46 | 0.37 | 21.20 | 0.00 |
| 1984 | 6173.71 | 7312 | 860 | 83.55 | 83.55 | 81.73 | 83.24 | 2.07 | 1.76 | 14.68 | 0.00 |
| 1985 | 7065.96 | 8424 | 860 | 96.25 | 96.25 | 93.79 | 96.16 | 3.75 | 3.75 | 0.00 | 0.00 |
| 1986 | 4793.94 | 5870 | 860 | 70.22 | 70.22 | 63.63 | 67.01 | 13.19 | 10.67 | 19.11 | 0.00 |
| 1987 | 5031.13 | 6693 | 860 | 76.82 | 76.82 | 66.78 | 76.40 | 4.83 | 3.90 | 19.28 | 0.00 |
| 1988 | 7192.19 | 8742 | 846 | 99.53 | 99.53 | 96.78 | 99.52 | 0.47 | 0.47 | 0.00 | 0.00 |
| 1989 | 5943.13 | 7264 | 846 | 82.95 | 82.95 | 80.19 | 82.92 | 3.54 | 3.04 | 14.01 | 0.00 |
| 1990 | 6454.83 | 7751 | 846 | 88.49 | 88.49 | 87.10 | 88.48 | 0.24 | 0.22 | 11.29 | 0.00 |
| 1991 | 6022.45 | 7245 | 846 | 82.73 | 82.73 | 81.26 | 82.71 | 2.59 | 2.20 | 15.07 | 0.00 |
| 1992 | 6277.69 | 7494 | 846 | 85.31 | 85.31 | 84.48 | 85.31 | 7.36 | 6.77 | 7.91 | 0.00 |
| 1993 | 6525.05 | 7833 | 846 | 89.42 | 89.42 | 88.05 | 89.42 | 2.19 | 2.00 | 8.58 | 0.00 |
| 1994 | 6088.71 | 7302 | 846 | 83.39 | 83.39 | 82.16 | 83.36 | 0.46 | 0.39 | 16.22 | 0.00 |
| 1995 | 6360.47 | 7537 | 846 | 86.07 | 86.07 | 85.83 | 86.04 | 3.88 | 3.47 | 10.46 | 0.00 |
| 1996 | 5566.97 | 6606 | 846 | 75.23 | 75.23 | 74.91 | 75.20 | 0.60 | 0.46 | 24.32 | 0.00 |
| 1997 | 3194.22 | 4482 | 846 | 51.28 | 51.28 | 43.10 | 51.16 | 25.69 | 17.73 | 30.99 | 0.00 |
| 1998 | 5996.40 | 7255 | 846 | 82.83 | 82.83 | 80.91 | 82.82 | 17.17 | 17.17 | 0.00 | 0.00 |
| 1999 | 6212.59 | 7383 | 846 | 85.11 | 85.11 | 83.83 | 84.28 | 3.81 | 3.37 | 11.52 | 0.00 |
| 2000 | 6312.68 | 7445 | 846 | 84.76 | 84.76 | 84.95 | 84.76 | 5.13 | 4.59 | 10.66 | 0.00 |
| 2001 | 6962.62 | 8210 | 846 | 94.03 | 94.03 | 93.95 | 93.72 | 5.71 | 5.70 | 0.28 | 0.00 |
| 2002 | 6607.46 | 7788 | 846 | 88.93 | 88.93 | 89.16 | 88.90 | 1.09 | 0.98 | 10.09 | 0.00 |
| 2003 | 5258.63 | 6288 | 846 | 71.77 | 71.77 | 70.96 | 71.78 | 7.75 | 6.03 | 22.20 | 0.00 |
| 2004 | 7260.23 | 8549 | 846 | 97.33 | 97.33 | 97.70 | 97.32 | 2.07 | 2.06 | 0.61 | 0.00 |
| 2005 | 6728.57 | 7879 | 846 | 89.96 | 89.96 | 90.78 | 89.93 | 0.00 | 1.27 | 8.77 | 0.00 |
| 2006 | 5819.36 | 6884 | 846 | 78.62 | 78.62 | 78.52 | 78.58 | 0.68 | 0.53 | 20.85 | 0.00 |
| 2007 | 7335.72 | 8562 | 846 | 97.74 | 97.74 | 98.98 | 97.74 | 2.26 | 2.26 | 0.00 | 0.00 |
| 2008 | 6222.80 | 7564 | 846 | 86.12 | 86.12 | 83.74 | 86.11 | 0.00 | 0.00 | 13.88 | 0.00 |
| 2009 | 6316.65 | 7393 | 846 | 84.41 | 84.41 | 85.23 | 84.39 | 0.00 | 0.00 | 15.59 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2010 | 7433.77 | 8695 | 846 | 99.27 | 99.27 | 100.31 | 99.26 | 0.73 | 0.73 | 0.00 | 0.00 |
| 2011 | 5876.33 | 6917 | 846 | 78.98 | 78.98 | 79.29 | 78.96 | 2.70 | 2.19 | 18.82 | 0.00 |
| 2012 | 6701.97 | 7902 | 846 | 89.98 | 89.98 | 90.19 | 89.96 | 0.77 | 0.70 | 9.32 | 0.00 |
| 2013 | 7075.28 | 8260 | 846 | 94.29 | 94.29 | 95.46 | 94.28 | 5.71 | 5.71 | 0.00 | 0.00 |
| 2014 | 6718.01 | 7880 | 846 | 89.95 | 89.95 | 90.65 | 89.95 | 0.00 | 0.00 | 10.05 | 0.00 |
| 2015 | 7436.93 | 8760 | 846 | 100.00 | 100.00 | 100.35 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 6472.06 | 7669 | 846 | 87.31 | 87.31 | 87.09 | 87.31 | 6.98 | 6.55 | 6.13 | 0.00 |
| 2017 | 7356.78 | 8583 | 847 | 97.98 | 97.98 | 99.15 | 97.98 | 0.00 | 0.00 | 2.02 | 0.00 |
| 2018 | 6745.64 | 7918 | 847 | 90.39 | 90.39 | 90.91 | 90.39 | 2.68 | 2.49 | 7.12 | 0.00 |
| 2019 | 7498.64 | 8760 | 847 | 100.00 | 100.00 | 101.06 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 6859.97 | 8011 | 847 | 91.19 | 91.19 | 92.20 | 91.20 | 0.00 | 0.00 | 8.81 | 0.00 |
| 2021 | 7558.02 | 8760 | 847 | 100.00 | 100.00 | 101.86 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 6988.17 | 8116 | 847 | 92.66 | 92.66 | 94.18 | 92.65 | 0.00 | 0.00 | 7.34 | 0.00 |
| 2023 | 7589.74 | 8760 | 847 | 99.84 | 99.84 | 102.29 | 100.00 | 0.00 | 0.00 | 0.16 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1973 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 422 | |
| B. Refuelling without maintenance | | | | 28 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 766 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 116 | | |
| E. Testing of plant systems or components | | | | 16 | 3 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 27 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 1 | |
| P. Fire | | | | | 11 | |
| Z. Other | | | | | 1 | |
| Subtotal | | | | 927 | 465 | 0 |
| Total | | 0 | | | 1392 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1973 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 32 |
| 12. Reactor I&C Systems | | 45 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 38 |
| 15. Reactor Cooling Systems | | 91 |
| 16. Steam generation systems | | 118 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 4 |
| 31. Turbine and auxiliaries | | 35 |
| 32. Feedwater and Main Steam System | | 16 |
| 34. Miscellaneous Systems | | 28 |
| 41. Main Generator Systems | | 12 |
| 42. Electrical Power Supply Systems | | 29 |
| Total | | 451 |

2023 Operating Experience

US-270

OCONEE-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : DUKEENER (Duke Energy Corp.)
 Owner : DUKEENER (Duke Energy Corp.)
 Reactor Supplier : B&W (BABCOCK & WILCOX CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / B&W LLP (DRYAMB)
 Thermal power : 2568 MWth
 Gross electrical power : 891 MWe
 Reference unit power (net) : 848 MWe

Key Dates

Construction Date : 1967-11-06
 Grid Date : 1973-12-05
 Commercial Date : 1974-09-09
 Age at end of year : 50 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 34
 Average discharge burnup [MWd/t] : 30000
 Active core diameter [m] : 3.27
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 177
 Fuel linear heat generation rate [kW/m] : 19.06
 Number of control rod assemblies : 28
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.5
 Reactor outlet temperature [°C] : 318
 Number of SG : 2
 Containment type : -
 Containment design pressure [MPa] : 0.513

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.33
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

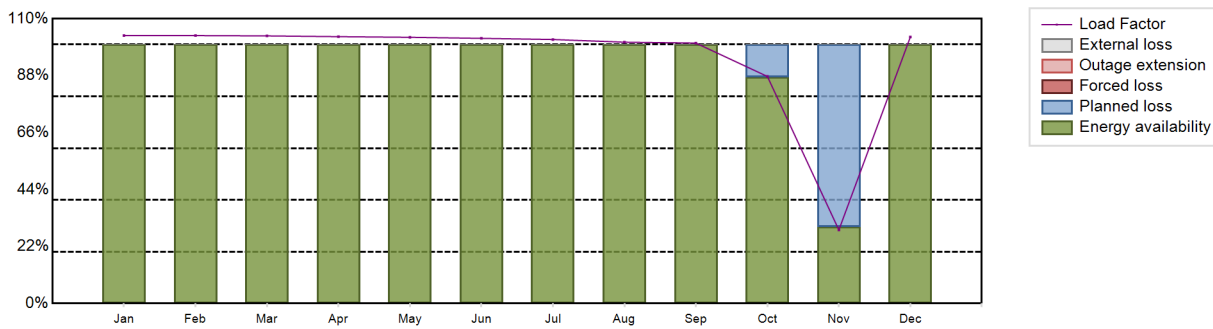
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7068 GW(e).h
 Energy Availability Factor (EAF) : 93.15 %
 Unit Capability Factor (UCF) : 93.15 %
 Load Factor (LF) : 95.15 %
 Operating Factor (OF) : 93.14 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 6.85 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 601 hours

Annual Summary

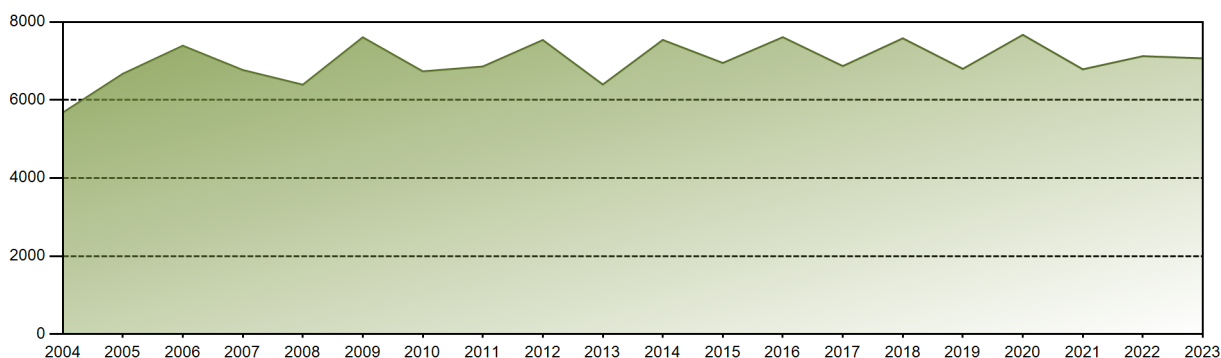


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 652.96 | 589.70 | 651.23 | 629.23 | 648.68 | 625.32 | 643.33 | 636.82 | 614.12 | 553.36 | 173.75 | 649.50 | 7068.01 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.40 | 29.74 | 100.00 | 93.15 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.40 | 29.74 | 100.00 | 93.15 |
| LF [%] | 103.49 | 103.48 | 103.36 | 103.06 | 102.82 | 102.42 | 101.97 | 100.94 | 100.58 | 87.71 | 28.42 | 102.95 | 95.15 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.37 | 29.68 | 100.00 | 93.14 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.60 | 70.26 | 0.00 | 6.85 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 308320.41 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.57 % |
| Cumulative Energy Availability Factor (EAF) | : 85.08 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.02 % |
| Cumulative Unit Capability Factor (UCF) | : 85.23 % | Cumulative Planned Unavailability Factor (PUF) | : 9.74 % |
| Cumulative Load Factor (LF) | : 83.83 % | Cumulative Externally cause unavailability (XUF) | : 0.16 % |
| Cumulative Operating Factor (OF) | : 85.57 % | | |

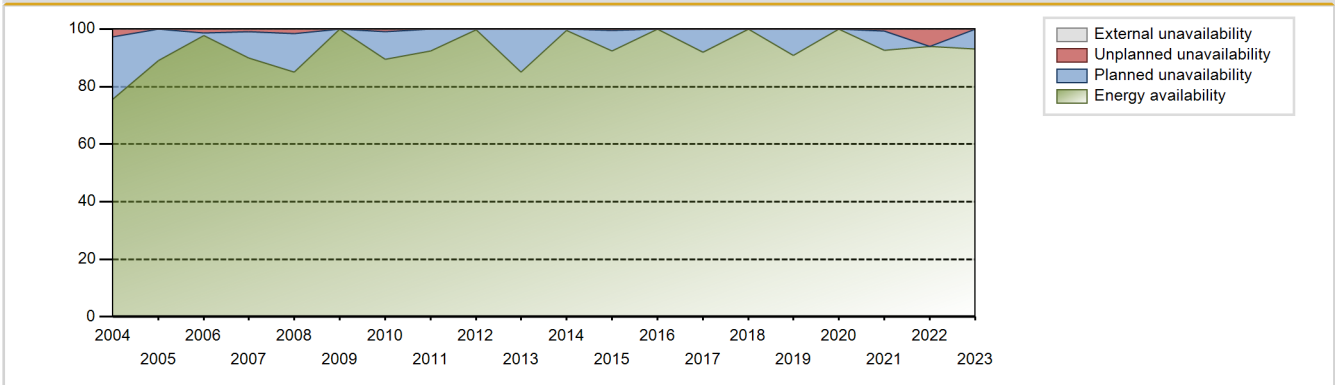
Electricity Production (net) [GWh]



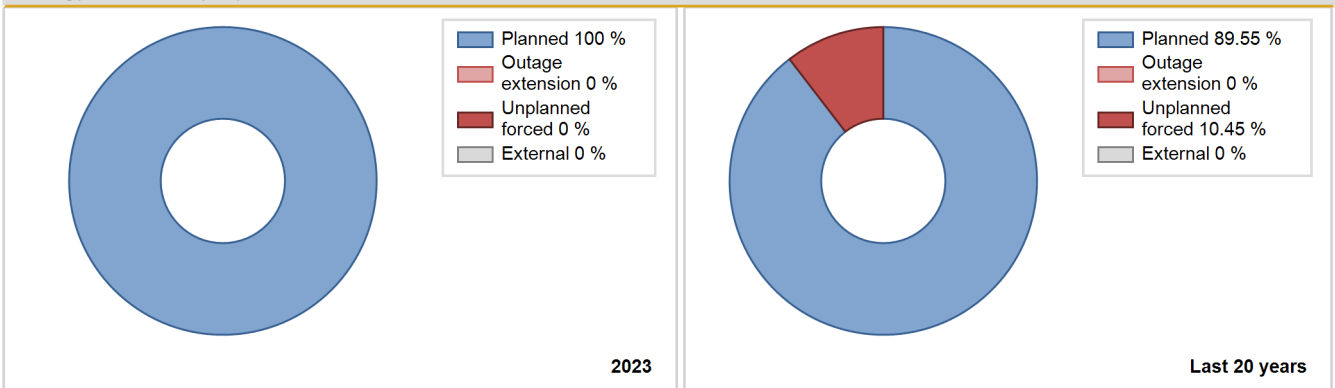
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1974 | 2115.50 | 2786 | 920 | 100.00 | 100.00 | 54.57 | 61.89 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1975 | 4970.60 | 6398 | 871 | 65.21 | 65.21 | 65.15 | 73.04 | 29.64 | 27.47 | 7.32 | 0.00 |
| 1976 | 4232.60 | 5483 | 871 | 55.38 | 55.38 | 55.32 | 62.42 | 32.45 | 26.61 | 18.02 | 0.00 |
| 1977 | 3830.00 | 5315 | 860 | 50.88 | 50.88 | 50.84 | 60.67 | 30.19 | 22.00 | 27.12 | 0.00 |
| 1978 | 4786.20 | 6155 | 860 | 63.54 | 63.54 | 63.53 | 70.26 | 25.09 | 21.28 | 15.17 | 0.00 |
| 1979 | 5968.20 | 7532 | 860 | 79.22 | 79.22 | 79.22 | 85.98 | 13.54 | 12.41 | 8.37 | 0.00 |
| 1980 | 3882.00 | 5397 | 860 | 62.03 | 69.65 | 51.39 | 61.44 | 0.20 | 0.14 | 30.21 | 7.62 |
| 1981 | 5198.90 | 7050 | 860 | 81.03 | 81.03 | 69.01 | 80.48 | 15.40 | 14.75 | 4.22 | 0.00 |
| 1982 | 3447.70 | 4580 | 860 | 53.48 | 53.48 | 45.76 | 52.28 | 17.17 | 11.09 | 35.44 | 0.00 |
| 1983 | 5147.00 | 6348 | 860 | 73.25 | 73.25 | 68.32 | 72.47 | 8.09 | 6.45 | 20.30 | 0.00 |
| 1984 | 7297.96 | 8784 | 860 | 100.00 | 100.00 | 96.61 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1985 | 5059.95 | 6654 | 860 | 76.28 | 76.28 | 67.17 | 75.96 | 4.92 | 3.95 | 19.77 | 0.00 |
| 1986 | 5803.10 | 7169 | 860 | 81.37 | 81.37 | 77.03 | 81.84 | 1.33 | 1.10 | 17.53 | 0.00 |
| 1987 | 6228.69 | 8565 | 860 | 98.02 | 98.02 | 82.68 | 97.77 | 1.98 | 1.98 | 0.00 | 0.00 |
| 1988 | 5539.98 | 6880 | 846 | 78.35 | 78.35 | 74.55 | 78.32 | 1.01 | 0.80 | 20.85 | 0.00 |
| 1989 | 6013.10 | 7272 | 846 | 83.06 | 83.06 | 81.14 | 83.01 | 4.79 | 4.18 | 12.76 | 0.00 |
| 1990 | 6269.36 | 7469 | 846 | 85.26 | 85.26 | 84.60 | 85.26 | 2.95 | 2.59 | 12.15 | 0.00 |
| 1991 | 7427.94 | 8760 | 846 | 100.00 | 100.00 | 100.23 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1992 | 5946.93 | 7103 | 846 | 80.89 | 80.89 | 80.03 | 80.86 | 4.00 | 3.37 | 15.74 | 0.00 |
| 1993 | 6236.28 | 7352 | 846 | 83.95 | 83.95 | 84.15 | 83.93 | 0.66 | 0.56 | 15.49 | 0.00 |
| 1994 | 6148.50 | 7292 | 846 | 83.33 | 83.33 | 82.96 | 83.24 | 5.53 | 4.87 | 11.79 | 0.00 |
| 1995 | 6973.94 | 8263 | 846 | 94.35 | 94.35 | 94.10 | 94.33 | 5.65 | 5.65 | 0.00 | 0.00 |
| 1996 | 4431.97 | 5304 | 846 | 60.42 | 60.42 | 59.64 | 60.38 | 32.36 | 28.90 | 10.68 | 0.00 |
| 1997 | 5876.79 | 6974 | 846 | 79.67 | 79.67 | 79.30 | 79.61 | 20.33 | 20.33 | 0.00 | 0.00 |
| 1998 | 5654.70 | 6776 | 846 | 77.39 | 77.39 | 76.30 | 77.35 | 4.49 | 3.64 | 18.97 | 0.00 |
| 1999 | 6257.60 | 7374 | 846 | 84.20 | 84.20 | 84.44 | 84.18 | 4.67 | 4.13 | 11.67 | 0.00 |
| 2000 | 7499.52 | 8784 | 846 | 100.00 | 100.00 | 100.92 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 6688.42 | 7836 | 846 | 89.45 | 89.45 | 90.25 | 89.45 | 0.00 | 0.00 | 10.55 | 0.00 |
| 2002 | 6611.11 | 7743 | 846 | 88.40 | 88.40 | 89.20 | 88.38 | 3.37 | 3.08 | 8.52 | 0.00 |
| 2003 | 7568.72 | 8760 | 846 | 100.00 | 100.00 | 102.13 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 5676.11 | 6652 | 846 | 75.76 | 75.76 | 76.38 | 75.73 | 3.40 | 2.67 | 21.57 | 0.00 |
| 2005 | 6672.33 | 7808 | 846 | 89.14 | 89.14 | 90.03 | 89.13 | 0.00 | 0.00 | 10.86 | 0.00 |
| 2006 | 7391.88 | 8552 | 846 | 97.65 | 97.65 | 99.74 | 97.63 | 1.36 | 1.35 | 1.01 | 0.00 |
| 2007 | 6768.99 | 7878 | 846 | 89.95 | 89.95 | 91.34 | 89.93 | 1.13 | 1.03 | 9.02 | 0.00 |
| 2008 | 6392.52 | 7470 | 846 | 85.06 | 85.06 | 86.02 | 85.04 | 1.88 | 1.63 | 13.31 | 0.00 |
| 2009 | 7606.99 | 8760 | 846 | 100.00 | 100.00 | 102.65 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 6734.26 | 7829 | 846 | 89.41 | 89.41 | 90.87 | 89.37 | 1.05 | 0.95 | 9.65 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2011 | 6858.68 | 8097 | 846 | 92.45 | 92.45 | 92.55 | 92.43 | 0.00 | 0.00 | 7.55 | 0.00 |
| 2012 | 7537.01 | 8756 | 846 | 99.69 | 99.69 | 101.42 | 99.68 | 0.00 | 0.00 | 0.31 | 0.00 |
| 2013 | 6396.65 | 7455 | 846 | 85.11 | 85.11 | 86.30 | 85.09 | 0.00 | 0.00 | 14.89 | 0.00 |
| 2014 | 7539.58 | 8711 | 846 | 99.44 | 99.44 | 101.74 | 99.44 | 0.00 | 0.00 | 0.56 | 0.00 |
| 2015 | 6949.48 | 8082 | 848 | 92.28 | 92.28 | 93.55 | 92.26 | 0.57 | 0.52 | 7.19 | 0.00 |
| 2016 | 7609.83 | 8784 | 848 | 100.00 | 100.00 | 102.16 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 6869.61 | 8045 | 848 | 91.83 | 91.83 | 92.48 | 91.84 | 0.00 | 0.00 | 8.17 | 0.00 |
| 2018 | 7581.17 | 8760 | 848 | 100.00 | 100.00 | 102.06 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 6798.42 | 7955 | 848 | 90.82 | 90.82 | 91.52 | 90.81 | 0.00 | 0.00 | 9.18 | 0.00 |
| 2020 | 7670.16 | 8783 | 848 | 100.00 | 100.00 | 102.97 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 6786.82 | 8106 | 848 | 92.53 | 92.53 | 91.36 | 92.53 | 0.74 | 0.69 | 6.78 | 0.00 |
| 2022 | 7123.87 | 8236 | 848 | 94.02 | 94.02 | 95.90 | 94.02 | 5.98 | 5.98 | 0.00 | 0.00 |
| 2023 | 7068.01 | 8159 | 848 | 93.15 | 93.15 | 95.15 | 93.14 | 0.00 | 0.00 | 6.85 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1974 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 403 | |
| B. Refuelling without maintenance | | | | 12 | | |
| C. Inspection, maintenance or repair combined with refuelling | 600 | | | 749 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 48 | | |
| E. Testing of plant systems or components | | | | 4 | 3 | |
| H. Nuclear regulatory requirements | | | | | 21 | |
| L. Human factor related | | | | | 1 | |
| Z. Other | | | | | 1 | |
| Subtotal | 600 | | | 813 | 429 | |
| Total | | 600 | | | 1242 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1974 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 29 |
| 12. Reactor I&C Systems | | 43 |
| 13. Reactor Auxiliary Systems | | 8 |
| 14. Safety Systems | | 32 |
| 15. Reactor Cooling Systems | | 74 |
| 16. Steam generation systems | | 79 |
| 31. Turbine and auxiliaries | | 106 |
| 32. Feedwater and Main Steam System | | 6 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 2 |
| 41. Main Generator Systems | | 16 |
| 42. Electrical Power Supply Systems | | 12 |
| Total | | 409 |

2023 Operating Experience

US-287 **OCONEE-3** **UNITED STATES OF AMERICA**

Status at end of year : **Operational**
 Operator : DUKEENER (Duke Energy Corp.)
 Owner : DUKEENER (Duke Energy Corp.)
 Reactor Supplier : B&W (BABCOCK & WILCOX CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)

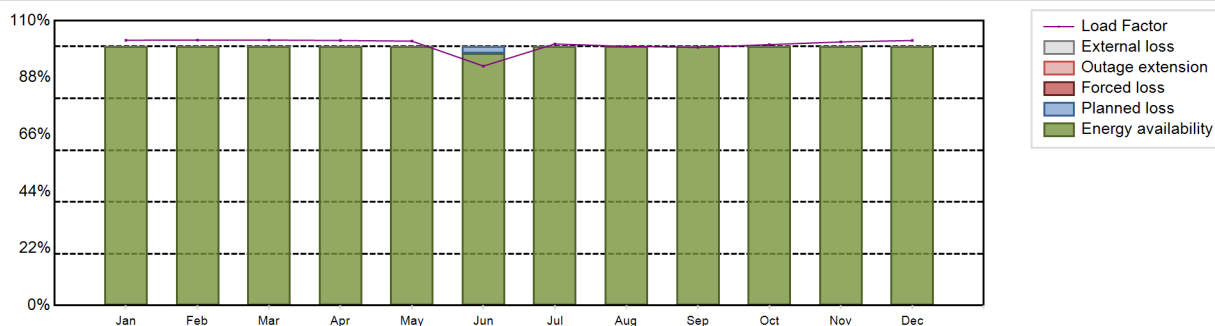


| Reactor Unit Details | | Key Dates | |
|----------------------------|--------------------------|--------------------|--------------|
| Reactor type and model | : PWR / B&W LLP (DRYAMB) | Construction Date | : 1967-11-06 |
| Thermal power | : 2568 MWth | Grid Date | : 1974-09-18 |
| Gross electrical power | : 900 MWe | Commercial Date | : 1974-12-16 |
| Reference unit power (net) | : 859 MWe | Age at end of year | : 49 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 318 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.513 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 34 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 30000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.27 | HP cylinder inlet steam pressure [MPa] | : 6.33 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 177 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 19.06 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 28 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|------------|
| Net Energy Production | : 7588.99 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.78 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 99.78 % | Planned Unavailability Factor (PUF) | : 0.22 % |
| Load Factor (LF) | : 100.85 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 99.42 % | Total off-line time | : 51 hours |

Annual Summary

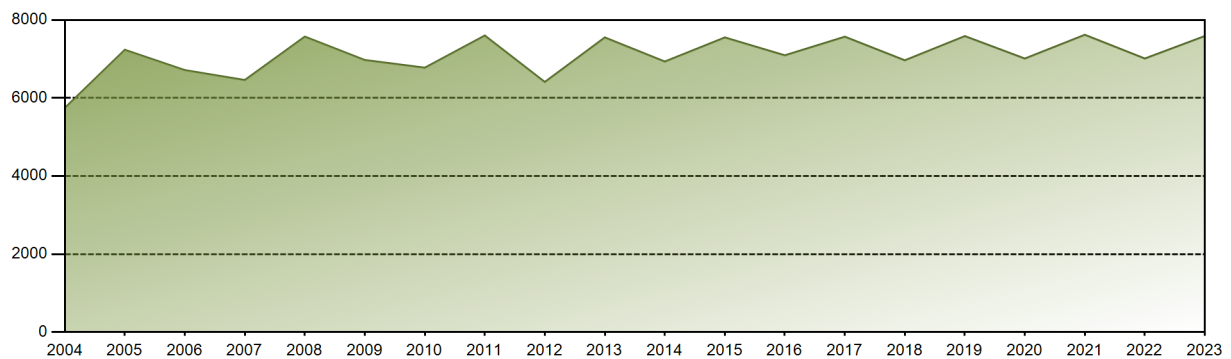


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 654.84 | 591.78 | 654.30 | 633.03 | 652.58 | 571.96 | 645.58 | 639.59 | 616.66 | 643.99 | 630.57 | 654.10 | 7588.99 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.33 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.78 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.33 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.78 |
| LF [%] | 102.46 | 102.52 | 102.52 | 102.35 | 102.11 | 92.48 | 101.01 | 100.08 | 99.71 | 100.77 | 101.81 | 102.35 | 100.85 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.92 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.42 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.22 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 307210.22 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.91 % |
| Cumulative Energy Availability Factor (EAF) | : 84.4 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.31 % |
| Cumulative Unit Capability Factor (UCF) | : 84.62 % | Cumulative Planned Unavailability Factor (PUF) | : 10.06 % |
| Cumulative Load Factor (LF) | : 83.89 % | Cumulative Externally cause unavailability (XUF) | : 0.23 % |
| Cumulative Operating Factor (OF) | : 84.71 % | | |

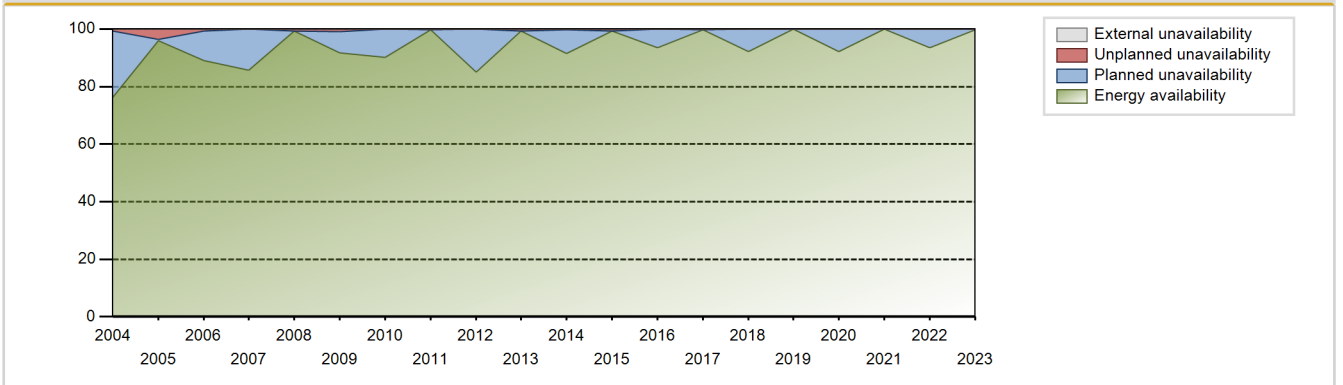
Electricity Production (net) [GWh]



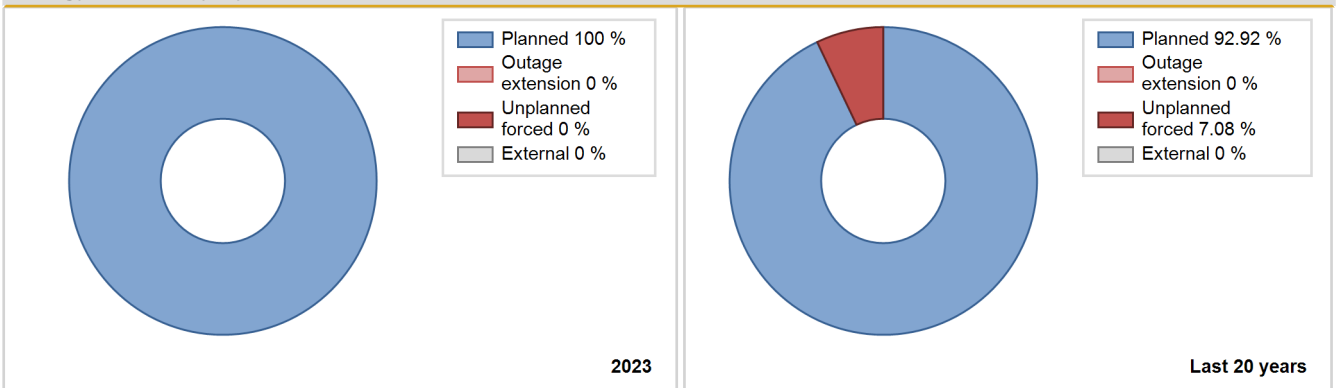
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|-------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1974 | | | | Data not provided | | | | | | | |
| 1975 | 5037.40 | 6761 | 871 | 66.09 | 66.09 | 66.02 | 77.18 | 22.28 | 18.95 | 14.96 | 0.00 |
| 1976 | 4758.00 | 6072 | 871 | 62.25 | 62.25 | 62.19 | 69.13 | 22.10 | 17.66 | 20.09 | 0.00 |
| 1977 | 5268.70 | 6545 | 860 | 69.90 | 69.90 | 69.94 | 74.71 | 19.50 | 16.94 | 13.16 | 0.00 |
| 1978 | 6064.30 | 7444 | 860 | 80.47 | 80.47 | 80.50 | 84.98 | 8.17 | 7.16 | 12.37 | 0.00 |
| 1979 | 3278.90 | 4038 | 860 | 43.53 | 43.53 | 43.52 | 46.10 | 47.13 | 38.81 | 17.67 | 0.00 |
| 1980 | 5224.60 | 6414 | 860 | 73.84 | 84.77 | 69.16 | 73.02 | 8.74 | 8.12 | 7.12 | 10.93 |
| 1981 | 5641.40 | 6835 | 860 | 78.63 | 78.63 | 74.88 | 78.03 | 2.19 | 1.76 | 19.61 | 0.00 |
| 1982 | 2128.40 | 2826 | 860 | 33.51 | 33.51 | 28.25 | 32.26 | 40.34 | 22.65 | 43.84 | 0.00 |
| 1983 | 7099.10 | 8436 | 860 | 96.52 | 96.52 | 94.23 | 96.30 | 3.48 | 3.48 | 0.00 | 0.00 |
| 1984 | 5355.51 | 6474 | 860 | 74.15 | 74.15 | 70.89 | 73.70 | 5.77 | 4.54 | 21.31 | 0.00 |
| 1985 | 4860.76 | 6071 | 860 | 69.67 | 69.67 | 64.52 | 69.30 | 16.59 | 13.85 | 16.47 | 0.00 |
| 1986 | 6064.31 | 7781 | 860 | 89.99 | 89.99 | 80.50 | 88.82 | 7.45 | 7.24 | 2.77 | 0.00 |
| 1987 | 5094.42 | 6068 | 860 | 69.81 | 69.81 | 67.62 | 69.27 | 3.48 | 2.52 | 27.67 | 0.00 |
| 1988 | 5965.75 | 7190 | 846 | 81.87 | 81.87 | 80.28 | 81.85 | 7.09 | 6.24 | 11.88 | 0.00 |
| 1989 | 6337.39 | 7585 | 846 | 86.61 | 86.61 | 85.51 | 86.59 | 2.39 | 2.12 | 11.27 | 0.00 |
| 1990 | 7427.84 | 8712 | 846 | 99.45 | 99.45 | 100.23 | 99.45 | 0.55 | 0.55 | 0.00 | 0.00 |
| 1991 | 5594.62 | 6691 | 846 | 86.59 | 86.59 | 75.49 | 76.38 | 9.61 | 9.20 | 4.21 | 0.00 |
| 1992 | 5448.23 | 6634 | 846 | 75.52 | 75.52 | 73.31 | 75.52 | 7.37 | 6.01 | 18.47 | 0.00 |
| 1993 | 7393.76 | 8647 | 846 | 98.72 | 98.72 | 99.77 | 98.71 | 0.20 | 0.19 | 1.08 | 0.00 |
| 1994 | 5670.82 | 6781 | 846 | 77.47 | 77.47 | 76.52 | 77.41 | 8.35 | 7.05 | 15.48 | 0.00 |
| 1995 | 6467.84 | 7625 | 846 | 87.09 | 87.09 | 87.27 | 87.04 | 3.09 | 2.77 | 10.14 | 0.00 |
| 1996 | 5454.03 | 6429 | 846 | 73.22 | 73.22 | 73.39 | 73.19 | 3.45 | 2.62 | 24.16 | 0.00 |
| 1997 | 4652.64 | 5633 | 846 | 64.65 | 64.65 | 62.78 | 64.30 | 19.58 | 15.74 | 19.61 | 0.00 |
| 1998 | 5786.35 | 7026 | 846 | 80.06 | 80.06 | 78.08 | 80.21 | 7.91 | 6.88 | 13.06 | 0.00 |
| 1999 | 7369.54 | 8676 | 846 | 99.05 | 99.05 | 99.44 | 99.04 | 0.40 | 0.40 | 0.56 | 0.00 |
| 2000 | 6577.84 | 7729 | 846 | 88.02 | 88.02 | 88.52 | 87.99 | 1.51 | 1.35 | 10.63 | 0.00 |
| 2001 | 5398.55 | 6355 | 846 | 72.57 | 72.57 | 72.85 | 72.55 | 21.17 | 19.48 | 7.95 | 0.00 |
| 2002 | 7465.52 | 8688 | 846 | 99.18 | 99.18 | 100.74 | 99.18 | 0.82 | 0.82 | 0.00 | 0.00 |
| 2003 | 6318.01 | 7467 | 846 | 85.25 | 85.25 | 85.25 | 85.24 | 5.72 | 5.17 | 9.58 | 0.00 |
| 2004 | 5747.05 | 6698 | 846 | 76.27 | 76.27 | 77.34 | 76.25 | 1.01 | 0.78 | 22.95 | 0.00 |
| 2005 | 7236.99 | 8395 | 846 | 95.87 | 95.87 | 97.64 | 95.82 | 3.62 | 3.60 | 0.53 | 0.00 |
| 2006 | 6716.23 | 7804 | 846 | 89.11 | 89.11 | 90.63 | 89.09 | 0.69 | 0.62 | 10.27 | 0.00 |
| 2007 | 6461.88 | 7498 | 846 | 85.60 | 85.60 | 87.19 | 85.59 | 0.00 | 0.00 | 14.40 | 0.00 |
| 2008 | 7575.11 | 8717 | 846 | 99.24 | 99.24 | 101.94 | 99.24 | 0.76 | 0.76 | 0.00 | 0.00 |
| 2009 | 6974.69 | 8041 | 846 | 91.81 | 91.81 | 94.11 | 91.79 | 0.96 | 0.89 | 7.31 | 0.00 |
| 2010 | 6778.51 | 7889 | 846 | 90.08 | 90.08 | 91.47 | 90.06 | 0.00 | 0.00 | 9.92 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2011 | 7602.37 | 8730 | 846 | 99.66 | 99.66 | 102.58 | 99.66 | 0.34 | 0.34 | 0.00 | 0.00 |
| 2012 | 6411.91 | 7469 | 846 | 85.05 | 85.05 | 86.28 | 85.03 | 0.00 | 0.00 | 14.95 | 0.00 |
| 2013 | 7553.22 | 8700 | 846 | 99.31 | 99.31 | 101.91 | 99.30 | 0.69 | 0.69 | 0.00 | 0.00 |
| 2014 | 6935.79 | 8022 | 846 | 91.57 | 91.57 | 93.59 | 91.58 | 0.30 | 0.28 | 8.15 | 0.00 |
| 2015 | 7553.32 | 8701 | 859 | 99.33 | 99.33 | 100.38 | 99.33 | 0.67 | 0.67 | 0.00 | 0.00 |
| 2016 | 7095.22 | 8216 | 859 | 93.53 | 93.53 | 94.03 | 93.53 | 0.00 | 0.00 | 6.47 | 0.00 |
| 2017 | 7572.35 | 8730 | 859 | 99.66 | 99.66 | 100.63 | 99.66 | 0.34 | 0.34 | 0.00 | 0.00 |
| 2018 | 6967.44 | 8083 | 859 | 92.26 | 92.26 | 92.59 | 92.27 | 0.00 | 0.00 | 7.74 | 0.00 |
| 2019 | 7587.62 | 8760 | 859 | 100.00 | 100.00 | 100.83 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 7012.14 | 8087 | 859 | 92.09 | 92.09 | 92.93 | 92.07 | 0.00 | 0.00 | 7.91 | 0.00 |
| 2021 | 7621.40 | 8760 | 859 | 100.00 | 100.00 | 101.28 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 7013.09 | 8193 | 859 | 93.53 | 93.53 | 93.20 | 93.53 | 0.00 | 0.00 | 6.47 | 0.00 |
| 2023 | 7588.99 | 8709 | 859 | 99.78 | 99.78 | 100.85 | 99.42 | 0.00 | 0.00 | 0.22 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1974 to 2023 | | |
|--|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 366 | |
| B. Refuelling without maintenance | | | | 26 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 731 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 88 | 0 | |
| E. Testing of plant systems or components | | | | 9 | 3 | |
| H. Nuclear regulatory requirements | | | | | 76 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 0 |
| L. Human factor related | | | | | 3 | |
| Z. Other | | | | 0 | 10 | |
| Subtotal | | | | 854 | 458 | 0 |
| Total | | 0 | | | 1312 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1974 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 12 |
| 12. Reactor I&C Systems | | 64 |
| 13. Reactor Auxiliary Systems | | 26 |
| 14. Safety Systems | | 18 |
| 15. Reactor Cooling Systems | | 49 |
| 16. Steam generation systems | | 95 |
| 21. Fuel Handling and Storage Facilities | | 3 |
| 31. Turbine and auxiliaries | | 50 |
| 32. Feedwater and Main Steam System | | 22 |
| 34. Miscellaneous Systems | | 26 |
| 41. Main Generator Systems | | 6 |
| 42. Electrical Power Supply Systems | | 5 |
| Total | | 376 |

2023 Operating Experience

US-528 **PALO VERDE-1** **UNITED STATES OF AMERICA**

Status at end of year : **Operational**
 Operator : APS (ARIZONA PUBLIC SERVICE CO.)
 Owner : APS (ARIZONA PUBLIC SERVICE CO.)
 Reactor Supplier : CE (COMBUSTION ENGINEERING CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)

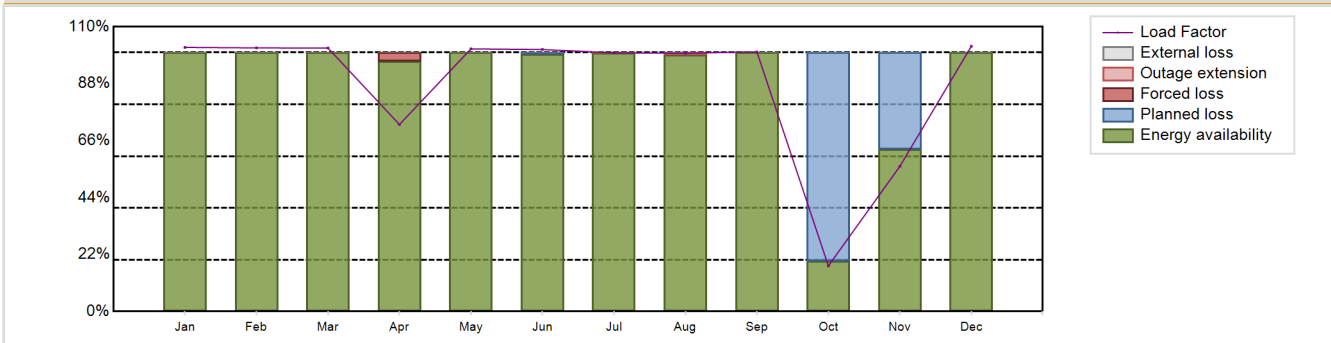


| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------------|--------------------|--------------|
| Reactor type and model | : PWR / CE80 2LP (DRYAMB) | Construction Date | : 1976-05-25 |
| Thermal power | : 3990 MWth | Grid Date | : 1985-06-10 |
| Gross electrical power | : 1414 MWe | Commercial Date | : 1986-01-28 |
| Reference unit power (net) | : 1311 MWe | Age at end of year | : 38 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.45 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 38000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.65 | HP cylinder inlet steam pressure [MPa] | : 7 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 241 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 18.14 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 76 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|--------------|
| Net Energy Production | : 10105.43 GW(e).h | Forced Loss Rate (FLR) | : 0.3 % |
| Energy Availability Factor (EAF) | : 89.66 % | Unplanned Capability Loss Factor (UCL) | : 0.36 % |
| Unit Capability Factor (UCF) | : 89.66 % | Planned Unavailability Factor (PUF) | : 9.98 % |
| Load Factor (LF) | : 87.99 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 88.55 % | Total off-line time | : 1003 hours |

Annual Summary

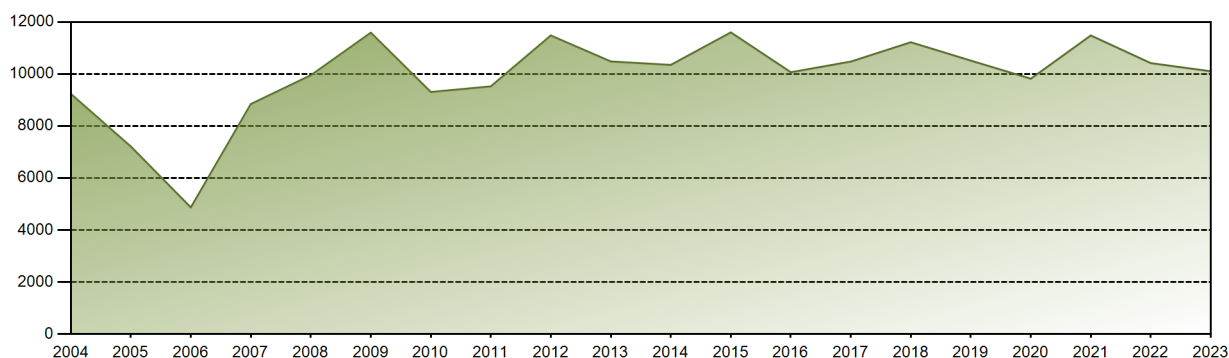


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 995.05 | 896.88 | 992.59 | 681.80 | 989.22 | 955.15 | 974.54 | 973.02 | 946.70 | 171.84 | 529.40 | 999.24 | 10105.43 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 96.67 | 100.00 | 99.37 | 99.77 | 99.23 | 100.00 | 19.35 | 62.59 | 100.00 | 89.66 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 96.67 | 100.00 | 99.37 | 99.77 | 99.23 | 100.00 | 19.35 | 62.59 | 100.00 | 89.66 |
| LF [%] | 102.02 | 101.80 | 101.76 | 72.23 | 101.42 | 101.19 | 99.91 | 99.76 | 100.29 | 17.62 | 56.09 | 102.45 | 87.99 |
| OF [%] | 100.00 | 100.00 | 100.00 | 81.39 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 19.35 | 62.64 | 100.00 | 88.55 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 3.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 3.33 | 0.00 | 0.00 | 0.23 | 0.77 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.63 | 0.00 | 0.00 | 0.00 | 80.65 | 37.41 | 0.00 | 9.98 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

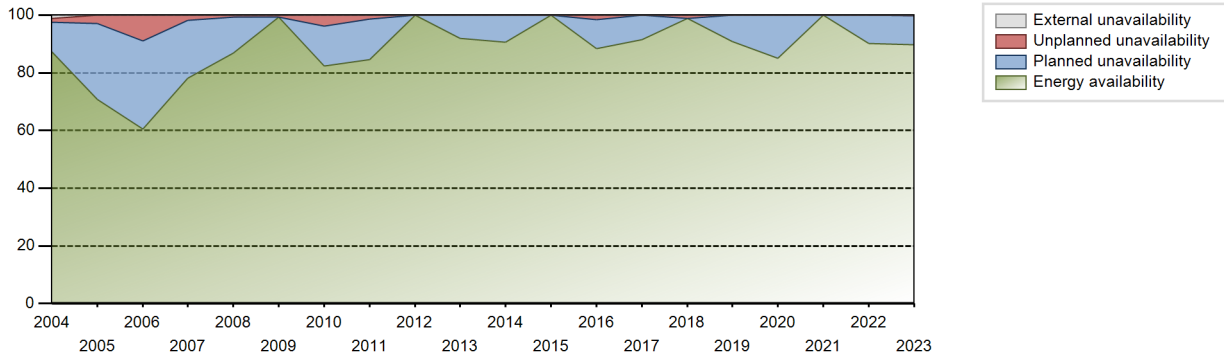
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 344811.53 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.28 % |
| Cumulative Energy Availability Factor (EAF) | : 83.07 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.72 % |
| Cumulative Unit Capability Factor (UCF) | : 83.19 % | Cumulative Planned Unavailability Factor (PUF) | : 13.08 % |
| Cumulative Load Factor (LF) | : 81.76 % | Cumulative Externally cause unavailability (XUF) | : 0.12 % |
| Cumulative Operating Factor (OF) | : 83.07 % | | |

Electricity Production (net) [GWh]

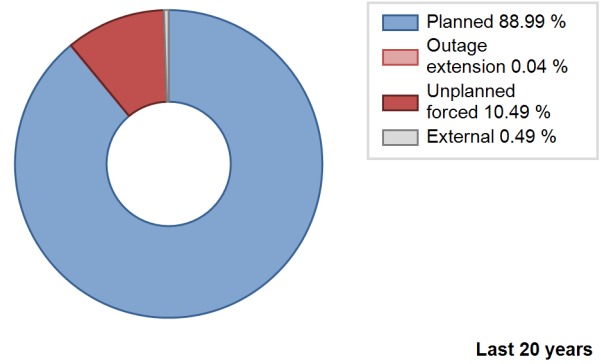
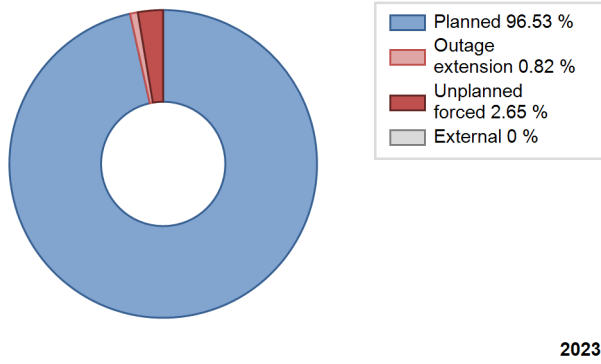


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 6264.75 | 5349 | 1221 | 63.26 | 63.26 | 62.16 | 64.51 | 36.74 | 36.74 | 0.00 | 0.00 |
| 1987 | 5268.27 | 4500 | 1221 | 50.89 | 50.89 | 49.26 | 51.38 | 32.44 | 24.43 | 24.67 | 0.00 |
| 1988 | 6668.69 | 5585 | 1221 | 62.81 | 62.81 | 62.18 | 63.58 | 35.00 | 33.82 | 3.37 | 0.00 |
| 1989 | 1796.57 | 1522 | 1221 | 14.06 | 14.06 | 16.80 | 17.37 | 40.50 | 9.57 | 76.37 | 0.00 |
| 1990 | 4719.46 | 3925 | 1221 | 42.61 | 42.61 | 44.12 | 44.81 | 9.64 | 4.55 | 52.84 | 0.00 |
| 1991 | 9312.14 | 7567 | 1221 | 85.85 | 87.09 | 87.06 | 86.38 | 1.56 | 1.38 | 11.53 | 1.25 |
| 1992 | 7118.80 | 6010 | 1221 | 67.16 | 67.16 | 66.37 | 68.42 | 6.70 | 4.82 | 28.02 | 0.00 |
| 1993 | 7514.76 | 6665 | 1221 | 76.06 | 76.06 | 70.26 | 76.08 | 1.41 | 1.09 | 22.85 | 0.00 |
| 1994 | 9772.54 | 8656 | 1221 | 98.78 | 98.78 | 91.37 | 98.81 | 1.22 | 1.22 | 0.00 | 0.00 |
| 1995 | 8526.82 | 7244 | 1224 | 82.10 | 82.10 | 79.52 | 82.69 | 2.15 | 1.80 | 16.10 | 0.00 |
| 1996 | 8713.00 | 7246 | 1227 | 81.97 | 84.39 | 80.84 | 82.49 | 0.01 | 0.01 | 15.60 | 2.42 |
| 1997 | 10737.71 | 8658 | 1244 | 98.82 | 98.82 | 98.47 | 98.82 | 1.18 | 1.18 | 0.00 | 0.00 |
| 1998 | 9575.01 | 7819 | 1243 | 89.04 | 89.04 | 87.94 | 89.26 | 0.76 | 0.68 | 10.28 | 0.00 |
| 1999 | 9653.94 | 7774 | 1243 | 88.76 | 88.76 | 88.66 | 88.74 | 0.76 | 0.68 | 10.56 | 0.00 |
| 2000 | 10966.60 | 8770 | 1243 | 99.84 | 99.84 | 100.44 | 99.84 | 0.16 | 0.16 | 0.00 | 0.00 |
| 2001 | 9559.58 | 7712 | 1243 | 88.04 | 88.04 | 87.79 | 88.04 | 0.00 | 0.00 | 11.96 | 0.00 |
| 2002 | 9705.03 | 7890 | 1243 | 90.14 | 90.14 | 89.13 | 90.07 | 0.90 | 0.82 | 9.04 | 0.00 |
| 2003 | 10587.11 | 8604 | 1243 | 98.24 | 98.24 | 97.23 | 98.22 | 1.76 | 1.76 | 0.00 | 0.00 |
| 2004 | 9235.80 | 7669 | 1243 | 87.33 | 88.53 | 84.59 | 87.31 | 1.33 | 1.19 | 10.28 | 1.20 |
| 2005 | 7212.30 | 6194 | 1243 | 70.73 | 70.73 | 66.24 | 70.71 | 3.95 | 2.91 | 26.36 | 0.00 |
| 2006 | 4868.23 | 5292 | 1314 | 60.44 | 60.44 | 42.29 | 60.41 | 12.90 | 8.95 | 30.61 | 0.00 |
| 2007 | 8844.90 | 6834 | 1311 | 78.04 | 78.04 | 77.02 | 78.01 | 2.23 | 1.78 | 20.18 | 0.00 |
| 2008 | 9953.15 | 7616 | 1311 | 86.71 | 86.71 | 86.43 | 86.70 | 0.88 | 0.77 | 12.52 | 0.00 |
| 2009 | 11589.72 | 8707 | 1311 | 99.40 | 99.40 | 100.92 | 99.39 | 0.60 | 0.60 | 0.00 | 0.00 |
| 2010 | 9307.97 | 7217 | 1311 | 82.41 | 82.41 | 81.05 | 82.39 | 4.46 | 3.85 | 13.74 | 0.00 |
| 2011 | 9525.07 | 7400 | 1311 | 84.50 | 84.50 | 82.94 | 84.47 | 1.69 | 1.46 | 14.05 | 0.00 |
| 2012 | 11482.17 | 8784 | 1311 | 100.00 | 100.00 | 99.71 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 10481.92 | 8044 | 1311 | 91.83 | 91.83 | 91.27 | 91.83 | 0.00 | 0.00 | 8.17 | 0.00 |
| 2014 | 10350.31 | 7943 | 1311 | 90.68 | 90.68 | 90.13 | 90.67 | 0.00 | 0.00 | 9.32 | 0.00 |
| 2015 | 11600.88 | 8760 | 1311 | 100.00 | 100.00 | 101.01 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 10068.74 | 7763 | 1311 | 88.37 | 88.37 | 87.43 | 88.38 | 1.67 | 1.50 | 10.13 | 0.00 |
| 2017 | 10477.95 | 8012 | 1311 | 91.46 | 91.46 | 91.24 | 91.46 | 0.00 | 0.00 | 8.54 | 0.00 |
| 2018 | 11220.88 | 8655 | 1311 | 98.80 | 98.80 | 97.71 | 98.80 | 1.20 | 1.20 | 0.00 | 0.00 |
| 2019 | 10515.17 | 7956 | 1311 | 90.83 | 90.83 | 91.56 | 90.82 | 0.00 | 0.00 | 9.17 | 0.00 |
| 2020 | 9818.48 | 7460 | 1311 | 84.93 | 84.93 | 85.26 | 84.93 | 0.00 | 0.00 | 15.07 | 0.00 |
| 2021 | 11482.05 | 8760 | 1311 | 100.00 | 100.00 | 99.98 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 10418.48 | 7907 | 1311 | 90.26 | 90.26 | 90.72 | 90.26 | 0.00 | 0.00 | 9.74 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 373 | |
| B. Refuelling without maintenance | | | | 57 | | |
| C. Inspection, maintenance or repair combined with refuelling | 869 | | | 953 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 127 | | |
| E. Testing of plant systems or components | | | | 3 | 7 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| L. Human factor related | | | | | 5 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 7 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 2 | |
| Z. Other | | | | | 13 | |
| Subtotal | 869 | 24 | | 1140 | 400 | 11 |
| Total | | 893 | | | 1551 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 24 | 2 |
| 12. Reactor I&C Systems | | 68 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 11 |
| 15. Reactor Cooling Systems | | 56 |
| 16. Steam generation systems | | 31 |
| 31. Turbine and auxiliaries | | 4 |
| 32. Feedwater and Main Steam System | | 82 |
| 33. Circulating Water System | | 22 |
| 34. Miscellaneous Systems | | 35 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 10 |
| 42. Electrical Power Supply Systems | | 54 |
| Total | 24 | 380 |

2023 Operating Experience

US-529 **PALO VERDE-2** **UNITED STATES OF AMERICA**

Status at end of year : **Operational**
 Operator : APS (ARIZONA PUBLIC SERVICE CO.)
 Owner : APS (ARIZONA PUBLIC SERVICE CO.)
 Reactor Supplier : CE (COMBUSTION ENGINEERING CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)

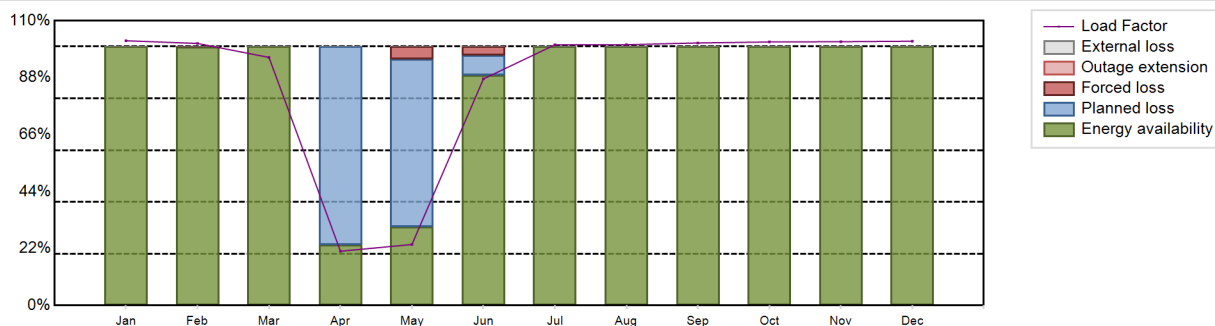


| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------------|--------------------|--------------|
| Reactor type and model | : PWR / CE80 2LP (DRYAMB) | Construction Date | : 1976-06-01 |
| Thermal power | : 3990 MWth | Grid Date | : 1986-05-20 |
| Gross electrical power | : 1414 MWe | Commercial Date | : 1986-09-19 |
| Reference unit power (net) | : 1314 MWe | Age at end of year | : 37 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.45 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 38000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.65 | HP cylinder inlet steam pressure [MPa] | : 7 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 241 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 18.21 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 76 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 9972.52 GW(e).h | Forced Loss Rate (FLR) | : 0.8 % |
| Energy Availability Factor (EAF) | : 86.87 % | Unplanned Capability Loss Factor (UCL) | : 0.7 % |
| Unit Capability Factor (UCF) | : 86.87 % | Planned Unavailability Factor (PUF) | : 12.43 % |
| Load Factor (LF) | : 86.64 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 87.58 % | Total off-line time | : 1088 hours |

Annual Summary

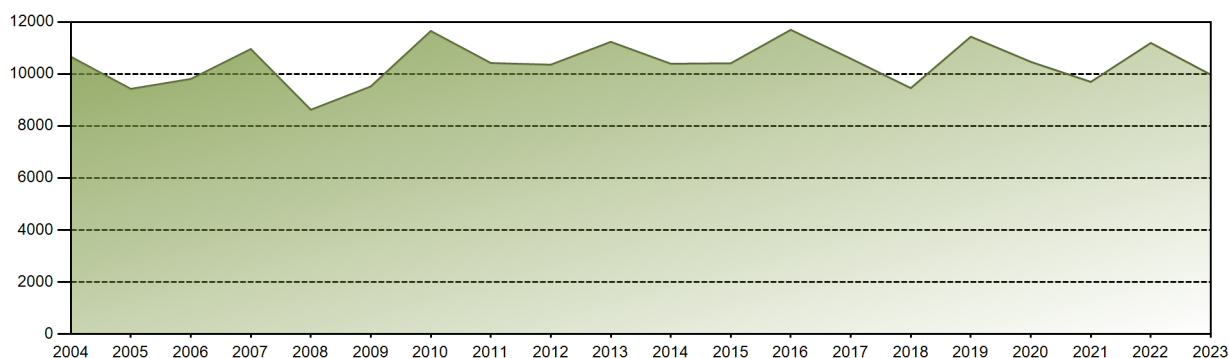


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 999.67 | 893.84 | 936.76 | 198.36 | 230.49 | 828.00 | 984.33 | 984.88 | 959.33 | 995.13 | 963.85 | 997.87 | 9972.52 |
| EAF [%] | 100.00 | 99.82 | 100.00 | 23.33 | 30.49 | 88.97 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.87 |
| UCF [%] | 100.00 | 99.82 | 100.00 | 23.33 | 30.49 | 88.97 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 86.87 |
| LF [%] | 102.26 | 101.23 | 95.82 | 20.97 | 23.58 | 87.52 | 100.69 | 100.74 | 101.40 | 101.79 | 101.88 | 102.07 | 86.64 |
| OF [%] | 100.00 | 100.00 | 100.00 | 23.33 | 35.35 | 92.36 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.58 |
| FLR [%] | 0.00 | 0.18 | 0.00 | 0.00 | 13.70 | 3.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.80 |
| UCL [%] | 0.00 | 0.18 | 0.00 | 0.00 | 4.84 | 3.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.70 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 76.67 | 64.67 | 7.69 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.43 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 353355.99 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.2 % |
| Cumulative Energy Availability Factor (EAF) | : 84.99 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.95 % |
| Cumulative Unit Capability Factor (UCF) | : 85.05 % | Cumulative Planned Unavailability Factor (PUF) | : 13 % |
| Cumulative Load Factor (LF) | : 84.69 % | Cumulative Externally cause unavailability (XUF) | : 0.06 % |
| Cumulative Operating Factor (OF) | : 85.01 % | | |

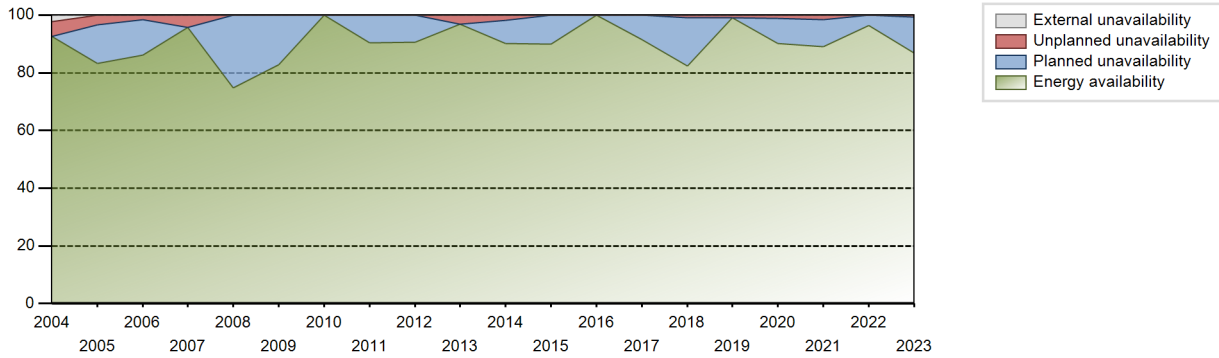
Electricity Production (net) [GWh]



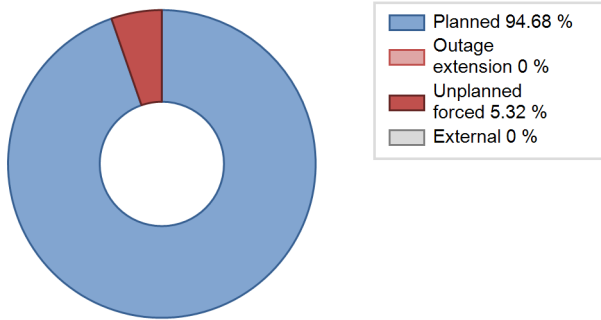
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | | | | Data not provided | | | | | | | |
| 1987 | 8190.04 | 6860 | 1221 | 77.59 | 77.59 | 76.57 | 78.31 | 6.73 | 5.60 | 16.81 | 0.00 |
| 1988 | 6747.17 | 5613 | 1221 | 62.56 | 62.56 | 62.91 | 63.90 | 3.50 | 2.27 | 35.17 | 0.00 |
| 1989 | 4698.76 | 4003 | 1221 | 44.31 | 44.31 | 43.93 | 45.70 | 25.08 | 14.83 | 40.86 | 0.00 |
| 1990 | 6242.22 | 5276 | 1221 | 58.63 | 58.63 | 58.36 | 60.23 | 0.00 | 0.00 | 41.37 | 0.00 |
| 1991 | 8265.19 | 6690 | 1221 | 76.27 | 76.27 | 77.27 | 76.37 | 3.69 | 2.92 | 20.81 | 0.00 |
| 1992 | 10104.51 | 8341 | 1221 | 94.85 | 94.85 | 94.21 | 94.96 | 2.94 | 2.87 | 2.27 | 0.00 |
| 1993 | 5125.31 | 4621 | 1221 | 50.91 | 50.91 | 47.92 | 52.75 | 3.50 | 1.84 | 47.25 | 0.00 |
| 1994 | 6573.86 | 5919 | 1221 | 66.82 | 66.82 | 61.46 | 67.57 | 5.45 | 3.85 | 29.33 | 0.00 |
| 1995 | 9070.86 | 7420 | 1224 | 84.16 | 84.16 | 84.60 | 84.70 | 0.53 | 0.45 | 15.39 | 0.00 |
| 1996 | 9346.14 | 7548 | 1227 | 85.46 | 85.46 | 86.72 | 85.93 | 0.73 | 0.62 | 13.92 | 0.00 |
| 1997 | 9322.67 | 7661 | 1244 | 87.22 | 87.22 | 85.49 | 87.44 | 2.65 | 2.38 | 10.40 | 0.00 |
| 1998 | 11084.83 | 8760 | 1243 | 100.00 | 100.00 | 101.80 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1999 | 9797.35 | 7857 | 1243 | 89.71 | 89.71 | 89.98 | 89.69 | 0.45 | 0.41 | 9.89 | 0.00 |
| 2000 | 9525.26 | 7743 | 1243 | 88.17 | 88.17 | 87.24 | 88.15 | 1.24 | 1.11 | 10.73 | 0.00 |
| 2001 | 10083.52 | 8002 | 1243 | 91.36 | 91.36 | 92.61 | 91.35 | 8.64 | 8.64 | 0.00 | 0.00 |
| 2002 | 10019.17 | 7981 | 1243 | 91.12 | 91.12 | 92.01 | 91.11 | 0.00 | 0.00 | 8.88 | 0.00 |
| 2003 | 8444.41 | 6809 | 1243 | 77.74 | 77.74 | 77.55 | 77.73 | 0.78 | 0.61 | 21.65 | 0.00 |
| 2004 | 10662.06 | 8138 | 1335 | 92.60 | 94.90 | 91.96 | 92.65 | 5.10 | 5.10 | 0.00 | 2.30 |
| 2005 | 9427.24 | 7284 | 1335 | 83.18 | 83.18 | 80.61 | 83.15 | 3.96 | 3.43 | 13.39 | 0.00 |
| 2006 | 9808.17 | 7535 | 1314 | 86.05 | 86.05 | 85.21 | 86.02 | 1.76 | 1.55 | 12.41 | 0.00 |
| 2007 | 10957.60 | 8384 | 1314 | 95.71 | 95.71 | 95.20 | 95.71 | 4.29 | 4.29 | 0.00 | 0.00 |
| 2008 | 8624.08 | 6577 | 1314 | 74.88 | 74.88 | 74.72 | 74.87 | 0.00 | 0.00 | 25.12 | 0.00 |
| 2009 | 9521.55 | 7254 | 1314 | 82.82 | 82.82 | 82.72 | 82.81 | 0.00 | 0.00 | 17.18 | 0.00 |
| 2010 | 11652.97 | 8760 | 1314 | 100.00 | 100.00 | 101.24 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 10421.32 | 7921 | 1314 | 90.43 | 90.43 | 90.54 | 90.42 | 0.00 | 0.10 | 9.47 | 0.00 |
| 2012 | 10358.07 | 7957 | 1314 | 90.59 | 90.59 | 89.74 | 90.59 | 0.00 | 0.00 | 9.41 | 0.00 |
| 2013 | 11235.03 | 8488 | 1314 | 96.90 | 96.90 | 97.61 | 96.89 | 3.10 | 3.10 | 0.00 | 0.00 |
| 2014 | 10394.10 | 7904 | 1314 | 90.22 | 90.22 | 90.30 | 90.23 | 2.00 | 1.84 | 7.94 | 0.00 |
| 2015 | 10410.84 | 7883 | 1314 | 89.98 | 89.98 | 90.45 | 89.99 | 0.00 | 0.00 | 10.02 | 0.00 |
| 2016 | 11696.95 | 8784 | 1314 | 100.00 | 100.00 | 101.34 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 10588.60 | 8011 | 1314 | 91.44 | 91.44 | 91.99 | 91.45 | 0.00 | 0.00 | 8.56 | 0.00 |
| 2018 | 9458.03 | 7216 | 1314 | 82.38 | 82.38 | 82.17 | 82.37 | 1.14 | 0.95 | 16.68 | 0.00 |
| 2019 | 11434.51 | 8670 | 1314 | 98.98 | 98.98 | 99.34 | 98.97 | 1.02 | 1.02 | 0.00 | 0.00 |
| 2020 | 10466.37 | 7929 | 1314 | 90.26 | 90.26 | 90.68 | 90.27 | 0.00 | 1.11 | 8.62 | 0.00 |
| 2021 | 9697.05 | 7802 | 1314 | 89.06 | 89.06 | 84.24 | 89.06 | 1.78 | 1.61 | 9.33 | 0.00 |
| 2022 | 11192.86 | 8437 | 1314 | 96.31 | 96.31 | 97.24 | 96.31 | 0.00 | 0.00 | 3.69 | 0.00 |

2023 9972.52 7672 1314 86.87 86.87 86.64 87.58 0.80 0.70 12.43 0.00

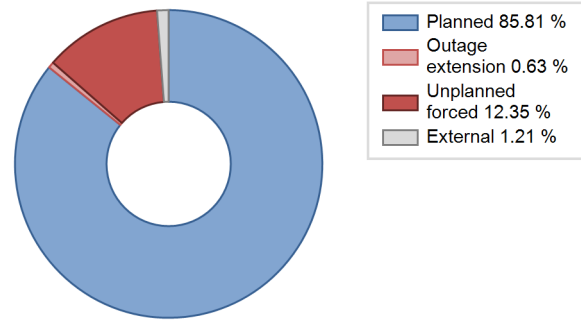
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 131 | |
| B. Refuelling without maintenance | | | | 43 | | |
| C. Inspection, maintenance or repair combined with refuelling | 853 | | | 859 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 158 | | |
| E. Testing of plant systems or components | | | | 0 | | |
| H. Nuclear regulatory requirements | | | | | 19 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 10 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| Z. Other | | | | 71 | 9 | 3 |
| Subtotal | 853 | 24 | | 1131 | 169 | 8 |
| Total | | 877 | | | 1308 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 24 | 1 |
| 12. Reactor I&C Systems | | 20 |
| 13. Reactor Auxiliary Systems | | 4 |
| 14. Safety Systems | | 19 |
| 15. Reactor Cooling Systems | | 14 |
| 16. Steam generation systems | | 20 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 31. Turbine and auxiliaries | | 14 |
| 32. Feedwater and Main Steam System | | 13 |
| 34. Miscellaneous Systems | | 30 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 3 |
| 42. Electrical Power Supply Systems | | 13 |
| Total | 24 | 155 |

2023 Operating Experience

US-530 **PALO VERDE-3** **UNITED STATES OF AMERICA**

Status at end of year : **Operational**
 Operator : APS (ARIZONA PUBLIC SERVICE CO.)
 Owner : APS (ARIZONA PUBLIC SERVICE CO.)
 Reactor Supplier : CE (COMBUSTION ENGINEERING CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)

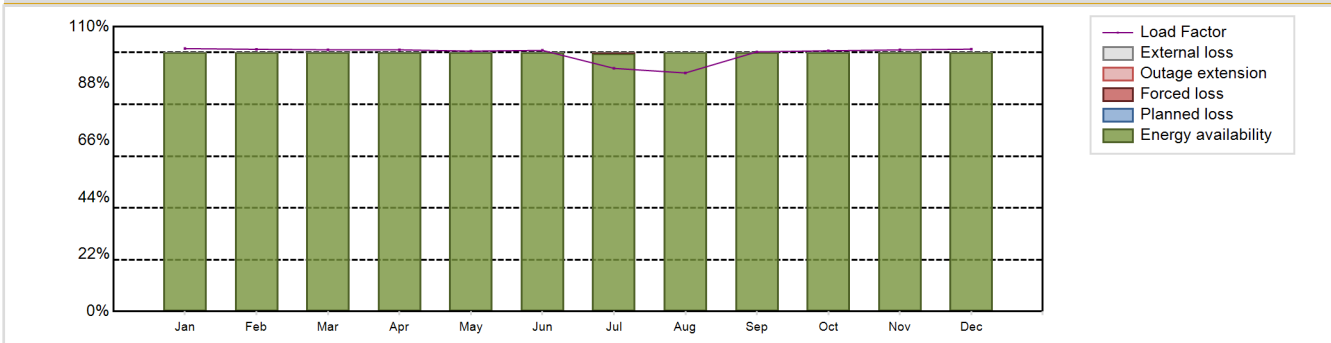


| Reactor Unit Details | | Key Dates | |
|----------------------------|---------------------------|--------------------|--------------|
| Reactor type and model | : PWR / CE80 2LP (DRYAMB) | Construction Date | : 1976-06-01 |
| Thermal power | : 3990 MWth | Grid Date | : 1987-11-28 |
| Gross electrical power | : 1414 MWe | Commercial Date | : 1988-01-08 |
| Reference unit power (net) | : 1312 MWe | Age at end of year | : 36 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 327 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.45 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 38000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.65 | HP cylinder inlet steam pressure [MPa] | : 7 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 241 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 18.37 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 76 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|------------|
| Net Energy Production | : 11449.96 GW(e).h | Forced Loss Rate (FLR) | : 0.04 % |
| Energy Availability Factor (EAF) | : 99.96 % | Unplanned Capability Loss Factor (UCL) | : 0.04 % |
| Unit Capability Factor (UCF) | : 99.96 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 99.62 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 99.78 % | Total off-line time | : 19 hours |

Annual Summary

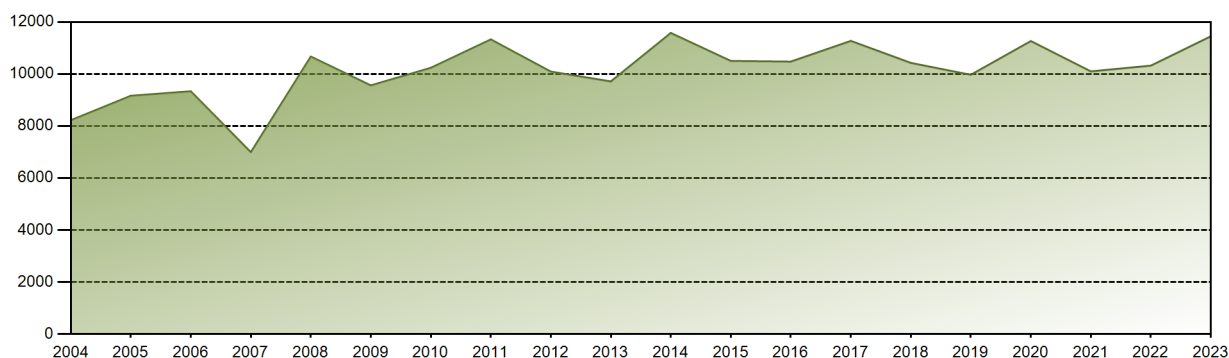


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 991.18 | 892.78 | 986.66 | 954.91 | 981.64 | 952.73 | 916.72 | 899.31 | 947.32 | 983.08 | 954.57 | 989.06 | 11449.96 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.58 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.96 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.58 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.96 |
| LF [%] | 101.54 | 101.26 | 101.08 | 101.09 | 100.56 | 100.86 | 93.91 | 92.13 | 100.28 | 100.71 | 101.05 | 101.32 | 99.62 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 97.45 | 100.00 | 100.00 | 100.00 | 100.00 | 99.78 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

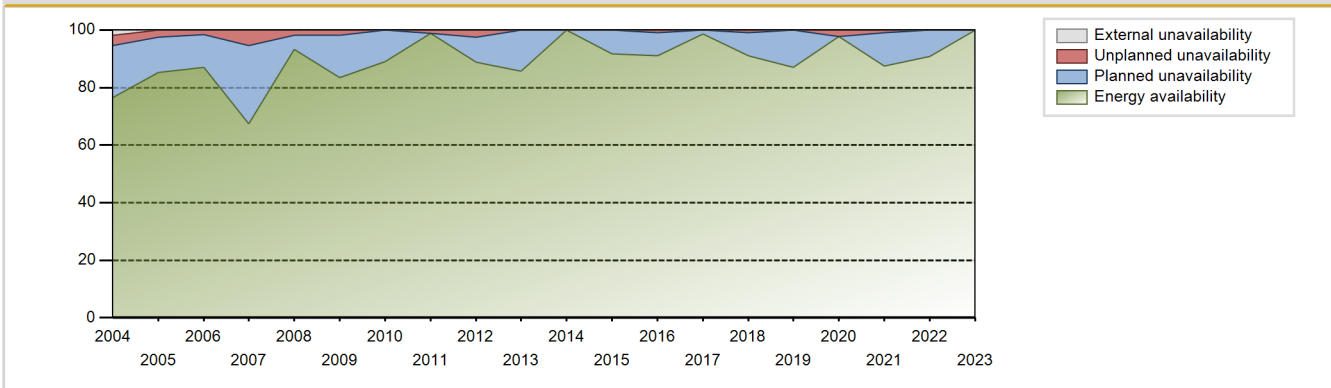
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 345763.44 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.82 % |
| Cumulative Energy Availability Factor (EAF) | : 86.84 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.61 % |
| Cumulative Unit Capability Factor (UCF) | : 87.02 % | Cumulative Planned Unavailability Factor (PUF) | : 11.37 % |
| Cumulative Load Factor (LF) | : 86.3 % | Cumulative Externally cause unavailability (XUF) | : 0.18 % |
| Cumulative Operating Factor (OF) | : 86.82 % | | |

Electricity Production (net) [GWh]

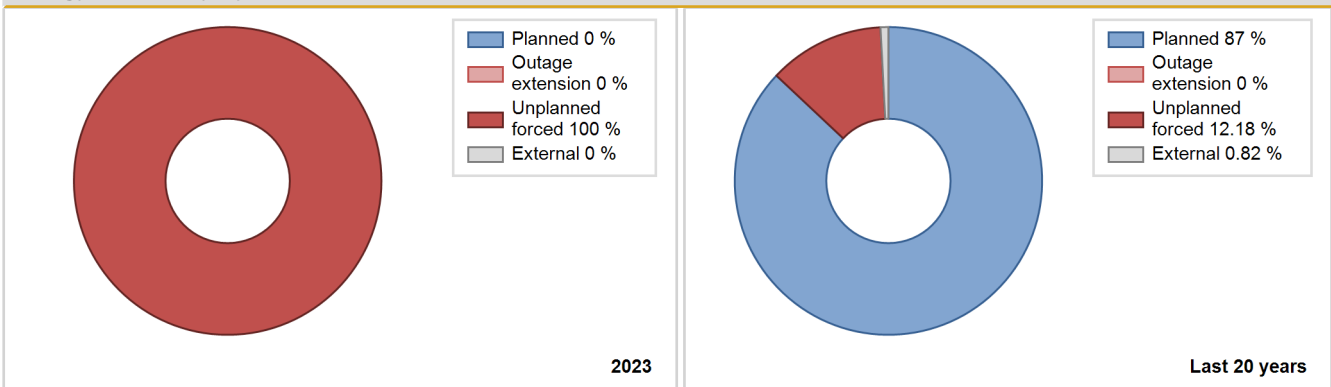


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 10035.48 | 8177 | 1221 | 94.92 | 94.92 | 95.39 | 94.90 | 5.08 | 5.08 | 0.00 | 0.00 |
| 1989 | 1327.99 | 1096 | 1221 | 9.01 | 9.01 | 12.42 | 12.51 | 40.97 | 6.25 | 84.74 | 0.00 |
| 1990 | 9636.01 | 8048 | 1221 | 91.58 | 91.58 | 90.09 | 91.87 | 8.36 | 8.35 | 0.07 | 0.00 |
| 1991 | 7518.45 | 6272 | 1221 | 70.78 | 75.30 | 70.29 | 71.60 | 2.63 | 2.03 | 22.67 | 4.52 |
| 1992 | 8386.20 | 6923 | 1221 | 78.72 | 78.72 | 78.19 | 78.81 | 3.48 | 2.84 | 18.44 | 0.00 |
| 1993 | 9393.90 | 7898 | 1221 | 90.12 | 90.12 | 87.83 | 90.16 | 2.69 | 2.49 | 7.39 | 0.00 |
| 1994 | 6824.49 | 5920 | 1221 | 66.35 | 66.35 | 63.80 | 67.58 | 1.29 | 0.87 | 32.78 | 0.00 |
| 1995 | 9386.83 | 7628 | 1225 | 86.63 | 86.63 | 87.44 | 87.08 | 0.00 | 0.00 | 13.37 | 0.00 |
| 1996 | 10789.60 | 8699 | 1230 | 99.04 | 99.52 | 99.86 | 99.03 | 0.48 | 0.48 | 0.00 | 0.48 |
| 1997 | 9456.06 | 7820 | 1247 | 89.13 | 89.13 | 86.50 | 89.26 | 0.38 | 0.34 | 10.54 | 0.00 |
| 1998 | 9600.91 | 7835 | 1247 | 89.26 | 89.26 | 87.89 | 89.44 | 0.00 | 0.00 | 10.74 | 0.00 |
| 1999 | 10956.48 | 8760 | 1247 | 100.00 | 100.00 | 100.30 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2000 | 9888.71 | 7898 | 1247 | 89.94 | 89.94 | 90.28 | 89.91 | 1.59 | 1.46 | 8.61 | 0.00 |
| 2001 | 9170.39 | 7439 | 1247 | 84.96 | 84.96 | 83.95 | 84.92 | 1.60 | 1.38 | 13.65 | 0.00 |
| 2002 | 11137.71 | 8760 | 1247 | 100.00 | 100.00 | 101.96 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 9554.71 | 7712 | 1247 | 88.05 | 88.05 | 87.47 | 88.04 | 2.18 | 1.96 | 9.99 | 0.00 |
| 2004 | 8223.32 | 6729 | 1247 | 76.65 | 78.41 | 75.07 | 76.61 | 4.32 | 3.54 | 18.06 | 1.76 |
| 2005 | 9163.97 | 7471 | 1247 | 85.31 | 85.31 | 83.89 | 85.29 | 2.88 | 2.53 | 12.16 | 0.00 |
| 2006 | 9335.83 | 7625 | 1247 | 87.07 | 87.07 | 85.46 | 87.04 | 1.70 | 1.51 | 11.43 | 0.00 |
| 2007 | 6993.69 | 5903 | 1247 | 67.42 | 67.42 | 64.02 | 67.39 | 7.47 | 5.45 | 27.13 | 0.00 |
| 2008 | 10673.28 | 8197 | 1317 | 93.32 | 93.32 | 92.26 | 93.32 | 1.90 | 1.81 | 4.87 | 0.00 |
| 2009 | 9562.61 | 7310 | 1317 | 83.46 | 83.46 | 82.89 | 83.45 | 2.11 | 1.80 | 14.74 | 0.00 |
| 2010 | 10238.99 | 7801 | 1317 | 89.06 | 89.06 | 88.75 | 89.05 | 0.00 | 0.00 | 10.94 | 0.00 |
| 2011 | 11331.50 | 8657 | 1312 | 98.84 | 98.84 | 98.59 | 98.82 | 1.16 | 1.16 | 0.00 | 0.00 |
| 2012 | 10093.67 | 7797 | 1312 | 88.78 | 88.78 | 87.58 | 88.76 | 2.82 | 2.58 | 8.64 | 0.00 |
| 2013 | 9714.13 | 7506 | 1312 | 85.68 | 85.68 | 84.52 | 85.68 | 0.00 | 0.00 | 14.32 | 0.00 |
| 2014 | 11579.13 | 8760 | 1312 | 100.00 | 100.00 | 100.75 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 10502.98 | 8037 | 1312 | 91.74 | 91.74 | 91.38 | 91.75 | 0.00 | 0.00 | 8.26 | 0.00 |
| 2016 | 10477.43 | 8001 | 1312 | 91.09 | 91.09 | 90.91 | 91.09 | 1.04 | 0.96 | 7.95 | 0.00 |
| 2017 | 11273.58 | 8626 | 1312 | 98.63 | 98.63 | 98.09 | 98.47 | 0.00 | 0.00 | 1.37 | 0.00 |
| 2018 | 10427.45 | 7983 | 1312 | 91.13 | 91.13 | 90.73 | 91.13 | 1.04 | 0.96 | 7.91 | 0.00 |
| 2019 | 9969.69 | 7619 | 1312 | 86.99 | 86.99 | 86.74 | 86.97 | 0.00 | 0.00 | 13.01 | 0.00 |
| 2020 | 11267.58 | 8587 | 1312 | 97.76 | 97.76 | 97.77 | 97.76 | 2.24 | 2.24 | 0.00 | 0.00 |
| 2021 | 10101.41 | 7663 | 1312 | 87.47 | 87.47 | 87.89 | 87.48 | 1.14 | 1.01 | 11.51 | 0.00 |
| 2022 | 10321.36 | 7952 | 1312 | 90.77 | 90.77 | 89.80 | 90.78 | 0.00 | 0.00 | 9.23 | 0.00 |
| 2023 | 11449.96 | 8741 | 1312 | 99.96 | 99.96 | 99.62 | 99.78 | 0.04 | 0.04 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 113 | |
| B. Refuelling without maintenance | | | | 50 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 861 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 79 | | |
| E. Testing of plant systems or components | | | | 4 | 6 | |
| H. Nuclear regulatory requirements | | | | | 2 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 5 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 23 |
| Z. Other | | | | | 9 | 0 |
| Subtotal | | | | 994 | 131 | 28 |
| Total | | 0 | | | 1153 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 9 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 17 |
| 16. Steam generation systems | | 2 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 25 |
| 32. Feedwater and Main Steam System | | 14 |
| 34. Miscellaneous Systems | | 18 |
| 41. Main Generator Systems | | 8 |
| 42. Electrical Power Supply Systems | | 41 |
| Total | | 138 |

2023 Operating Experience

US-277 **PEACH BOTTOM-2** **UNITED STATES OF AMERICA**

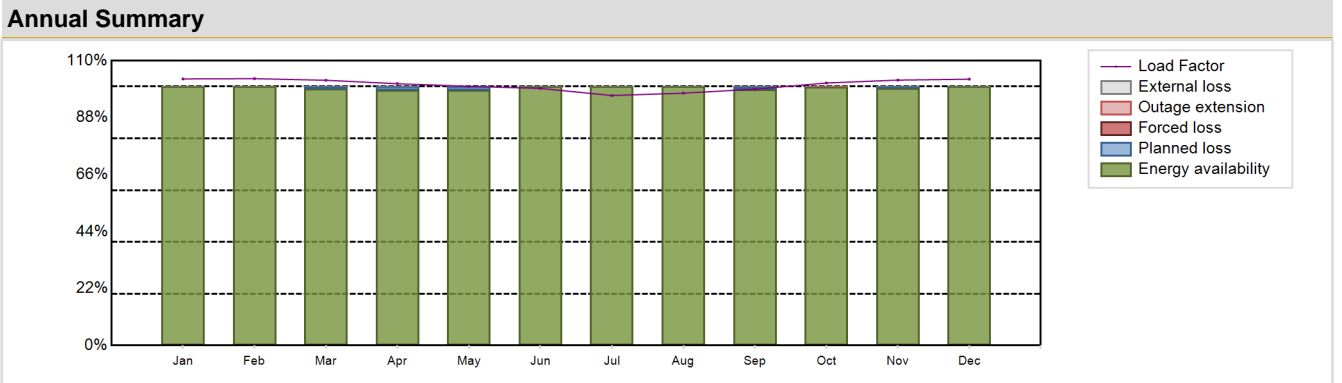
Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXE/PSEG (EXELON Corp. (50%))
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 1) | Construction Date | : 1968-01-31 |
| Thermal power | : 3951 MWth | Grid Date | : 1974-02-18 |
| Gross electrical power | : 1412 MWe | Commercial Date | : 1974-07-05 |
| Reference unit power (net) | : 1300 MWe | Age at end of year | : 49 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.1 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 287 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.16 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 40 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 48000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.57 | HP cylinder inlet steam pressure [MPa] | : 6.65 |
| Active core height/length [m] | : 3.71 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 764 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 16.37 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|-----------|
| Net Energy Production | : 11469.21 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.55 % | Unplanned Capability Loss Factor (UCL) | : 0.01 % |
| Unit Capability Factor (UCF) | : 99.55 % | Planned Unavailability Factor (PUF) | : 0.44 % |
| Load Factor (LF) | : 100.71 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

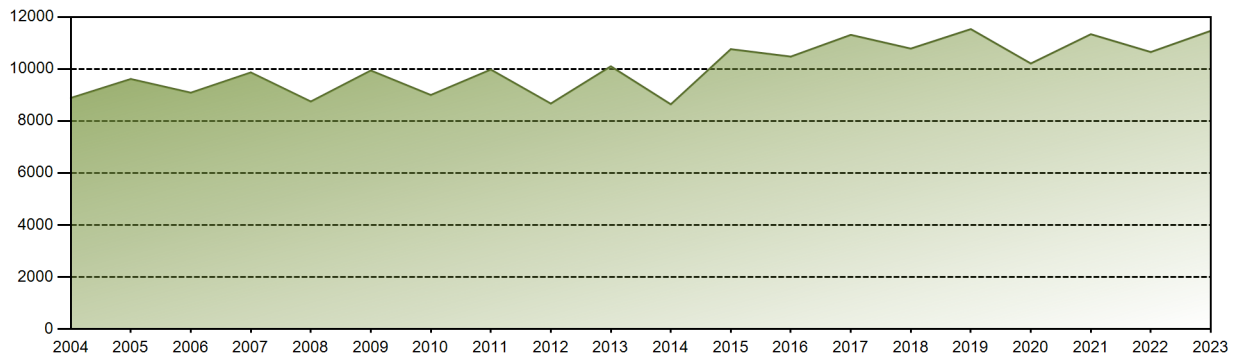


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 995.86 | 900.40 | 989.50 | 946.35 | 968.16 | 929.47 | 933.84 | 942.74 | 926.64 | 980.63 | 960.80 | 994.82 | 11469.21 |
| EAF [%] | 100.00 | 100.00 | 99.20 | 98.70 | 98.56 | 100.00 | 100.00 | 100.00 | 98.89 | 99.85 | 99.37 | 100.00 | 99.55 |
| UCF [%] | 100.00 | 100.00 | 99.20 | 98.70 | 98.56 | 100.00 | 100.00 | 100.00 | 98.89 | 99.85 | 99.37 | 100.00 | 99.55 |
| LF [%] | 102.96 | 103.07 | 102.44 | 101.11 | 100.10 | 99.30 | 96.55 | 97.47 | 99.00 | 101.39 | 102.51 | 102.86 | 100.71 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 | 0.01 |
| PUF [%] | 0.00 | 0.00 | 0.80 | 1.30 | 1.44 | 0.00 | 0.00 | 0.00 | 1.11 | 0.00 | 0.63 | 0.00 | 0.44 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | | | |
|---|---|-------------------|---|---|---------|
| Lifetime energy generation | : | 384356.95 GW(e).h | Cumulative Forced Loss Rate (FLR) | : | 4.12 % |
| Cumulative Energy Availability Factor (EAF) | : | 81.15 % | Cumulative Unplanned Capability Loss Factor (UCL) | : | 3.49 % |
| Cumulative Unit Capability Factor (UCF) | : | 81.16 % | Cumulative Planned Unavailability Factor (PUF) | : | 15.35 % |
| Cumulative Load Factor (LF) | : | 79.27 % | Cumulative Externally cause unavailability (XUF) | : | 0.01 % |
| Cumulative Operating Factor (OF) | : | 81.51 % | | | |

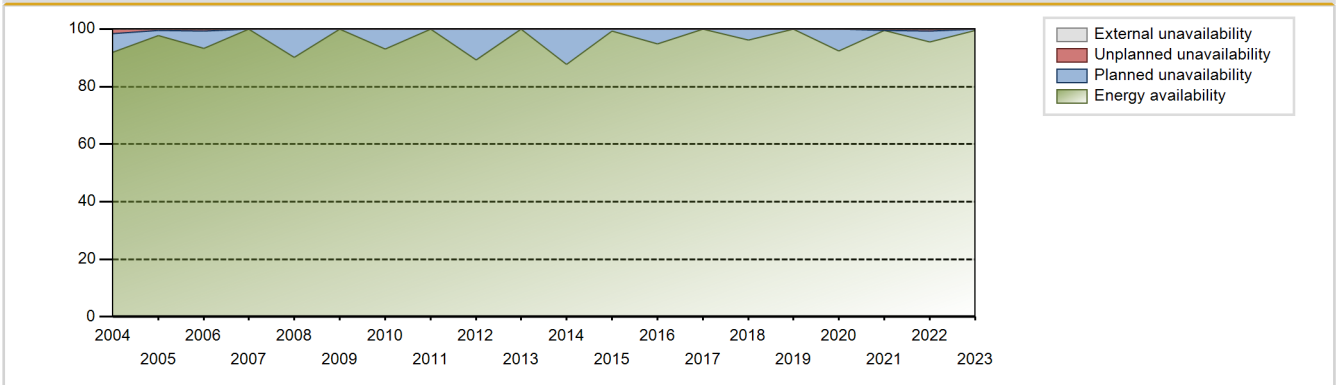
Electricity Production (net) [GWh]



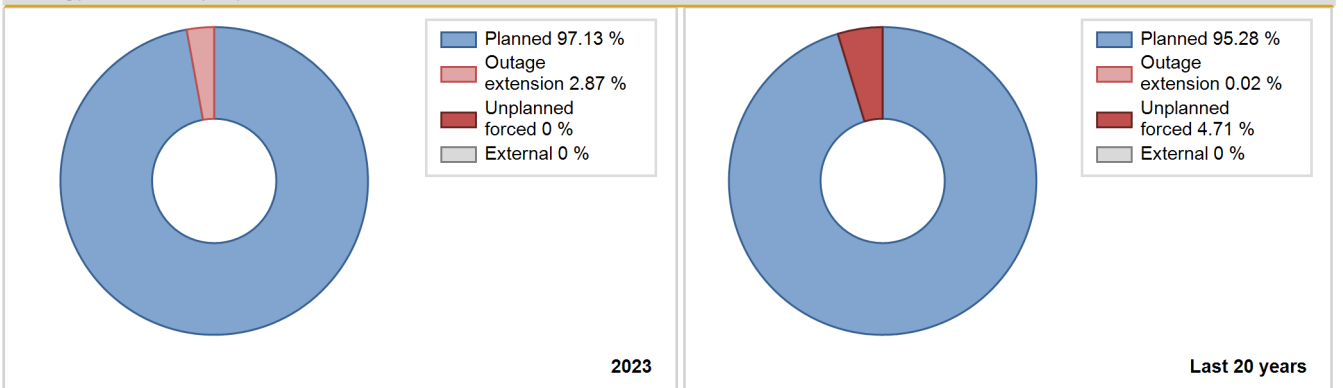
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|--------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1974 | 4982.70 | 6162 | 1053 | 90.55 | 90.55 | 78.92 | 90.58 | 7.84 | 7.70 | 1.75 | 0.00 |
| 1975 | 5082.50 | 6638 | 1051 | 55.26 | 55.26 | 55.20 | 75.78 | 22.93 | 16.44 | 28.31 | 0.00 |
| 1976 | 5580.40 | 5998 | 1051 | 60.51 | 60.51 | 60.45 | 68.28 | 13.21 | 9.21 | 30.28 | 0.00 |
| 1977 | 4051.60 | 4836 | 1051 | 44.04 | 44.04 | 44.01 | 55.21 | 23.10 | 13.23 | 42.73 | 0.00 |
| 1978 | 6793.60 | 7299 | 1051 | 73.79 | 73.79 | 73.79 | 83.32 | 7.88 | 6.31 | 19.89 | 0.00 |
| 1979 | 8574.40 | 8295 | 1051 | 92.91 | 92.91 | 93.13 | 94.69 | 0.92 | 0.86 | 6.23 | 0.00 |
| 1980 | 4372.60 | 4529 | 1051 | 49.95 | 49.95 | 47.36 | 51.56 | 4.19 | 2.18 | 47.87 | 0.00 |
| 1981 | 6635.30 | 6938 | 1051 | 78.53 | 78.53 | 72.07 | 79.20 | 19.56 | 19.10 | 2.37 | 0.00 |
| 1982 | 4816.80 | 5089 | 1051 | 56.46 | 56.46 | 52.32 | 58.09 | 3.36 | 1.96 | 41.57 | 0.00 |
| 1983 | 4481.10 | 4461 | 1051 | 49.03 | 49.56 | 48.67 | 50.92 | 11.53 | 6.46 | 43.98 | 0.53 |
| 1984 | 2465.82 | 2544 | 1051 | 28.85 | 28.85 | 26.71 | 28.96 | 4.54 | 1.37 | 69.77 | 0.00 |
| 1985 | 2378.20 | 2570 | 1051 | 28.67 | 28.67 | 25.83 | 29.34 | 24.48 | 9.30 | 62.03 | 0.00 |
| 1986 | 6896.57 | 7010 | 1051 | 79.76 | 79.76 | 74.91 | 80.02 | 18.80 | 18.46 | 1.77 | 0.00 |
| 1987 | 1599.91 | 1724 | 1051 | 16.48 | 16.48 | 17.38 | 19.68 | 48.28 | 15.39 | 68.13 | 0.00 |
| 1988 | 0.00 | 0 | 1051 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 |
| 1989 | 3880.86 | 4735 | 1051 | 52.26 | 52.26 | 42.15 | 54.05 | 12.44 | 7.42 | 40.32 | 0.00 |
| 1990 | 6699.80 | 6977 | 1055 | 78.92 | 78.92 | 72.49 | 79.65 | 8.26 | 7.11 | 13.97 | 0.00 |
| 1991 | 5120.97 | 5277 | 1055 | 58.82 | 58.82 | 55.41 | 60.24 | 18.91 | 13.72 | 27.46 | 0.00 |
| 1992 | 5677.94 | 5811 | 1055 | 64.94 | 64.94 | 61.27 | 66.15 | 13.16 | 9.84 | 25.23 | 0.00 |
| 1993 | 7704.08 | 7571 | 1053 | 85.92 | 85.92 | 83.47 | 86.43 | 5.53 | 5.03 | 9.05 | 0.00 |
| 1994 | 7450.65 | 7783 | 1055 | 88.80 | 88.80 | 80.60 | 88.85 | 1.59 | 1.43 | 9.77 | 0.00 |
| 1995 | 9363.44 | 8598 | 1093 | 98.15 | 98.15 | 97.79 | 98.15 | 0.00 | 0.00 | 1.85 | 0.00 |
| 1996 | 7660.56 | 8176 | 1093 | 93.09 | 93.09 | 79.79 | 93.08 | 1.75 | 1.66 | 5.25 | 0.00 |
| 1997 | 9570.35 | 8663 | 1093 | 98.89 | 98.89 | 99.95 | 98.89 | 0.43 | 0.42 | 0.68 | 0.00 |
| 1998 | 7658.77 | 7923 | 1093 | 90.45 | 90.45 | 79.99 | 90.45 | 0.00 | 0.00 | 9.55 | 0.00 |
| 1999 | 9462.31 | 8635 | 1093 | 98.58 | 98.58 | 98.83 | 98.57 | 1.42 | 1.42 | 0.00 | 0.00 |
| 2000 | 8523.01 | 8169 | 1093 | 93.01 | 93.01 | 88.77 | 93.00 | 0.00 | 0.00 | 6.99 | 0.00 |
| 2001 | 9369.24 | 8563 | 1093 | 97.76 | 97.76 | 97.85 | 97.75 | 2.24 | 2.24 | 0.00 | 0.00 |
| 2002 | 8838.93 | 8149 | 1093 | 93.03 | 93.03 | 92.32 | 93.03 | 0.81 | 0.76 | 6.21 | 0.00 |
| 2003 | 9265.77 | 8430 | 1112 | 96.32 | 96.32 | 94.86 | 96.23 | 3.68 | 3.68 | 0.00 | 0.00 |
| 2004 | 8886.06 | 8066 | 1112 | 91.85 | 91.85 | 90.97 | 91.83 | 1.61 | 1.51 | 6.65 | 0.00 |
| 2005 | 9615.14 | 8569 | 1112 | 97.83 | 97.83 | 98.70 | 97.81 | 0.40 | 0.40 | 1.78 | 0.00 |
| 2006 | 9088.33 | 8172 | 1112 | 93.30 | 93.30 | 93.30 | 93.29 | 0.72 | 0.68 | 6.02 | 0.00 |
| 2007 | 9867.90 | 8737 | 1112 | 100.00 | 100.00 | 101.57 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 8750.03 | 7914 | 1112 | 90.11 | 90.11 | 89.58 | 90.10 | 0.00 | 0.00 | 9.89 | 0.00 |
| 2009 | 9941.74 | 8760 | 1112 | 100.00 | 100.00 | 102.06 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 9000.11 | 8139 | 1122 | 92.99 | 92.99 | 91.57 | 92.91 | 0.00 | 0.00 | 7.01 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|--------|--------|--------|--------|------|------|-------|------|
| 2011 | 9978.33 | 8760 | 1122 | 100.00 | 100.00 | 101.52 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 8671.08 | 7832 | 1125 | 89.18 | 89.18 | 87.94 | 89.16 | 0.00 | 0.00 | 10.82 | 0.00 |
| 2013 | 10103.52 | 8760 | 1125 | 100.00 | 100.00 | 102.51 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 8641.88 | 7685 | 1125 | 87.74 | 87.74 | 87.69 | 87.73 | 0.00 | 0.00 | 12.26 | 0.00 |
| 2015 | 10762.56 | 8692 | 1308 | 99.29 | 99.29 | 99.70 | 99.22 | 0.00 | 0.00 | 0.71 | 0.00 |
| 2016 | 10476.69 | 8322 | 1308 | 94.74 | 94.74 | 91.19 | 94.74 | 0.00 | 0.00 | 5.26 | 0.00 |
| 2017 | 11313.07 | 8760 | 1308 | 100.00 | 100.00 | 98.73 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 10784.58 | 8395 | 1308 | 96.07 | 96.07 | 94.12 | 95.83 | 0.00 | 0.00 | 3.93 | 0.00 |
| 2019 | 11534.21 | 8760 | 1300 | 100.00 | 100.00 | 101.28 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 10211.82 | 8111 | 1300 | 92.34 | 92.34 | 89.43 | 92.34 | 0.00 | 0.00 | 7.66 | 0.00 |
| 2021 | 11337.91 | 8724 | 1300 | 99.59 | 99.59 | 99.56 | 99.59 | 0.41 | 0.41 | 0.00 | 0.00 |
| 2022 | 10652.64 | 8362 | 1300 | 95.46 | 95.46 | 93.54 | 95.46 | 0.80 | 0.77 | 3.77 | 0.00 |
| 2023 | 11469.21 | 8760 | 1300 | 99.55 | 99.55 | 100.71 | 100.00 | 0.00 | 0.01 | 0.44 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1974 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 292 | |
| B. Refuelling without maintenance | | | | 28 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 981 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 175 | | |
| E. Testing of plant systems or components | | | | 4 | 0 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 109 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 4 |
| L. Human factor related | | | | | 5 | |
| Z. Other | | | | 24 | 6 | 1 |
| Subtotal | | | | 1213 | 412 | 5 |
| Total | | 0 | | | 1630 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1974 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 0 |
| 12. Reactor I&C Systems | | 17 |
| 13. Reactor Auxiliary Systems | | 12 |
| 14. Safety Systems | | 37 |
| 15. Reactor Cooling Systems | | 75 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 21. Fuel Handling and Storage Facilities | | 47 |
| 31. Turbine and auxiliaries | | 37 |
| 32. Feedwater and Main Steam System | | 22 |
| 34. Miscellaneous Systems | | 4 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 6 |
| 42. Electrical Power Supply Systems | | 48 |
| Total | | 307 |

2023 Operating Experience

US-278 **PEACH BOTTOM-3** **UNITED STATES OF AMERICA**

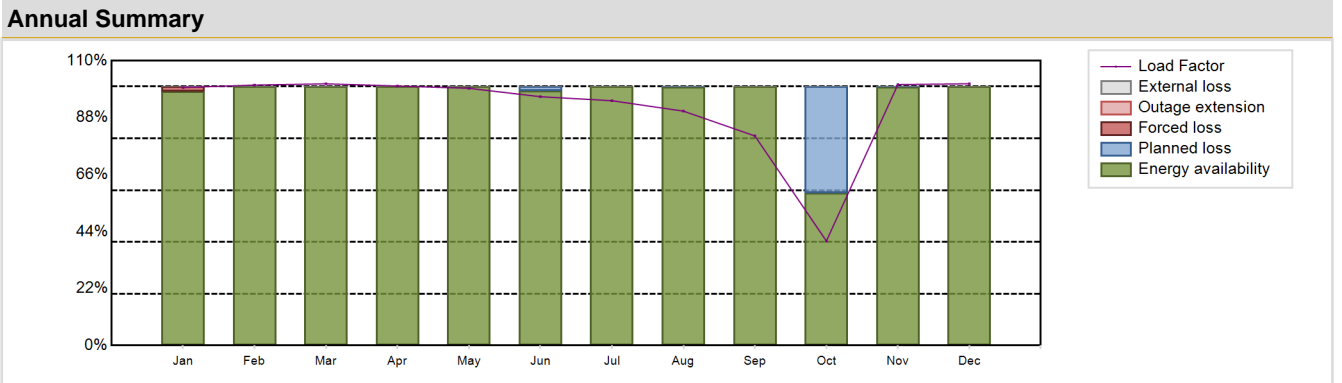
Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXE/PSEG (EXELON Corp. (50%))
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 1) | Construction Date | : 1968-01-31 |
| Thermal power | : 3951 MWth | Grid Date | : 1974-09-01 |
| Gross electrical power | : 1412 MWe | Commercial Date | : 1974-12-23 |
| Reference unit power (net) | : 1331 MWe | Age at end of year | : 49 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.1 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 287 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.16 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 40 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 48000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.75 | HP cylinder inlet steam pressure [MPa] | : 6.65 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 764 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.24 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|-------------|
| Net Energy Production | : 10727.42 GW(e).h | Forced Loss Rate (FLR) | : 0.16 % |
| Energy Availability Factor (EAF) | : 96.21 % | Unplanned Capability Loss Factor (UCL) | : 0.15 % |
| Unit Capability Factor (UCF) | : 96.21 % | Planned Unavailability Factor (PUF) | : 3.64 % |
| Load Factor (LF) | : 92.01 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 96.29 % | Total off-line time | : 325 hours |

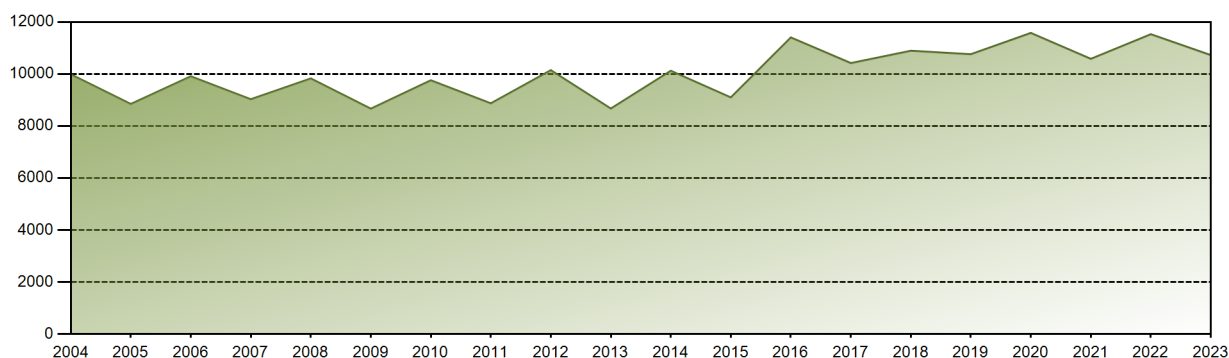


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|----------|
| GW(e)-h | 986.80 | 899.63 | 999.57 | 960.43 | 983.72 | 920.89 | 936.26 | 896.46 | 775.77 | 399.70 | 967.14 | 1001.05 | 10727.42 |
| EAF [%] | 98.18 | 100.00 | 100.00 | 100.00 | 100.00 | 98.28 | 100.00 | 99.97 | 100.00 | 58.99 | 99.87 | 100.00 | 96.21 |
| UCF [%] | 98.18 | 100.00 | 100.00 | 100.00 | 100.00 | 98.28 | 100.00 | 99.97 | 100.00 | 58.99 | 99.87 | 100.00 | 96.21 |
| LF [%] | 99.65 | 100.58 | 101.08 | 100.22 | 99.34 | 96.09 | 94.55 | 90.53 | 80.95 | 40.36 | 100.78 | 101.09 | 92.01 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 56.32 | 100.00 | 100.00 | 96.29 |
| FLR [%] | 1.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 |
| UCL [%] | 1.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.72 | 0.00 | 0.03 | 0.00 | 41.01 | 0.13 | 0.00 | 3.64 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 381945.16 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.47 % |
| Cumulative Energy Availability Factor (EAF) | : 81.44 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.71 % |
| Cumulative Unit Capability Factor (UCF) | : 81.51 % | Cumulative Planned Unavailability Factor (PUF) | : 13.77 % |
| Cumulative Load Factor (LF) | : 80 % | Cumulative Externally cause unavailability (XUF) | : 0.07 % |
| Cumulative Operating Factor (OF) | : 82.14 % | | |

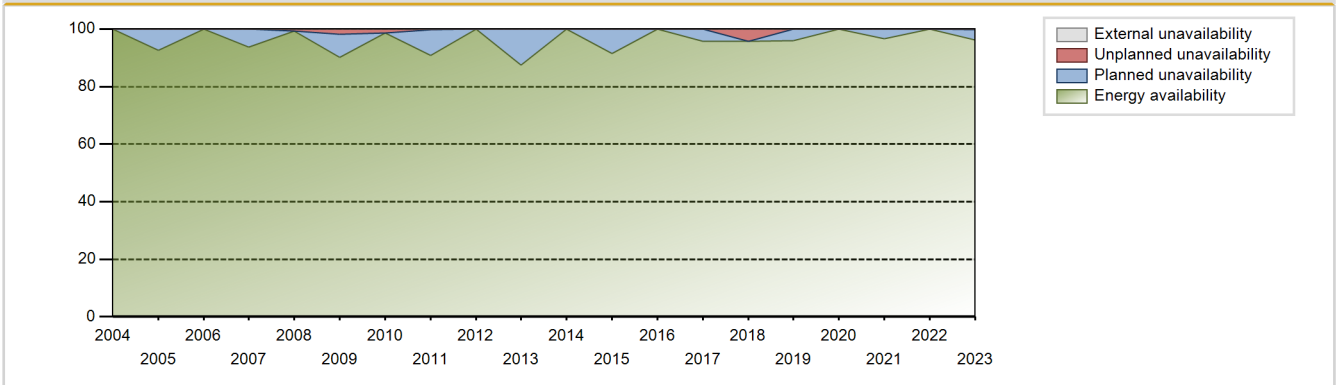
Electricity Production (net) [GWh]



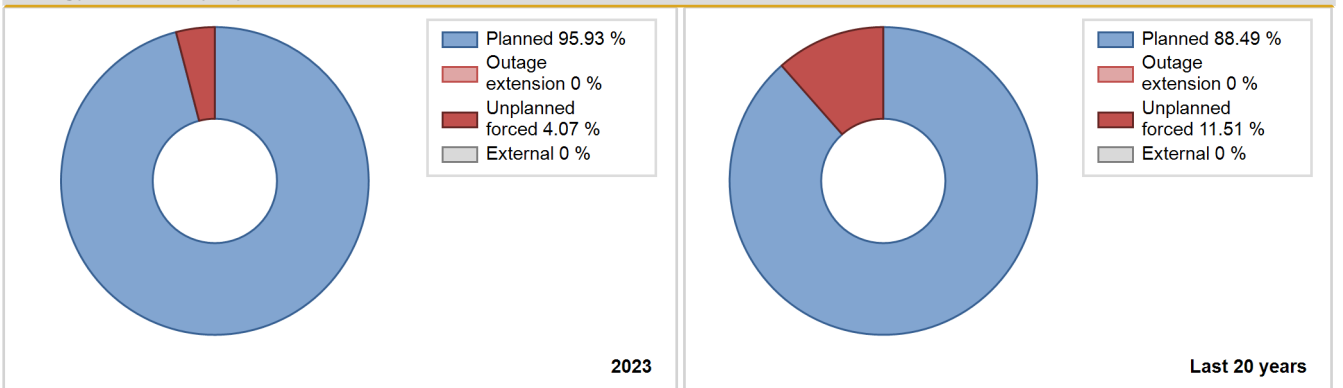
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|--------|------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF | |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] | |
| 1974 | 1095.30 | 1902 | 1073 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1975 | 5282.40 | 7520 | 1035 | 58.19 | 58.19 | 58.26 | 85.84 | 24.55 | 18.94 | 22.87 | 0.00 | 0.00 |
| 1976 | 6056.80 | 6829 | 1035 | 66.68 | 66.68 | 66.62 | 77.74 | 18.98 | 15.62 | 17.70 | 0.00 | 0.00 |
| 1977 | 4787.80 | 5450 | 1035 | 52.84 | 52.84 | 52.81 | 62.21 | 14.35 | 8.85 | 38.30 | 0.00 | 0.00 |
| 1978 | 6973.60 | 7412 | 1035 | 76.91 | 76.91 | 76.92 | 84.61 | 6.53 | 5.37 | 17.71 | 0.00 | 0.00 |
| 1979 | 6110.40 | 6500 | 1035 | 67.21 | 67.21 | 67.39 | 74.20 | 5.73 | 4.09 | 28.71 | 0.00 | 0.00 |
| 1980 | 7233.40 | 7089 | 1035 | 79.70 | 80.12 | 79.56 | 80.70 | 11.47 | 10.38 | 9.49 | 0.43 | 0.00 |
| 1981 | 3171.10 | 3201 | 1035 | 33.00 | 33.00 | 34.98 | 36.54 | 13.97 | 5.36 | 61.64 | 0.00 | 0.00 |
| 1982 | 8532.30 | 8372 | 1035 | 95.35 | 95.35 | 94.11 | 95.57 | 4.65 | 4.65 | 0.00 | 0.00 | 0.00 |
| 1983 | 2465.70 | 2714 | 1035 | 27.14 | 27.50 | 27.20 | 30.98 | 4.64 | 1.34 | 71.16 | 0.36 | 0.00 |
| 1984 | 7445.52 | 7545 | 1035 | 85.15 | 86.21 | 81.90 | 85.89 | 13.79 | 13.79 | 0.00 | 1.06 | 0.00 |
| 1985 | 3320.84 | 3988 | 1035 | 45.11 | 45.11 | 36.63 | 45.53 | 0.83 | 0.38 | 54.51 | 0.00 | 0.00 |
| 1986 | 4858.84 | 5542 | 1035 | 60.94 | 60.94 | 53.59 | 63.26 | 20.95 | 16.15 | 22.91 | 0.00 | 0.00 |
| 1987 | 1507.72 | 1658 | 1035 | 14.41 | 14.41 | 16.63 | 18.93 | 85.59 | 85.59 | 0.00 | 0.00 | 0.00 |
| 1988 | 0.00 | 0 | 1035 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 |
| 1989 | 247.31 | 472 | 1035 | 0.10 | 0.10 | 2.73 | 5.39 | 47.89 | 0.09 | 99.81 | 0.00 | 0.00 |
| 1990 | 7534.10 | 7684 | 1035 | 87.08 | 87.08 | 83.10 | 87.72 | 5.30 | 4.87 | 8.05 | 0.00 | 0.00 |
| 1991 | 5118.92 | 5212 | 1035 | 57.26 | 59.14 | 56.46 | 59.50 | 13.61 | 9.32 | 31.54 | 1.88 | 0.00 |
| 1992 | 7180.95 | 7391 | 1035 | 83.65 | 83.65 | 78.99 | 84.14 | 12.72 | 12.19 | 4.16 | 0.00 | 0.00 |
| 1993 | 6314.03 | 6594 | 1035 | 73.89 | 73.89 | 69.64 | 75.27 | 7.25 | 5.77 | 20.34 | 0.00 | 0.00 |
| 1994 | 8867.35 | 8588 | 1035 | 97.93 | 97.93 | 97.80 | 98.04 | 2.07 | 2.07 | 0.00 | 0.00 | 0.00 |
| 1995 | 7172.49 | 7929 | 1049 | 90.12 | 90.12 | 78.01 | 90.51 | 3.20 | 2.98 | 6.89 | 0.00 | 0.00 |
| 1996 | 9424.69 | 8627 | 1093 | 98.21 | 98.21 | 98.16 | 98.21 | 1.79 | 1.79 | 0.00 | 0.00 | 0.00 |
| 1997 | 7566.58 | 7909 | 1093 | 90.29 | 90.29 | 79.03 | 90.29 | 1.75 | 1.61 | 8.11 | 0.00 | 0.00 |
| 1998 | 8823.63 | 8172 | 1093 | 93.30 | 93.30 | 92.16 | 93.29 | 1.41 | 1.34 | 5.36 | 0.00 | 0.00 |
| 1999 | 8558.61 | 8100 | 1093 | 92.48 | 92.48 | 89.39 | 92.47 | 0.00 | 0.00 | 7.52 | 0.00 | 0.00 |
| 2000 | 9556.78 | 8722 | 1093 | 99.30 | 99.30 | 99.54 | 99.29 | 0.70 | 0.70 | 0.00 | 0.00 | 0.00 |
| 2001 | 8524.44 | 8153 | 1093 | 93.09 | 93.09 | 89.03 | 93.07 | 0.00 | 0.00 | 6.91 | 0.00 | 0.00 |
| 2002 | 9647.38 | 8740 | 1093 | 99.78 | 99.78 | 100.76 | 99.77 | 0.00 | 0.00 | 0.22 | 0.00 | 0.00 |
| 2003 | 8937.81 | 8089 | 1112 | 92.38 | 92.38 | 92.94 | 92.34 | 4.49 | 4.35 | 3.27 | 0.00 | 0.00 |
| 2004 | 9989.10 | 8784 | 1112 | 100.00 | 100.00 | 102.27 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 8848.91 | 8105 | 1112 | 92.55 | 92.55 | 90.84 | 92.52 | 0.00 | 0.00 | 7.45 | 0.00 | 0.00 |
| 2006 | 9912.75 | 8760 | 1112 | 100.00 | 100.00 | 101.76 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 9030.82 | 8207 | 1112 | 93.70 | 93.70 | 92.71 | 93.69 | 0.00 | 0.00 | 6.30 | 0.00 | 0.00 |
| 2008 | 9830.48 | 8729 | 1112 | 99.38 | 99.38 | 100.64 | 99.37 | 0.62 | 0.62 | 0.00 | 0.00 | 0.00 |
| 2009 | 8668.09 | 7888 | 1112 | 90.09 | 90.09 | 88.98 | 90.05 | 2.04 | 1.88 | 8.04 | 0.00 | 0.00 |
| 2010 | 9759.27 | 8640 | 1112 | 98.64 | 98.64 | 100.19 | 98.63 | 1.36 | 1.36 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|--------|--------|--------|--------|------|------|-------|------|
| 2011 | 8873.28 | 7952 | 1122 | 90.81 | 90.81 | 90.95 | 90.78 | 0.33 | 0.30 | 8.89 | 0.00 |
| 2012 | 10148.35 | 8784 | 1138 | 100.00 | 100.00 | 101.52 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 8673.15 | 7656 | 1138 | 87.40 | 87.40 | 86.99 | 87.39 | 0.00 | 0.00 | 12.60 | 0.00 |
| 2014 | 10124.97 | 8757 | 1138 | 99.96 | 99.96 | 101.57 | 99.97 | 0.04 | 0.04 | 0.00 | 0.00 |
| 2015 | 9101.27 | 8006 | 1308 | 91.50 | 91.50 | 90.15 | 91.39 | 0.00 | 0.00 | 8.50 | 0.00 |
| 2016 | 11406.74 | 8784 | 1309 | 100.00 | 100.00 | 99.20 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 10421.37 | 8378 | 1309 | 95.64 | 95.64 | 90.88 | 95.64 | 0.00 | 0.00 | 4.36 | 0.00 |
| 2018 | 10895.50 | 8384 | 1251 | 95.70 | 95.70 | 99.54 | 95.71 | 4.30 | 4.30 | 0.00 | 0.00 |
| 2019 | 10761.63 | 8377 | 1331 | 95.90 | 95.90 | 92.30 | 95.63 | 0.00 | 0.00 | 4.10 | 0.00 |
| 2020 | 11580.51 | 8783 | 1331 | 100.00 | 100.00 | 99.05 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 10584.21 | 8458 | 1331 | 96.55 | 96.55 | 90.78 | 96.55 | 0.00 | 0.00 | 3.45 | 0.00 |
| 2022 | 11531.32 | 8760 | 1331 | 100.00 | 100.00 | 98.90 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 10727.42 | 8435 | 1331 | 96.21 | 96.21 | 92.01 | 96.29 | 0.16 | 0.15 | 3.64 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1974 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 274 | |
| B. Refuelling without maintenance | | | | 6 | | |
| C. Inspection, maintenance or repair combined with refuelling | 348 | | | 1047 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 62 | | |
| E. Testing of plant systems or components | | | | 13 | 1 | |
| H. Nuclear regulatory requirements | | | | | 139 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 8 |
| L. Human factor related | | | | | 13 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 7 |
| Z. Other | | | | 17 | 0 | 1 |
| Subtotal | 348 | | | 1145 | 427 | 16 |
| Total | | 348 | | | 1588 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1974 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 19 |
| 13. Reactor Auxiliary Systems | | 9 |
| 14. Safety Systems | | 33 |
| 15. Reactor Cooling Systems | | 77 |
| 31. Turbine and auxiliaries | | 35 |
| 32. Feedwater and Main Steam System | | 47 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 0 |
| 41. Main Generator Systems | | 14 |
| 42. Electrical Power Supply Systems | | 51 |
| Total | | 287 |

2023 Operating Experience

US-440

PERRY-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : FENOC (FIRST ENERGY NUCLEAR OPERATING CO.)
 Owner : CEI (CLEVELAND ELECTRIC ILLUMINATING CO.)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-6 (Mark 3) | Construction Date | : 1974-10-01 |
| Thermal power | : 3758 MWth | Grid Date | : 1986-12-19 |
| Gross electrical power | : 1303 MWe | Commercial Date | : 1987-11-18 |
| Reference unit power (net) | : 1240 MWe | Age at end of year | : 37 years |

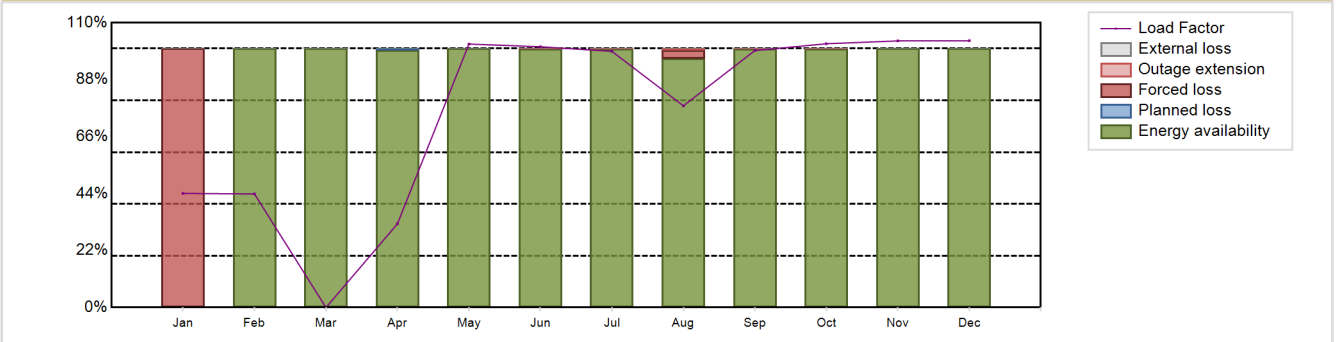
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 7.31 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 285.5 |
| Refuelling type | : OFF-line | Number of SG | : NA |
| Moderator material | : H2O | Containment type | : Confinement |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 0.105 |
| Refuelling frequency [month] | : 24 | Secondary systems | |
| Part of the core refuelled [%] | : 25 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 7614 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 4.65 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.81 | HP cylinder inlet steam pressure [MPa] | : 6.78 |
| Number of fissile fuel assemblies/bundles | : 748 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 19.85 | Primary means of condenser cooling | : Cooling Towers |
| Number of control rod assemblies | : 177 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 2 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 8227.22 GW(e).h | Forced Loss Rate (FLR) | : 8.78 % |
| Energy Availability Factor (EAF) | : 91.1 % | Unplanned Capability Loss Factor (UCL) | : 8.85 % |
| Unit Capability Factor (UCF) | : 91.1 % | Planned Unavailability Factor (PUF) | : 0.04 % |
| Load Factor (LF) | : 75.74 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 82.64 % | Total off-line time | : 1521 hours |

Annual Summary

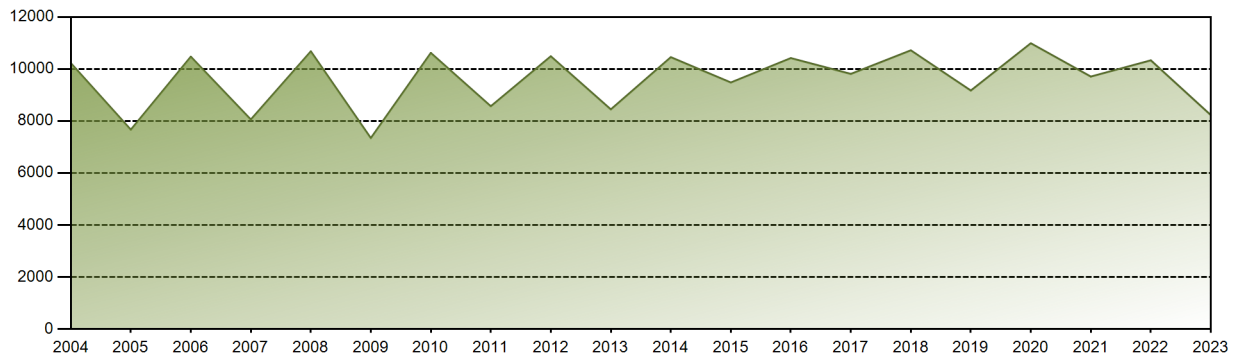


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 406.72 | 365.50 | 0.00 | 288.70 | 938.80 | 899.05 | 912.74 | 718.65 | 886.14 | 939.75 | 920.67 | 950.50 | 8227.22 |
| EAF [%] | 0.00 | 100.00 | 100.00 | 99.47 | 100.00 | 99.87 | 99.74 | 96.26 | 99.93 | 99.94 | 100.00 | 100.00 | 91.10 |
| UCF [%] | 0.00 | 100.00 | 100.00 | 99.47 | 100.00 | 99.87 | 99.74 | 96.26 | 99.93 | 99.94 | 100.00 | 100.00 | 91.10 |
| LF [%] | 44.09 | 43.86 | 0.00 | 32.34 | 101.76 | 100.70 | 98.94 | 77.90 | 99.25 | 101.86 | 102.98 | 103.03 | 75.74 |
| OF [%] | 89.11 | 89.29 | 0.00 | 36.39 | 100.00 | 100.00 | 100.00 | 77.55 | 100.00 | 100.00 | 100.00 | 100.00 | 82.64 |
| FLR [%] | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.24 | 0.00 | 0.00 | 0.00 | 0.00 | 8.78 |
| UCL [%] | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.26 | 3.74 | 0.07 | 0.06 | 0.00 | 0.00 | 8.85 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

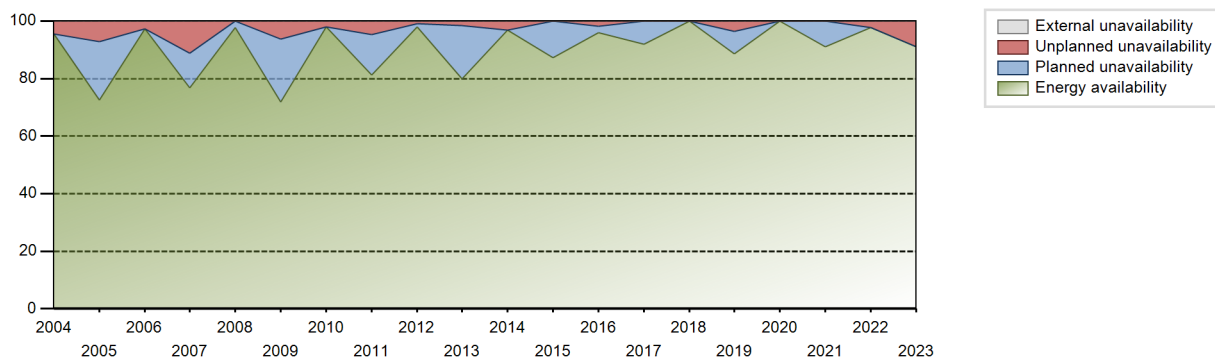
| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 317322.91 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.81 % |
| Cumulative Energy Availability Factor (EAF) | : 84.94 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.3 % |
| Cumulative Unit Capability Factor (UCF) | : 84.94 % | Cumulative Planned Unavailability Factor (PUF) | : 10.76 % |
| Cumulative Load Factor (LF) | : 82.51 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 84.45 % | | |

Electricity Production (net) [GWh]

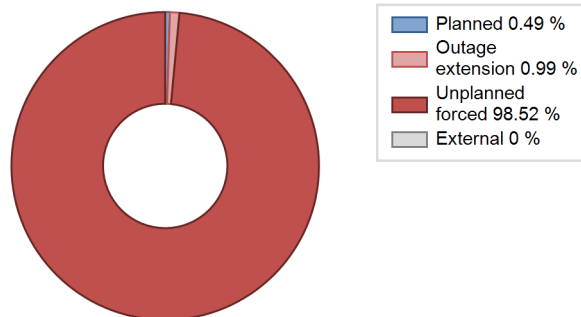


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | | | | Data not provided | | | | | | | |
| 1988 | 7233.82 | 6664 | 1203 | 76.34 | 76.34 | 68.44 | 75.87 | 14.72 | 13.18 | 10.48 | 0.00 |
| 1989 | 5357.58 | 4776 | 1141 | 53.43 | 53.43 | 53.60 | 54.52 | 0.80 | 0.43 | 46.14 | 0.00 |
| 1990 | 6638.89 | 5723 | 1141 | 65.27 | 65.27 | 66.42 | 65.33 | 1.27 | 0.84 | 33.89 | 0.00 |
| 1991 | 8975.67 | 7949 | 1166 | 90.74 | 90.74 | 87.87 | 90.74 | 8.38 | 8.30 | 0.96 | 0.00 |
| 1992 | 7168.56 | 6383 | 1166 | 72.62 | 72.62 | 69.99 | 72.67 | 7.41 | 5.81 | 21.57 | 0.00 |
| 1993 | 3973.21 | 3853 | 1166 | 43.86 | 43.86 | 38.90 | 43.98 | 37.99 | 26.87 | 29.26 | 0.00 |
| 1994 | 4591.90 | 4151 | 1166 | 47.28 | 47.28 | 44.96 | 47.39 | 1.34 | 0.64 | 52.07 | 0.00 |
| 1995 | 9112.12 | 8174 | 1166 | 93.36 | 93.36 | 89.21 | 93.31 | 6.64 | 6.64 | 0.00 | 0.00 |
| 1996 | 7481.95 | 6673 | 1164 | 75.92 | 75.92 | 73.18 | 75.97 | 4.60 | 3.66 | 20.42 | 0.00 |
| 1997 | 8151.83 | 7178 | 1160 | 81.88 | 81.88 | 80.22 | 81.94 | 7.35 | 6.50 | 11.62 | 0.00 |
| 1998 | 10188.94 | 8684 | 1160 | 99.14 | 99.14 | 100.27 | 99.13 | 0.86 | 0.86 | 0.00 | 0.00 |
| 1999 | 9124.91 | 7850 | 1160 | 89.62 | 89.62 | 89.80 | 89.61 | 0.00 | 0.00 | 10.38 | 0.00 |
| 2000 | 10085.68 | 8506 | 1191 | 96.90 | 96.90 | 96.35 | 96.84 | 0.00 | 0.00 | 3.10 | 0.00 |
| 2001 | 7781.77 | 6708 | 1241 | 77.89 | 77.89 | 71.84 | 76.58 | 14.30 | 12.99 | 9.12 | 0.00 |
| 2002 | 9974.81 | 8196 | 1235 | 93.56 | 93.56 | 92.20 | 93.56 | 6.44 | 6.44 | 0.00 | 0.00 |
| 2003 | 8553.20 | 7217 | 1235 | 82.36 | 82.36 | 79.06 | 82.39 | 2.38 | 2.00 | 15.63 | 0.00 |
| 2004 | 10227.34 | 8378 | 1235 | 95.41 | 95.41 | 94.28 | 95.38 | 4.59 | 4.59 | 0.00 | 0.00 |
| 2005 | 7667.52 | 6363 | 1235 | 72.65 | 72.65 | 70.87 | 72.63 | 8.93 | 7.12 | 20.23 | 0.00 |
| 2006 | 10475.37 | 8521 | 1235 | 97.27 | 97.27 | 96.83 | 97.27 | 2.73 | 2.73 | 0.00 | 0.00 |
| 2007 | 8058.25 | 6704 | 1245 | 76.84 | 76.84 | 73.89 | 76.53 | 12.74 | 11.22 | 11.95 | 0.00 |
| 2008 | 10680.58 | 8580 | 1245 | 97.68 | 97.68 | 97.66 | 97.68 | 0.00 | 0.00 | 2.32 | 0.00 |
| 2009 | 7345.14 | 6284 | 1245 | 71.77 | 71.77 | 67.35 | 71.74 | 7.95 | 6.20 | 22.03 | 0.00 |
| 2010 | 10619.71 | 8590 | 1240 | 98.06 | 98.06 | 97.77 | 98.06 | 1.94 | 1.94 | 0.00 | 0.00 |
| 2011 | 8569.09 | 7115 | 1240 | 81.24 | 81.24 | 78.89 | 81.22 | 5.41 | 4.64 | 14.12 | 0.00 |
| 2012 | 10490.30 | 8607 | 1240 | 98.00 | 98.00 | 96.31 | 97.98 | 0.94 | 0.93 | 1.07 | 0.00 |
| 2013 | 8448.62 | 6981 | 1256 | 79.88 | 79.88 | 77.10 | 79.68 | 1.84 | 1.50 | 18.63 | 0.00 |
| 2014 | 10455.27 | 8490 | 1256 | 96.92 | 96.92 | 95.03 | 96.92 | 3.08 | 3.08 | 0.00 | 0.00 |
| 2015 | 9482.84 | 7639 | 1256 | 87.20 | 87.20 | 86.19 | 87.20 | 0.00 | 0.00 | 12.80 | 0.00 |
| 2016 | 10420.29 | 8434 | 1256 | 96.02 | 96.02 | 94.45 | 96.02 | 1.84 | 1.80 | 2.18 | 0.00 |
| 2017 | 9812.38 | 8054 | 1256 | 91.92 | 91.92 | 89.18 | 91.94 | 0.00 | 0.00 | 8.08 | 0.00 |
| 2018 | 10718.96 | 8760 | 1240 | 100.00 | 100.00 | 98.68 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 9173.10 | 7763 | 1240 | 88.64 | 88.64 | 84.45 | 88.62 | 3.79 | 3.49 | 7.86 | 0.00 |
| 2020 | 10990.96 | 8783 | 1240 | 100.00 | 100.00 | 100.91 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 9709.68 | 7975 | 1240 | 91.04 | 91.04 | 89.39 | 91.04 | 0.00 | 0.00 | 8.96 | 0.00 |
| 2022 | 10334.45 | 8553 | 1240 | 97.64 | 97.64 | 95.14 | 97.64 | 2.36 | 2.36 | 0.00 | 0.00 |
| 2023 | 8227.22 | 7239 | 1240 | 91.10 | 91.10 | 75.74 | 82.64 | 8.78 | 8.85 | 0.04 | 0.00 |

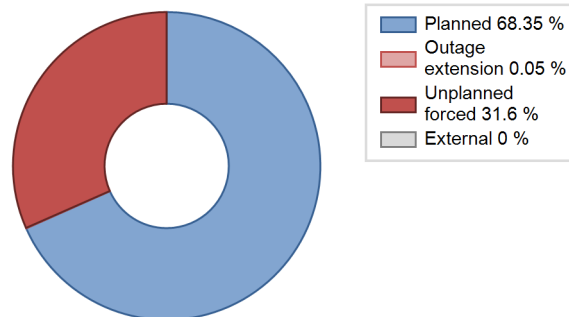
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 329 | |
| B. Refuelling without maintenance | | | | 22 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1272 | | | 840 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 133 | | |
| E. Testing of plant systems or components | | | | 0 | | |
| H. Nuclear regulatory requirements | | | | | 6 | |
| L. Human factor related | | | | | 10 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 1 | |
| Z. Other | | | | | 5 | |
| Subtotal | 1272 | 24 | | 995 | 351 | |
| Total | | 1296 | | | 1346 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 24 | 4 |
| 12. Reactor I&C Systems | | 31 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 0 |
| 15. Reactor Cooling Systems | | 46 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 4 |
| 31. Turbine and auxiliaries | | 45 |
| 32. Feedwater and Main Steam System | | 24 |
| 33. Circulating Water System | | 9 |
| 34. Miscellaneous Systems | | 78 |
| 35. All other I&C Systems | | 17 |
| 41. Main Generator Systems | | 28 |
| 42. Electrical Power Supply Systems | | 57 |
| Total | 24 | 345 |

2023 Operating Experience

US-266

POINT BEACH-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : NEXTERA (NextEra Energy Resources, LLC)
 Owner : NEXTERA (NextEra Energy Resources, LLC)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 2LP (DRYAMB)
 Thermal power : 1800 MWth
 Gross electrical power : 640 MWe
 Reference unit power (net) : 591 MWe

Key Dates

Construction Date : 1967-07-19
 Grid Date : 1970-11-06
 Commercial Date : 1970-12-21
 Age at end of year : 53 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 74
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 2.46
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 121
 Fuel linear heat generation rate [kW/m] : 18.7
 Number of control rod assemblies : 21
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 316
 Number of SG : 2
 Containment type : -
 Containment design pressure [MPa] : 0.422

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.55
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

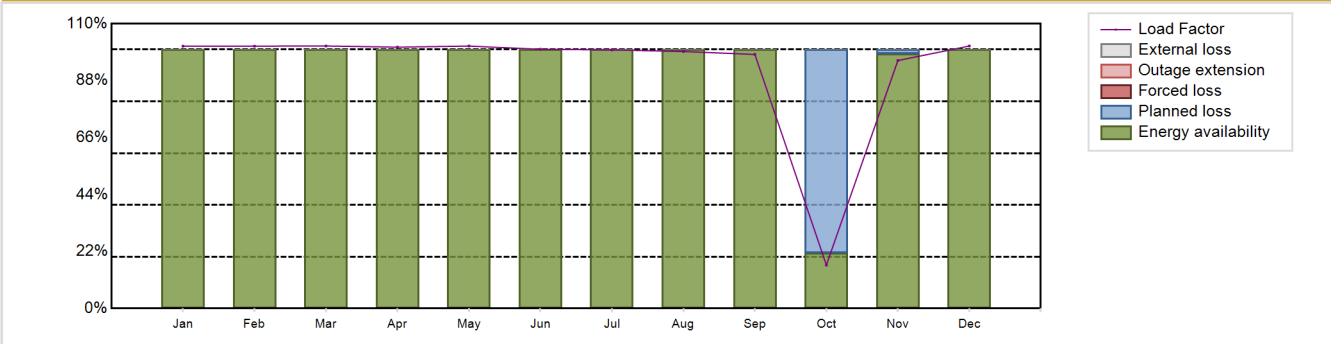
Non-electrical applications

: none

Annual Production Results (2023)

Net Energy Production : 4815.15 GW(e).h
 Energy Availability Factor (EAF) : 93.18 %
 Unit Capability Factor (UCF) : 93.18 %
 Load Factor (LF) : 93.01 %
 Operating Factor (OF) : 93 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 6.82 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 613 hours

Annual Summary

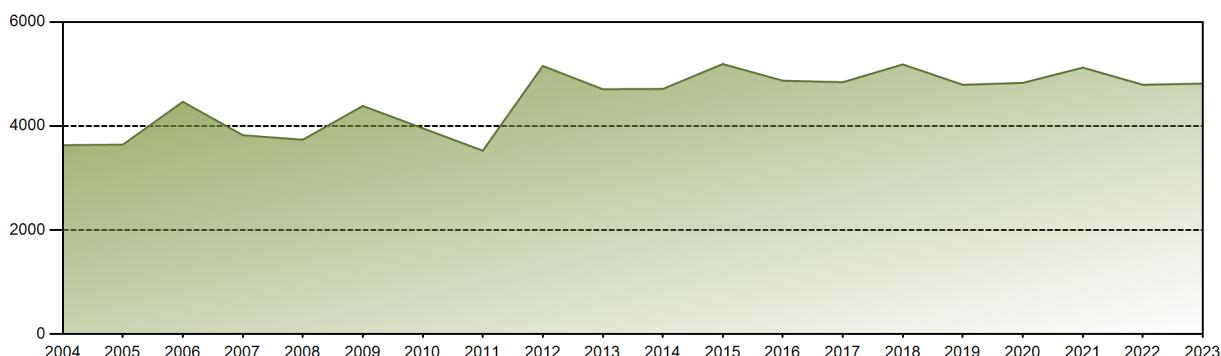


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|---------|
| GW(e)-h | 445.39 | 402.50 | 445.24 | 429.54 | 445.70 | 426.02 | 439.26 | 436.40 | 417.55 | 73.69 | 408.11 | 445.76 | 4815.15 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 21.41 | 98.29 | 100.00 | 93.18 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 21.41 | 98.29 | 100.00 | 93.18 |
| LF [%] | 101.29 | 101.35 | 101.40 | 100.94 | 101.36 | 100.12 | 99.90 | 99.25 | 98.13 | 16.76 | 95.77 | 101.38 | 93.01 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 19.35 | 98.20 | 100.00 | 93.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 78.59 | 1.71 | 0.00 | 6.82 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 199857.2 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.14 % |
| Cumulative Energy Availability Factor (EAF) | : 86.2 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.8 % |
| Cumulative Unit Capability Factor (UCF) | : 86.46 % | Cumulative Planned Unavailability Factor (PUF) | : 10.74 % |
| Cumulative Load Factor (LF) | : 83.12 % | Cumulative Externally cause unavailability (XUF) | : 0.26 % |
| Cumulative Operating Factor (OF) | : 85.48 % | | |

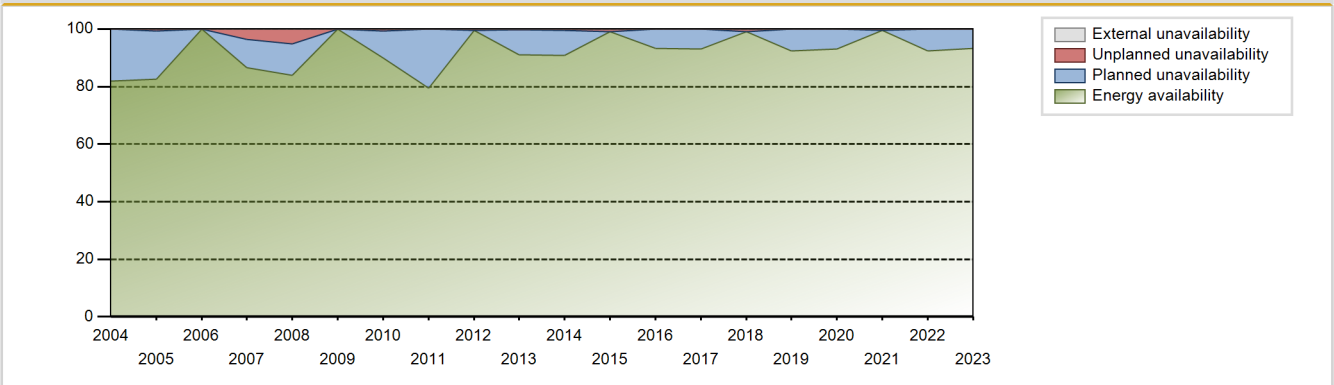
Electricity Production (net) [GWh]



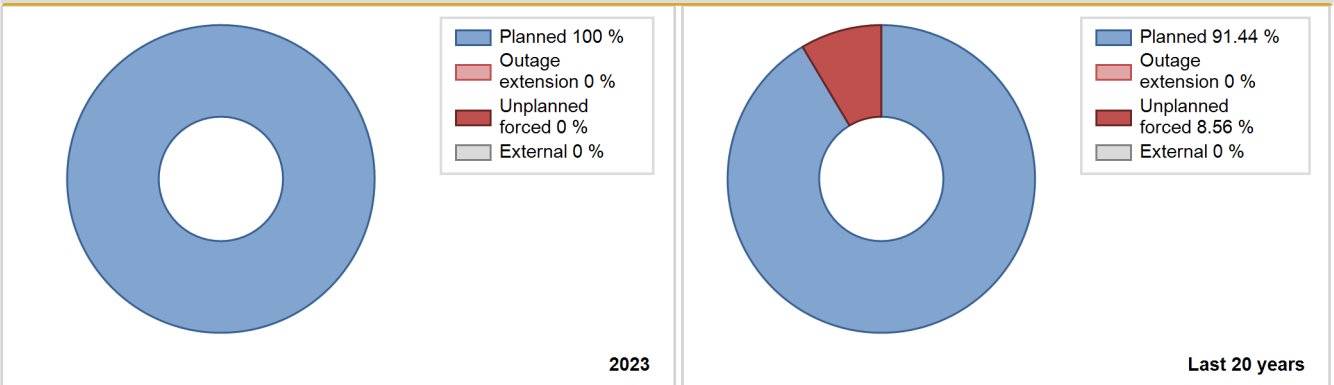
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1970 | | | | Data not provided | | | | | | | |
| 1971 | 3446.20 | 7699 | 524 | 100.00 | 100.00 | 75.08 | 87.89 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1972 | 3085.50 | 6349 | 524 | 100.00 | 100.00 | 67.04 | 72.28 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | 2742.30 | 6867 | 497 | 67.61 | 67.61 | 62.99 | 78.39 | 15.83 | 12.72 | 19.67 | 0.00 |
| 1974 | 3144.30 | 7136 | 497 | 81.45 | 81.45 | 72.22 | 81.46 | 4.61 | 3.93 | 14.62 | 0.00 |
| 1975 | 2924.90 | 6297 | 480 | 69.52 | 69.52 | 69.56 | 71.88 | 17.11 | 14.35 | 16.14 | 0.00 |
| 1976 | 3392.50 | 7239 | 492 | 78.43 | 78.43 | 78.50 | 82.41 | 0.08 | 0.06 | 21.52 | 0.00 |
| 1977 | 3687.10 | 7733 | 495 | 85.08 | 85.08 | 85.03 | 88.28 | 3.92 | 3.47 | 11.45 | 0.00 |
| 1978 | 3794.50 | 7864 | 495 | 87.50 | 87.50 | 87.51 | 89.77 | 2.83 | 2.55 | 9.95 | 0.00 |
| 1979 | 3059.60 | 6455 | 495 | 70.56 | 70.56 | 70.56 | 73.69 | 12.40 | 9.99 | 19.45 | 0.00 |
| 1980 | 2479.30 | 6739 | 495 | 76.96 | 91.02 | 57.02 | 76.72 | 0.40 | 0.37 | 8.62 | 14.06 |
| 1981 | 2614.90 | 6834 | 495 | 78.30 | 78.30 | 60.30 | 78.01 | 0.22 | 0.18 | 21.52 | 0.00 |
| 1982 | 2701.70 | 7134 | 495 | 81.51 | 81.51 | 62.31 | 81.44 | 0.18 | 0.15 | 18.34 | 0.00 |
| 1983 | 2384.90 | 6498 | 495 | 74.26 | 74.26 | 55.00 | 74.18 | 0.00 | 0.00 | 25.74 | 0.00 |
| 1984 | 3109.21 | 6379 | 485 | 72.63 | 72.63 | 72.98 | 72.62 | 0.00 | 0.00 | 27.37 | 0.00 |
| 1985 | 3354.18 | 6917 | 485 | 78.65 | 78.65 | 78.95 | 78.96 | 0.10 | 0.08 | 21.27 | 0.00 |
| 1986 | 3770.07 | 7786 | 485 | 88.73 | 88.73 | 88.74 | 88.88 | 0.40 | 0.36 | 10.92 | 0.00 |
| 1987 | 3567.09 | 7348 | 485 | 83.64 | 83.64 | 83.96 | 83.88 | 0.28 | 0.23 | 16.12 | 0.00 |
| 1988 | 3830.95 | 7787 | 485 | 88.48 | 88.48 | 89.92 | 88.65 | 0.00 | 0.00 | 11.52 | 0.00 |
| 1989 | 3606.22 | 7706 | 485 | 87.78 | 87.78 | 84.88 | 87.97 | 0.00 | 0.00 | 12.22 | 0.00 |
| 1990 | 3531.73 | 7362 | 485 | 83.80 | 83.80 | 83.13 | 84.04 | 0.00 | 0.00 | 16.20 | 0.00 |
| 1991 | 3628.73 | 7524 | 485 | 85.68 | 85.68 | 85.41 | 85.89 | 1.33 | 1.16 | 13.17 | 0.00 |
| 1992 | 3605.64 | 7409 | 485 | 84.10 | 84.10 | 84.63 | 84.35 | 0.66 | 0.56 | 15.34 | 0.00 |
| 1993 | 3804.79 | 7799 | 485 | 88.85 | 88.85 | 89.55 | 89.03 | 0.00 | 0.00 | 11.15 | 0.00 |
| 1994 | 3905.06 | 8071 | 485 | 92.04 | 92.04 | 91.91 | 92.13 | 0.00 | 0.00 | 7.96 | 0.00 |
| 1995 | 3792.43 | 7768 | 485 | 88.52 | 88.52 | 89.26 | 88.68 | 1.28 | 1.15 | 10.33 | 0.00 |
| 1996 | 4003.33 | 8173 | 485 | 92.95 | 92.95 | 93.97 | 93.04 | 0.00 | 0.00 | 7.05 | 0.00 |
| 1997 | 853.50 | 1872 | 485 | 21.33 | 21.33 | 20.09 | 21.37 | 78.67 | 78.67 | 0.00 | 0.00 |
| 1998 | 2584.22 | 5489 | 485 | 62.69 | 62.69 | 60.83 | 62.66 | 0.00 | 0.00 | 37.31 | 0.00 |
| 1999 | 3489.33 | 7070 | 489 | 80.02 | 80.02 | 81.43 | 80.71 | 3.79 | 3.15 | 16.83 | 0.00 |
| 2000 | 4134.62 | 8391 | 510 | 95.59 | 96.10 | 92.29 | 95.53 | 3.90 | 3.90 | 0.00 | 0.51 |
| 2001 | 3702.10 | 7611 | 510 | 87.04 | 87.04 | 82.87 | 86.88 | 3.35 | 3.01 | 9.95 | 0.00 |
| 2002 | 3975.79 | 7964 | 510 | 91.01 | 91.01 | 88.99 | 90.91 | 0.00 | 0.00 | 8.99 | 0.00 |
| 2003 | 4343.00 | 8538 | 516 | 97.52 | 97.52 | 96.18 | 97.47 | 2.48 | 2.48 | 0.00 | 0.00 |
| 2004 | 3631.04 | 7186 | 516 | 81.89 | 81.89 | 80.11 | 81.81 | 0.00 | 0.00 | 18.11 | 0.00 |
| 2005 | 3641.04 | 7232 | 512 | 82.58 | 82.58 | 81.18 | 82.56 | 0.76 | 0.63 | 16.79 | 0.00 |
| 2006 | 4465.63 | 8760 | 512 | 100.00 | 100.00 | 99.57 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2007 | 3822.30 | 7582 | 512 | 86.57 | 86.57 | 85.22 | 86.55 | 3.89 | 3.51 | 9.92 | 0.00 |
| 2008 | 3737.01 | 7365 | 512 | 83.87 | 83.87 | 83.09 | 83.85 | 5.89 | 5.24 | 10.89 | 0.00 |
| 2009 | 4385.38 | 8760 | 512 | 100.00 | 100.00 | 97.78 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 3956.14 | 7870 | 512 | 89.89 | 89.89 | 88.21 | 89.84 | 0.83 | 0.75 | 9.36 | 0.00 |
| 2011 | 3525.04 | 6954 | 512 | 79.39 | 79.39 | 78.59 | 79.38 | 0.00 | 0.00 | 20.61 | 0.00 |
| 2012 | 5154.43 | 8737 | 591 | 99.47 | 99.47 | 99.29 | 99.46 | 0.53 | 0.53 | 0.00 | 0.00 |
| 2013 | 4707.21 | 7981 | 591 | 91.11 | 91.11 | 90.91 | 91.10 | 0.40 | 0.36 | 8.53 | 0.00 |
| 2014 | 4713.10 | 7956 | 591 | 90.82 | 90.82 | 91.04 | 90.82 | 0.49 | 0.45 | 8.73 | 0.00 |
| 2015 | 5191.57 | 8671 | 591 | 98.99 | 98.99 | 100.28 | 98.98 | 1.01 | 1.01 | 0.00 | 0.00 |
| 2016 | 4871.11 | 8196 | 591 | 93.30 | 93.30 | 93.83 | 93.31 | 0.00 | 0.00 | 6.70 | 0.00 |
| 2017 | 4842.86 | 8158 | 591 | 93.13 | 93.13 | 93.54 | 93.13 | 0.00 | 0.00 | 6.87 | 0.00 |
| 2018 | 5184.30 | 8675 | 591 | 99.06 | 99.06 | 100.14 | 99.03 | 0.94 | 0.94 | 0.00 | 0.00 |
| 2019 | 4792.60 | 8098 | 591 | 92.45 | 92.45 | 92.57 | 92.44 | 0.00 | 0.00 | 7.55 | 0.00 |
| 2020 | 4828.77 | 8181 | 591 | 93.15 | 93.15 | 93.02 | 93.14 | 0.00 | 0.00 | 6.85 | 0.00 |
| 2021 | 5123.07 | 8719 | 591 | 99.53 | 99.53 | 98.96 | 99.53 | 0.47 | 0.47 | 0.00 | 0.00 |
| 2022 | 4793.10 | 8097 | 591 | 92.43 | 92.43 | 92.58 | 92.43 | 0.00 | 0.00 | 7.57 | 0.00 |
| 2023 | 4815.15 | 8147 | 591 | 93.18 | 93.18 | 93.01 | 93.00 | 0.00 | 0.00 | 6.82 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1970 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 116 | |
| B. Refuelling without maintenance | | | | 24 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1225 | | | 931 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 42 | | |
| E. Testing of plant systems or components | | | | 2 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 23 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 130 |
| Z. Other | | | | 1 | 3 | |
| Subtotal | 1225 | | | 1001 | 143 | 131 |
| Total | | 1225 | | | 1275 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1970 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 3 |
| 12. Reactor I&C Systems | | 1 |
| 15. Reactor Cooling Systems | | 7 |
| 16. Steam generation systems | | 69 |
| 31. Turbine and auxiliaries | | 14 |
| 32. Feedwater and Main Steam System | | 19 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 138 |
| 41. Main Generator Systems | | 8 |
| 42. Electrical Power Supply Systems | | 12 |
| Total | | 272 |

2023 Operating Experience

US-301 POINT BEACH-2 UNITED STATES OF AMERICA

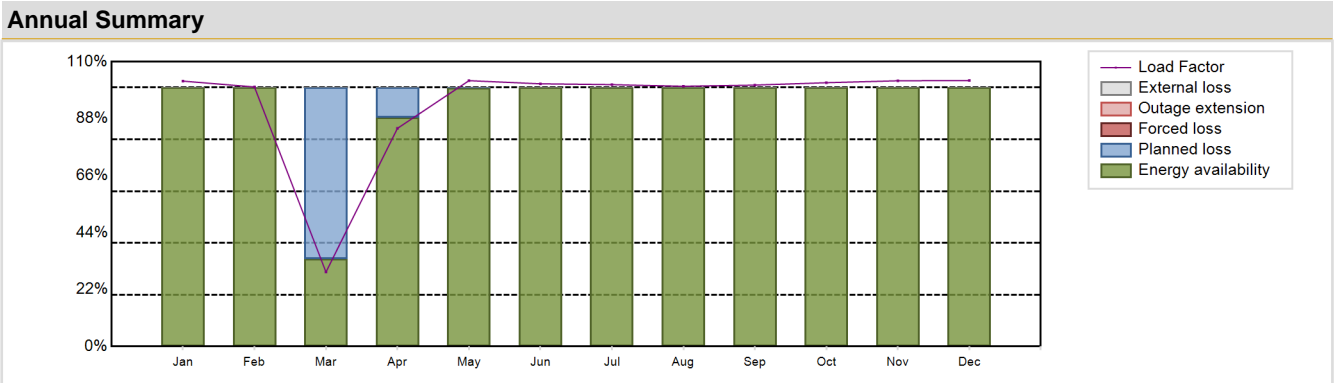
Status at end of year : **Operational**
 Operator : NEXTERA (NextEra Energy Resources, LLC)
 Owner : NEXTERA (NextEra Energy Resources, LLC)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 2LP (DRYAMB) | Construction Date | : 1968-07-25 |
| Thermal power | : 1800 MWth | Grid Date | : 1972-08-02 |
| Gross electrical power | : 640 MWe | Commercial Date | : 1972-10-01 |
| Reference unit power (net) | : 591 MWe | Age at end of year | : 51 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.7 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 316 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.422 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 74 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 45000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 2.44 | HP cylinder inlet steam pressure [MPa] | : 5.55 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 121 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18.7 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 21 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 4870.22 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 93.44 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 93.44 % | Planned Unavailability Factor (PUF) | : 6.56 % |
| Load Factor (LF) | : 94.07 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 93.29 % | Total off-line time | : 588 hours |

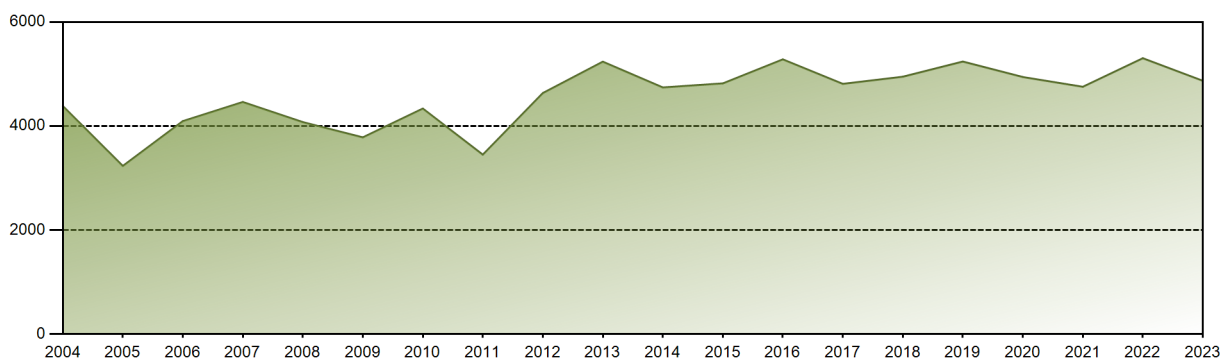


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 450.75 | 398.12 | 126.30 | 358.52 | 451.44 | 431.76 | 444.71 | 441.94 | 429.67 | 447.99 | 437.31 | 451.71 | 4870.22 |
| EAF [%] | 100.00 | 100.00 | 33.79 | 88.51 | 99.97 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.44 |
| UCF [%] | 100.00 | 100.00 | 33.79 | 88.51 | 99.97 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.44 |
| LF [%] | 102.51 | 100.24 | 28.76 | 84.25 | 102.67 | 101.47 | 101.14 | 100.51 | 100.98 | 101.88 | 102.63 | 102.73 | 94.07 |
| OF [%] | 100.00 | 100.00 | 32.30 | 88.19 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 93.29 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 66.21 | 11.49 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.56 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 200031.79 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.59 % |
| Cumulative Energy Availability Factor (EAF) | : 87.32 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.41 % |
| Cumulative Unit Capability Factor (UCF) | : 87.33 % | Cumulative Planned Unavailability Factor (PUF) | : 11.26 % |
| Cumulative Load Factor (LF) | : 85.9 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 86.95 % | | |

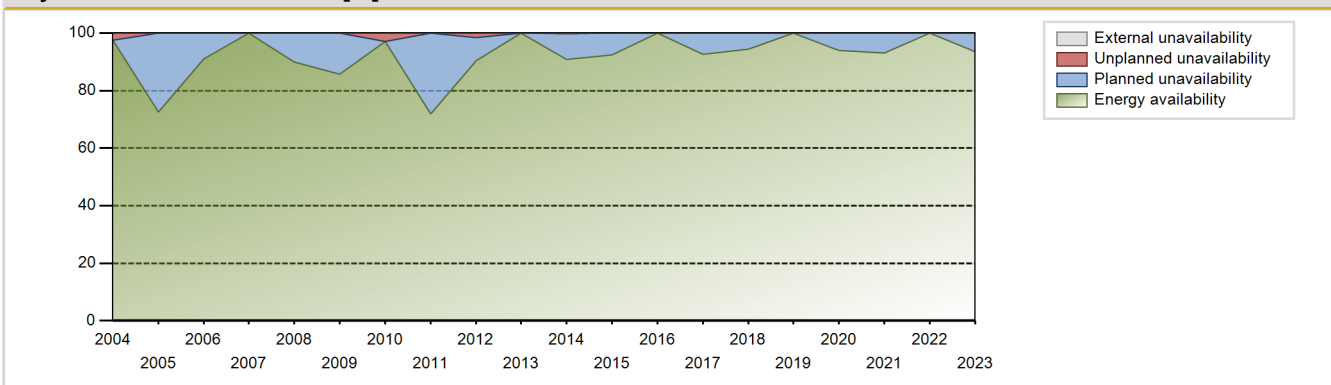
Electricity Production (net) [GWh]



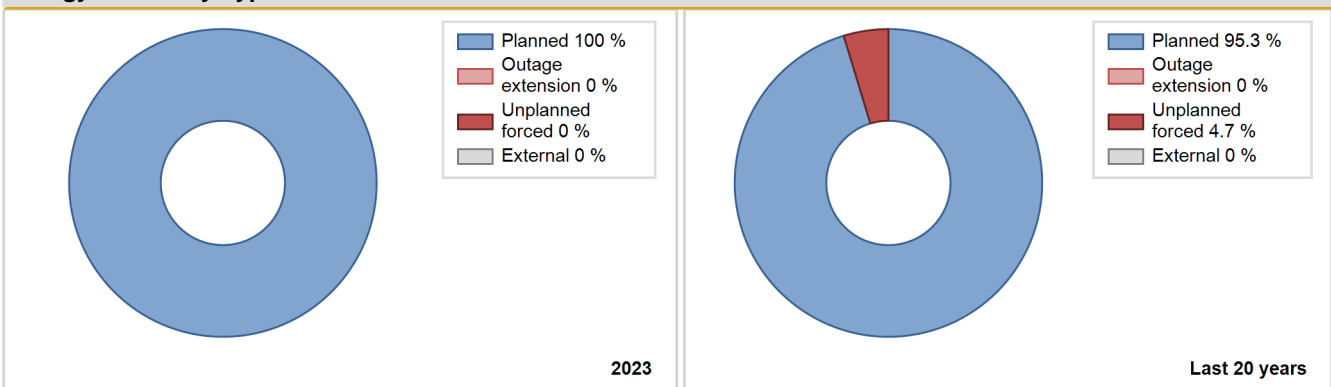
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1972 | 225.70 | 2987 | 288 | 100.00 | 100.00 | 84.78 | 81.48 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | 2991.00 | 8192 | 497 | 80.16 | 80.16 | 68.70 | 93.52 | 16.63 | 15.99 | 3.85 | 0.00 |
| 1974 | 3179.30 | 7100 | 497 | 81.05 | 81.05 | 73.02 | 81.05 | 1.22 | 1.00 | 17.95 | 0.00 |
| 1975 | 3741.40 | 8224 | 485 | 87.92 | 87.92 | 88.06 | 93.88 | 3.19 | 2.89 | 9.19 | 0.00 |
| 1976 | 3749.20 | 7959 | 491 | 86.80 | 86.80 | 86.93 | 90.61 | 0.78 | 0.68 | 12.52 | 0.00 |
| 1977 | 3622.30 | 7496 | 495 | 83.51 | 83.51 | 83.54 | 85.57 | 0.54 | 0.45 | 16.05 | 0.00 |
| 1978 | 3858.90 | 8039 | 495 | 88.99 | 88.99 | 88.99 | 91.77 | 0.64 | 0.58 | 10.43 | 0.00 |
| 1979 | 3707.50 | 7728 | 495 | 85.50 | 85.50 | 85.50 | 88.22 | 0.52 | 0.44 | 14.06 | 0.00 |
| 1980 | 3587.90 | 7569 | 495 | 88.03 | 88.03 | 82.52 | 86.17 | 3.86 | 3.54 | 8.44 | 0.00 |
| 1981 | 3720.30 | 7757 | 495 | 89.89 | 89.89 | 85.80 | 88.55 | 0.00 | 0.00 | 10.11 | 0.00 |
| 1982 | 3605.40 | 7595 | 495 | 88.22 | 88.22 | 83.15 | 86.70 | 0.00 | 0.00 | 11.78 | 0.00 |
| 1983 | 3016.30 | 6245 | 495 | 74.47 | 74.47 | 69.56 | 71.29 | 0.49 | 0.37 | 25.16 | 0.00 |
| 1984 | 3512.37 | 7405 | 495 | 86.04 | 86.04 | 80.78 | 84.30 | 0.06 | 0.05 | 13.91 | 0.00 |
| 1985 | 3603.08 | 7491 | 485 | 86.84 | 86.84 | 84.81 | 85.51 | 0.57 | 0.50 | 12.66 | 0.00 |
| 1986 | 3417.55 | 7186 | 485 | 82.12 | 82.12 | 80.44 | 82.03 | 0.30 | 0.25 | 17.64 | 0.00 |
| 1987 | 3606.15 | 7478 | 485 | 85.50 | 85.90 | 84.88 | 85.37 | 0.58 | 0.50 | 13.60 | 0.39 |
| 1988 | 3718.68 | 7626 | 485 | 88.02 | 88.02 | 87.29 | 86.82 | 0.28 | 0.24 | 11.74 | 0.00 |
| 1989 | 3485.10 | 7107 | 485 | 82.87 | 82.87 | 82.03 | 81.13 | 1.57 | 1.32 | 15.81 | 0.00 |
| 1990 | 3793.46 | 7713 | 485 | 89.14 | 89.14 | 89.29 | 88.05 | 0.00 | 0.00 | 10.86 | 0.00 |
| 1991 | 3689.18 | 7569 | 485 | 87.60 | 87.60 | 86.83 | 86.40 | 0.61 | 0.54 | 11.86 | 0.00 |
| 1992 | 3668.19 | 7492 | 485 | 86.63 | 86.63 | 86.10 | 85.29 | 0.00 | 0.00 | 13.37 | 0.00 |
| 1993 | 3844.50 | 7883 | 485 | 90.91 | 90.91 | 90.49 | 89.99 | 0.24 | 0.22 | 8.87 | 0.00 |
| 1994 | 3752.30 | 7827 | 485 | 90.34 | 90.34 | 88.32 | 89.35 | 0.00 | 0.00 | 9.66 | 0.00 |
| 1995 | 3385.96 | 7158 | 485 | 83.41 | 83.41 | 79.70 | 81.71 | 0.17 | 0.15 | 16.44 | 0.00 |
| 1996 | 2950.35 | 6653 | 485 | 77.95 | 77.95 | 69.25 | 75.74 | 0.25 | 0.20 | 21.85 | 0.00 |
| 1997 | 825.49 | 1788 | 485 | 21.45 | 21.45 | 19.43 | 20.41 | 43.40 | 16.44 | 62.11 | 0.00 |
| 1998 | 3123.75 | 6609 | 485 | 75.46 | 75.46 | 73.52 | 75.45 | 18.52 | 17.15 | 7.40 | 0.00 |
| 1999 | 3578.50 | 7195 | 498 | 82.57 | 82.57 | 81.93 | 82.13 | 0.00 | 0.00 | 17.43 | 0.00 |
| 2000 | 3527.45 | 7094 | 512 | 80.89 | 80.89 | 78.43 | 80.76 | 0.81 | 0.66 | 18.45 | 0.00 |
| 2001 | 4342.97 | 8631 | 512 | 98.55 | 98.55 | 96.83 | 98.53 | 1.45 | 1.45 | 0.00 | 0.00 |
| 2002 | 4004.30 | 7934 | 512 | 90.69 | 90.69 | 89.28 | 90.57 | 0.89 | 0.81 | 8.50 | 0.00 |
| 2003 | 3713.28 | 7469 | 518 | 85.59 | 85.59 | 81.91 | 85.26 | 2.00 | 1.75 | 12.66 | 0.00 |
| 2004 | 4384.88 | 8559 | 518 | 97.47 | 97.47 | 96.37 | 97.44 | 2.53 | 2.53 | 0.00 | 0.00 |
| 2005 | 3232.63 | 6355 | 514 | 72.57 | 72.57 | 71.79 | 72.54 | 0.00 | 0.00 | 27.43 | 0.00 |
| 2006 | 4094.78 | 7972 | 514 | 91.03 | 91.03 | 90.94 | 91.00 | 0.00 | 0.00 | 8.97 | 0.00 |
| 2007 | 4462.21 | 8760 | 514 | 100.00 | 100.00 | 99.10 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 4075.91 | 7904 | 514 | 89.99 | 89.99 | 90.28 | 89.98 | 0.00 | 0.00 | 10.01 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2009 | 3782.45 | 7501 | 516 | 85.69 | 85.69 | 83.68 | 85.63 | 0.00 | 0.00 | 14.31 | 0.00 |
| 2010 | 4336.29 | 8495 | 515 | 96.99 | 96.99 | 96.12 | 96.97 | 3.01 | 3.01 | 0.00 | 0.00 |
| 2011 | 3450.08 | 6098 | 586 | 71.91 | 71.91 | 70.75 | 69.61 | 0.00 | 0.00 | 28.09 | 0.00 |
| 2012 | 4633.79 | 7935 | 591 | 90.36 | 90.36 | 89.26 | 90.33 | 1.68 | 1.55 | 8.09 | 0.00 |
| 2013 | 5237.69 | 8760 | 591 | 100.00 | 100.00 | 101.16 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 4742.28 | 7962 | 591 | 90.89 | 90.89 | 91.60 | 90.89 | 0.36 | 0.33 | 8.78 | 0.00 |
| 2015 | 4819.90 | 8095 | 591 | 92.40 | 92.40 | 93.10 | 92.41 | 0.00 | 0.00 | 7.60 | 0.00 |
| 2016 | 5282.17 | 8784 | 591 | 100.00 | 100.00 | 101.75 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 4810.70 | 8113 | 591 | 92.61 | 92.61 | 92.92 | 92.61 | 0.00 | 0.00 | 7.39 | 0.00 |
| 2018 | 4948.38 | 8267 | 591 | 94.49 | 94.49 | 95.58 | 94.37 | 0.00 | 0.00 | 5.51 | 0.00 |
| 2019 | 5239.90 | 8760 | 591 | 100.00 | 100.00 | 101.21 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 4942.57 | 8244 | 591 | 93.87 | 93.87 | 95.21 | 93.85 | 0.00 | 0.00 | 6.13 | 0.00 |
| 2021 | 4754.72 | 8145 | 591 | 92.98 | 92.98 | 91.84 | 92.98 | 0.00 | 0.00 | 7.02 | 0.00 |
| 2022 | 5303.96 | 8760 | 591 | 100.00 | 100.00 | 102.45 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 4870.22 | 8172 | 591 | 93.44 | 93.44 | 94.07 | 93.29 | 0.00 | 0.00 | 6.56 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1972 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 84 | |
| B. Refuelling without maintenance | | | | 32 | | |
| C. Inspection, maintenance or repair combined with refuelling | 587 | | | 950 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 33 | | |
| E. Testing of plant systems or components | | | | 1 | 18 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 2 | | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| L. Human factor related | | | | | 5 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 13 | |
| Subtotal | 587 | | | 1018 | 123 | 1 |
| Total | | 587 | | | 1142 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1972 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 4 |
| 12. Reactor I&C Systems | | 40 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 0 |
| 15. Reactor Cooling Systems | | 26 |
| 16. Steam generation systems | | 13 |
| 31. Turbine and auxiliaries | | 8 |
| 32. Feedwater and Main Steam System | | 6 |
| 41. Main Generator Systems | | 1 |
| 42. Electrical Power Supply Systems | | 14 |
| Total | | 113 |

2023 Operating Experience

US-282 PRAIRIE ISLAND-1 UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : NSP (Northern States Power Co. (subsidiary of Xcel Energy))
 Owner : XCEL (Xcel Energy)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)

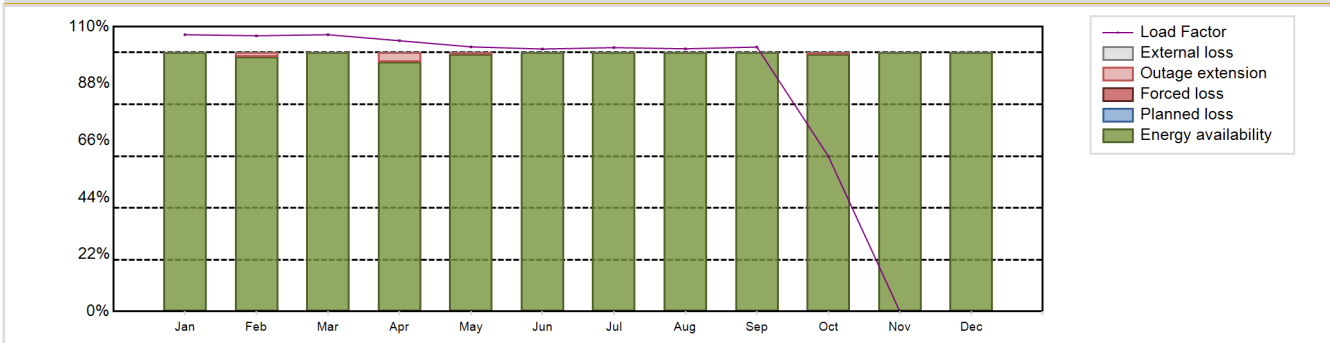


| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 2LP (DRYAMB) | Construction Date | : 1968-06-25 |
| Thermal power | : 1677 MWth | Grid Date | : 1973-12-04 |
| Gross electrical power | : 566 MWe | Commercial Date | : 1973-12-16 |
| Reference unit power (net) | : 522 MWe | Age at end of year | : 50 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 315 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.291 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 40 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 51000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 2.45 | HP cylinder inlet steam pressure [MPa] | : 5.06 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 121 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 20.3 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 21 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 3780.99 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 99.46 % | Unplanned Capability Loss Factor (UCL) | : 0.54 % |
| Unit Capability Factor (UCF) | : 99.46 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 82.69 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 79.84 % | Total off-line time | : 1766 hours |

Annual Summary

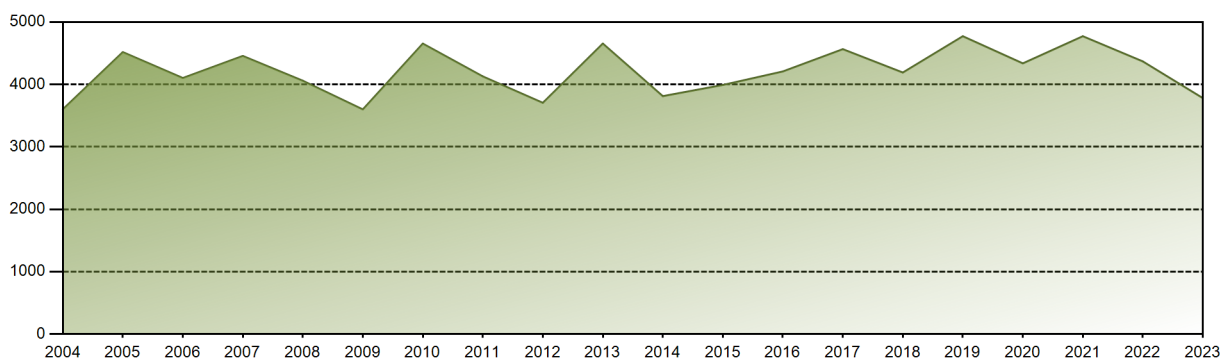


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 415.19 | 373.53 | 414.64 | 393.09 | 396.94 | 380.98 | 395.80 | 394.07 | 383.88 | 232.85 | 0.00 | 0.00 | 3780.99 |
| EAF [%] | 100.00 | 98.39 | 100.00 | 96.37 | 99.29 | 100.00 | 100.00 | 100.00 | 100.00 | 99.29 | 100.00 | 100.00 | 99.46 |
| UCF [%] | 100.00 | 98.39 | 100.00 | 96.37 | 99.29 | 100.00 | 100.00 | 100.00 | 100.00 | 99.29 | 100.00 | 100.00 | 99.46 |
| LF [%] | 106.91 | 106.48 | 106.91 | 104.59 | 102.21 | 101.37 | 101.91 | 101.47 | 102.14 | 59.96 | 0.00 | 0.00 | 82.69 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 59.54 | 0.00 | 0.00 | 79.84 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 1.61 | 0.00 | 3.63 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 0.54 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 197909.83 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.74 % |
| Cumulative Energy Availability Factor (EAF) | : 87.84 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.42 % |
| Cumulative Unit Capability Factor (UCF) | : 87.85 % | Cumulative Planned Unavailability Factor (PUF) | : 8.73 % |
| Cumulative Load Factor (LF) | : 87.27 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 87.94 % | | |

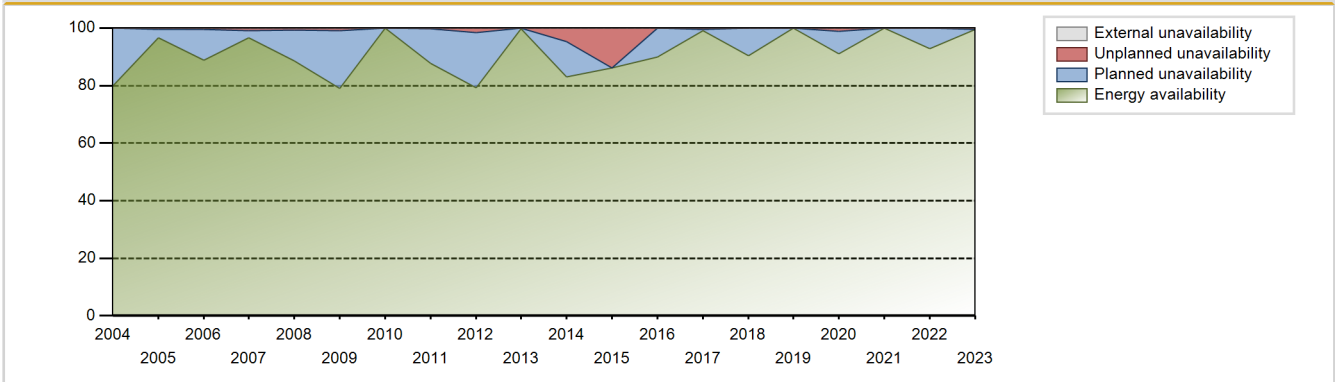
Electricity Production (net) [GWh]



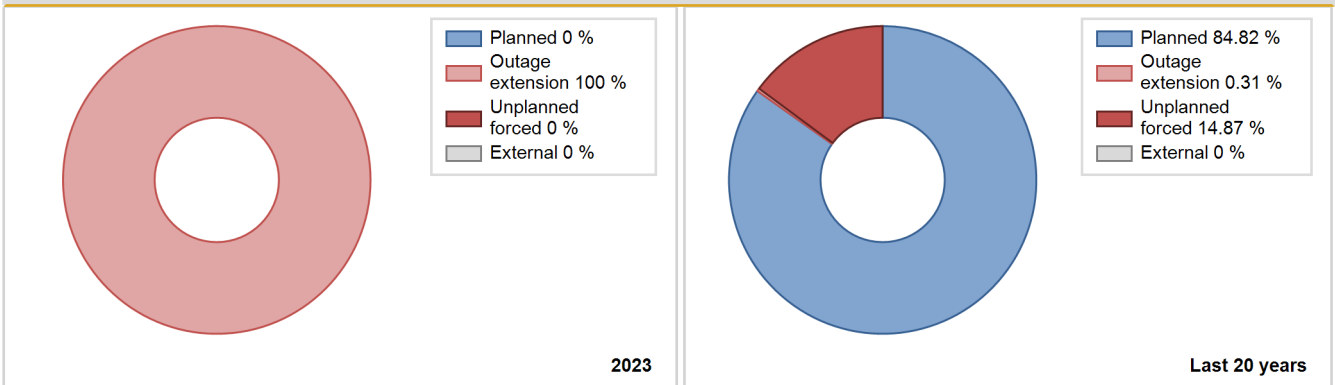
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|--------|-------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1973 | 7.20 | 312 | 514 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1974 | 1452.20 | 3848 | 520 | 43.95 | 43.95 | 31.88 | 43.93 | 51.66 | 46.97 | 9.08 | 0.00 |
| 1975 | 3694.20 | 7560 | 520 | 81.18 | 81.18 | 81.10 | 86.30 | 6.61 | 5.75 | 13.07 | 0.00 |
| 1976 | 3268.70 | 6801 | 520 | 71.55 | 71.55 | 71.56 | 77.42 | 11.20 | 9.03 | 19.43 | 0.00 |
| 1977 | 3714.50 | 7453 | 511 | 82.93 | 82.93 | 82.98 | 85.08 | 0.92 | 0.77 | 16.29 | 0.00 |
| 1978 | 3810.70 | 8012 | 507 | 85.86 | 85.86 | 85.80 | 91.46 | 4.44 | 3.99 | 10.14 | 0.00 |
| 1979 | 2910.90 | 6402 | 503 | 65.84 | 65.84 | 66.06 | 73.08 | 24.15 | 20.96 | 13.20 | 0.00 |
| 1980 | 3105.70 | 6863 | 503 | 77.80 | 77.80 | 70.29 | 78.13 | 2.56 | 2.05 | 20.15 | 0.00 |
| 1981 | 3838.60 | 7803 | 503 | 88.87 | 88.87 | 87.12 | 89.08 | 0.27 | 0.24 | 10.88 | 0.00 |
| 1982 | 3918.00 | 7960 | 503 | 90.90 | 90.90 | 88.92 | 90.87 | 0.20 | 0.18 | 8.92 | 0.00 |
| 1983 | 3888.90 | 7621 | 503 | 87.20 | 87.20 | 88.26 | 87.00 | 4.99 | 4.58 | 8.22 | 0.00 |
| 1984 | 4159.39 | 8285 | 503 | 94.34 | 94.34 | 94.14 | 94.32 | 4.95 | 4.91 | 0.75 | 0.00 |
| 1985 | 3678.45 | 7333 | 503 | 83.39 | 83.39 | 83.48 | 83.71 | 0.60 | 0.51 | 16.11 | 0.00 |
| 1986 | 3819.56 | 7870 | 503 | 89.64 | 89.64 | 86.68 | 89.84 | 0.31 | 0.28 | 10.08 | 0.00 |
| 1987 | 3590.27 | 7232 | 503 | 82.22 | 82.22 | 81.48 | 82.56 | 4.08 | 3.50 | 14.29 | 0.00 |
| 1988 | 3823.39 | 7800 | 503 | 89.26 | 89.26 | 86.53 | 88.80 | 0.11 | 0.10 | 10.65 | 0.00 |
| 1989 | 4392.28 | 8737 | 503 | 99.75 | 99.75 | 99.68 | 99.74 | 0.25 | 0.25 | 0.00 | 0.00 |
| 1990 | 3829.68 | 7764 | 503 | 81.66 | 81.66 | 86.91 | 88.63 | 8.30 | 7.39 | 10.94 | 0.00 |
| 1991 | 3987.08 | 7943 | 505 | 90.51 | 90.51 | 90.09 | 90.67 | 1.27 | 1.16 | 8.33 | 0.00 |
| 1992 | 3497.78 | 6844 | 503 | 77.44 | 77.44 | 79.16 | 77.91 | 4.38 | 3.55 | 19.01 | 0.00 |
| 1993 | 4377.99 | 8480 | 505 | 96.83 | 96.83 | 98.86 | 96.80 | 0.18 | 0.17 | 3.00 | 0.00 |
| 1994 | 3718.20 | 7258 | 513 | 82.84 | 82.84 | 82.74 | 82.85 | 2.23 | 1.89 | 15.27 | 0.00 |
| 1995 | 4519.04 | 8752 | 513 | 99.91 | 99.91 | 100.56 | 99.91 | 0.00 | 0.00 | 0.09 | 0.00 |
| 1996 | 3741.65 | 7327 | 513 | 92.18 | 92.86 | 83.03 | 83.41 | 0.00 | 0.00 | 7.14 | 0.68 |
| 1997 | 3522.80 | 6965 | 513 | 79.53 | 79.53 | 78.39 | 79.51 | 4.83 | 4.04 | 16.43 | 0.00 |
| 1998 | 4209.16 | 7948 | 514 | 90.78 | 90.78 | 93.46 | 90.73 | 8.98 | 8.96 | 0.27 | 0.00 |
| 1999 | 4068.78 | 7643 | 522 | 87.17 | 87.17 | 88.98 | 87.25 | 2.02 | 1.80 | 11.02 | 0.00 |
| 2000 | 4536.51 | 8499 | 522 | 96.74 | 96.74 | 98.94 | 96.76 | 0.00 | 0.00 | 3.26 | 0.00 |
| 2001 | 3641.74 | 6890 | 522 | 78.77 | 78.77 | 79.64 | 78.65 | 12.28 | 11.02 | 10.21 | 0.00 |
| 2002 | 4373.23 | 8268 | 522 | 94.36 | 94.36 | 95.64 | 94.38 | 0.00 | 0.00 | 5.64 | 0.00 |
| 2003 | 4596.35 | 8619 | 522 | 98.38 | 98.38 | 100.96 | 98.39 | 1.62 | 1.62 | 0.00 | 0.00 |
| 2004 | 3602.14 | 7017 | 522 | 79.89 | 79.89 | 78.56 | 79.88 | 0.00 | 0.00 | 20.11 | 0.00 |
| 2005 | 4518.40 | 8465 | 522 | 96.66 | 96.66 | 98.80 | 96.62 | 0.44 | 0.43 | 2.91 | 0.00 |
| 2006 | 4103.24 | 7785 | 523 | 88.88 | 88.88 | 89.56 | 88.87 | 0.57 | 0.51 | 10.62 | 0.00 |
| 2007 | 4457.09 | 8472 | 551 | 96.72 | 96.72 | 92.34 | 96.71 | 0.98 | 0.96 | 2.32 | 0.00 |
| 2008 | 4059.45 | 7780 | 551 | 88.58 | 88.58 | 83.87 | 88.57 | 0.83 | 0.74 | 10.67 | 0.00 |
| 2009 | 3600.15 | 6923 | 551 | 79.04 | 79.04 | 74.59 | 79.03 | 1.20 | 0.96 | 20.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|-------|-------|-------|------|
| 2010 | 4654.86 | 8760 | 560 | 100.00 | 100.00 | 96.04 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 4128.39 | 7717 | 521 | 87.69 | 87.69 | 87.22 | 88.09 | 0.39 | 0.34 | 11.96 | 0.00 |
| 2012 | 3705.98 | 6961 | 522 | 79.26 | 79.26 | 80.82 | 79.25 | 1.99 | 1.61 | 19.13 | 0.00 |
| 2013 | 4654.69 | 8732 | 522 | 99.68 | 99.68 | 101.78 | 99.67 | 0.00 | 0.00 | 0.32 | 0.00 |
| 2014 | 3812.46 | 7264 | 522 | 82.92 | 82.92 | 83.37 | 82.92 | 5.28 | 4.62 | 12.45 | 0.00 |
| 2015 | 3991.22 | 7539 | 522 | 86.06 | 86.06 | 87.28 | 86.06 | 13.94 | 13.94 | 0.00 | 0.00 |
| 2016 | 4207.70 | 7903 | 522 | 89.97 | 89.97 | 91.77 | 89.97 | 0.00 | 0.00 | 10.03 | 0.00 |
| 2017 | 4565.00 | 8689 | 522 | 99.18 | 99.18 | 99.83 | 99.19 | 0.54 | 0.54 | 0.28 | 0.00 |
| 2018 | 4190.47 | 7916 | 522 | 90.36 | 90.36 | 91.64 | 90.37 | 0.00 | 0.00 | 9.64 | 0.00 |
| 2019 | 4772.56 | 8760 | 522 | 100.00 | 100.00 | 104.37 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 4337.58 | 8092 | 522 | 91.02 | 91.02 | 94.60 | 92.12 | 1.21 | 1.12 | 7.86 | 0.00 |
| 2021 | 4772.37 | 8760 | 522 | 100.00 | 100.00 | 104.37 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 4368.70 | 8137 | 522 | 92.88 | 92.88 | 95.54 | 92.89 | 0.00 | 0.00 | 7.12 | 0.00 |
| 2023 | 3780.99 | 6994 | 522 | 99.46 | 99.46 | 82.69 | 79.84 | 0.00 | 0.54 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1973 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 251 | |
| B. Refuelling without maintenance | | | | 24 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 642 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 64 | | |
| E. Testing of plant systems or components | | | | 5 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 0 | | |
| H. Nuclear regulatory requirements | | | | | 3 | |
| L. Human factor related | | | | | 1 | |
| P. Fire | | | | | 18 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 0 | |
| Z. Other | | | | | 2 | 1 |
| Subtotal | | | | 735 | 276 | 1 |
| Total | | 0 | | | 1012 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1973 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 11 |
| 12. Reactor I&C Systems | | 40 |
| 14. Safety Systems | | 7 |
| 15. Reactor Cooling Systems | | 30 |
| 16. Steam generation systems | | 28 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 92 |
| 32. Feedwater and Main Steam System | | 28 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 3 |
| 35. All other I&C Systems | | 6 |
| 41. Main Generator Systems | | 15 |
| 42. Electrical Power Supply Systems | | 12 |
| Total | | 275 |

2023 Operating Experience

US-306 PRAIRIE ISLAND-2 UNITED STATES OF AMERICA

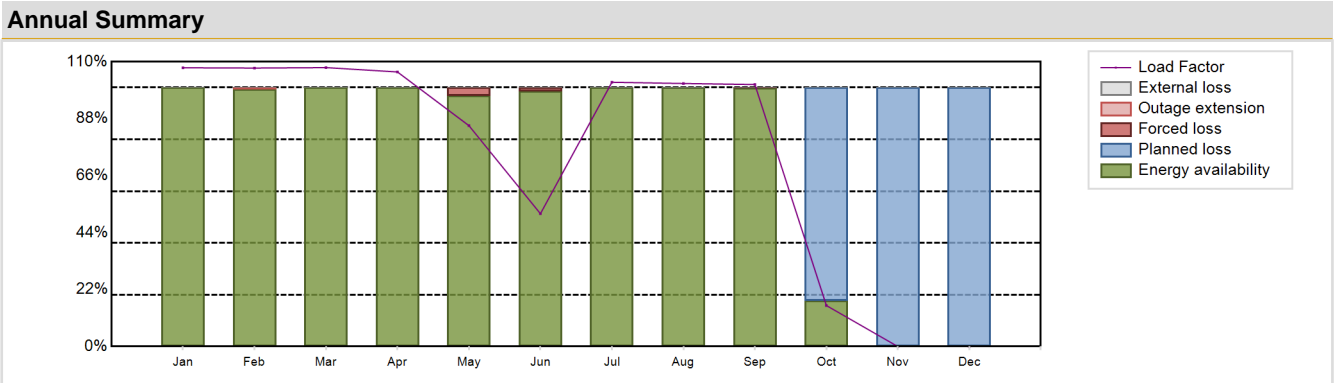
Status at end of year : **Operational**
 Operator : NSP (Northern States Power Co. (subsidiary of Xcel Energy))
 Owner : XCEL (Xcel Energy)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 2LP (DRYAMB) | Construction Date | : 1969-06-25 |
| Thermal power | : 1677 MWth | Grid Date | : 1974-12-21 |
| Gross electrical power | : 560 MWe | Commercial Date | : 1974-12-21 |
| Reference unit power (net) | : 519 MWe | Age at end of year | : 49 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 315 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.291 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 40 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 51000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 2.45 | HP cylinder inlet steam pressure [MPa] | : 5.06 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 121 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 20.3 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 21 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 3349.16 GW(e).h | Forced Loss Rate (FLR) | : 0.51 % |
| Energy Availability Factor (EAF) | : 75.85 % | Unplanned Capability Loss Factor (UCL) | : 0.45 % |
| Unit Capability Factor (UCF) | : 75.85 % | Planned Unavailability Factor (PUF) | : 23.7 % |
| Load Factor (LF) | : 73.67 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 72.21 % | Total off-line time | : 2434 hours |

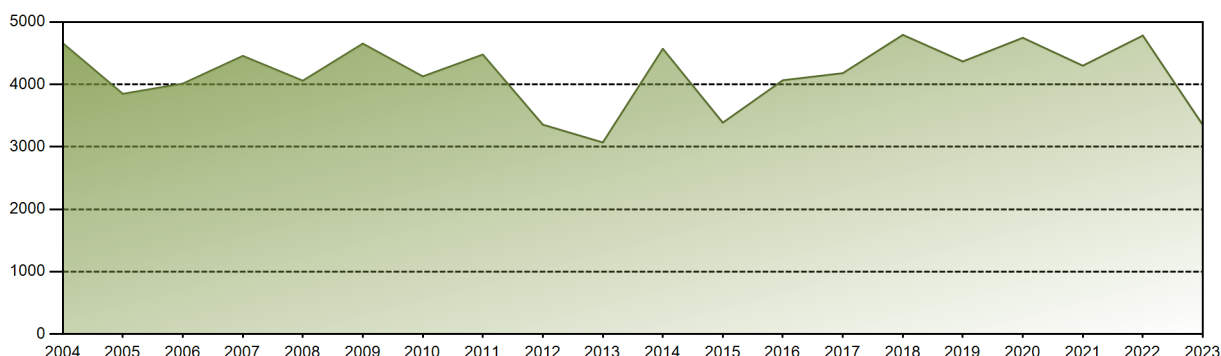


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|-------|---------|
| GW(e)-h | 415.72 | 375.12 | 415.41 | 396.26 | 329.41 | 191.64 | 394.07 | 392.30 | 378.06 | 61.17 | 0.00 | 0.00 | 3349.16 |
| EAF [%] | 100.00 | 99.25 | 100.00 | 100.00 | 96.78 | 98.60 | 100.00 | 100.00 | 99.97 | 17.77 | 0.04 | 0.04 | 75.85 |
| UCF [%] | 100.00 | 99.25 | 100.00 | 100.00 | 96.78 | 98.60 | 100.00 | 100.00 | 99.97 | 17.77 | 0.04 | 0.04 | 75.85 |
| LF [%] | 107.66 | 107.55 | 107.73 | 106.04 | 85.31 | 51.29 | 102.06 | 101.60 | 101.17 | 15.84 | 0.00 | 0.00 | 73.67 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 86.29 | 64.58 | 100.00 | 100.00 | 100.00 | 17.74 | 0.00 | 0.00 | 72.21 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 3.22 | 1.40 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.51 |
| UCL [%] | 0.00 | 0.75 | 0.00 | 0.00 | 3.22 | 1.40 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.45 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 82.23 | 99.96 | 99.96 | 23.70 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 195631.6 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.12 % |
| Cumulative Energy Availability Factor (EAF) | : 88.29 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.84 % |
| Cumulative Unit Capability Factor (UCF) | : 88.31 % | Cumulative Planned Unavailability Factor (PUF) | : 8.85 % |
| Cumulative Load Factor (LF) | : 88.49 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 88.75 % | | |

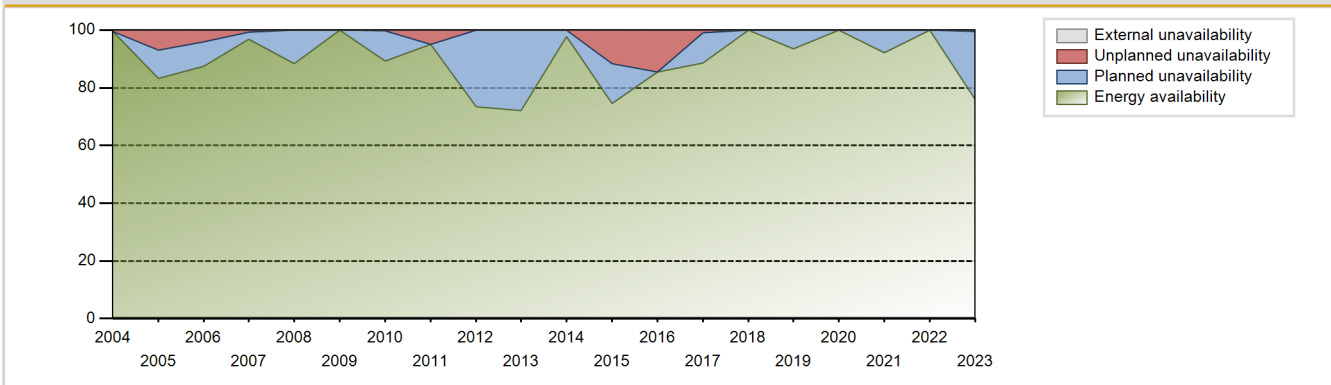
Electricity Production (net) [GWh]



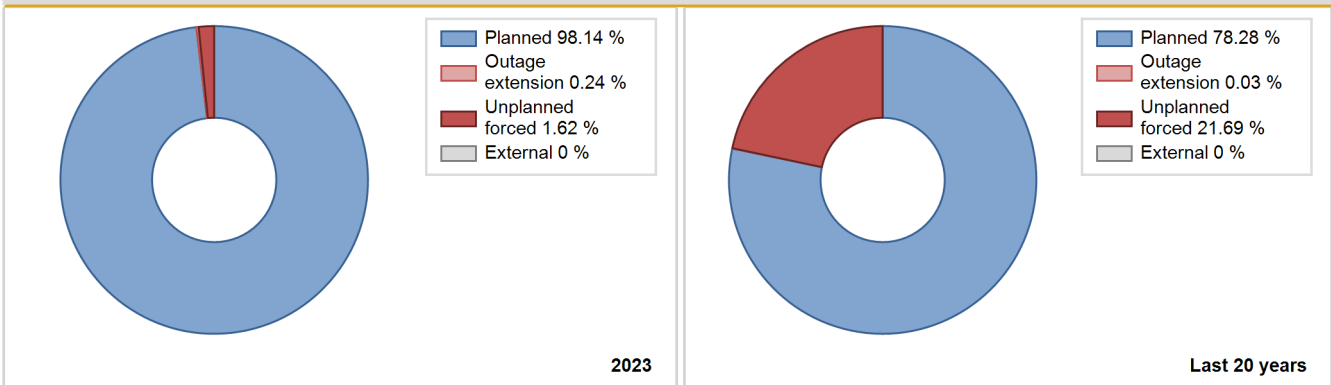
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1974 | 7.40 | 104 | 513 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1975 | 3176.20 | 7035 | 520 | 69.91 | 69.91 | 69.92 | 80.53 | 22.79 | 20.63 | 9.46 | 0.00 |
| 1976 | 2660.60 | 6657 | 520 | 58.24 | 58.24 | 58.25 | 75.79 | 16.48 | 11.50 | 30.27 | 0.00 |
| 1977 | 3882.30 | 7807 | 511 | 86.68 | 86.68 | 86.73 | 89.12 | 1.79 | 1.58 | 11.74 | 0.00 |
| 1978 | 3924.40 | 8126 | 507 | 88.16 | 88.16 | 88.36 | 92.76 | 2.09 | 1.88 | 9.96 | 0.00 |
| 1979 | 4193.00 | 8661 | 500 | 94.61 | 94.61 | 95.73 | 98.87 | 3.46 | 3.39 | 2.00 | 0.00 |
| 1980 | 3468.70 | 7167 | 500 | 81.41 | 81.54 | 78.98 | 81.59 | 0.24 | 0.20 | 18.26 | 0.13 |
| 1981 | 3092.90 | 6292 | 500 | 71.40 | 71.40 | 70.61 | 71.83 | 15.28 | 12.88 | 15.72 | 0.00 |
| 1982 | 3857.70 | 7844 | 500 | 89.85 | 89.99 | 88.08 | 89.54 | 0.26 | 0.24 | 9.77 | 0.15 |
| 1983 | 3716.30 | 7574 | 500 | 86.51 | 86.51 | 84.85 | 86.46 | 2.88 | 2.56 | 10.93 | 0.00 |
| 1984 | 3905.96 | 7830 | 500 | 89.16 | 89.16 | 88.93 | 89.14 | 0.00 | 0.00 | 10.84 | 0.00 |
| 1985 | 3612.47 | 7378 | 500 | 92.95 | 92.95 | 82.48 | 84.22 | 0.00 | 0.00 | 7.05 | 0.00 |
| 1986 | 3853.98 | 7930 | 500 | 90.55 | 90.55 | 87.99 | 90.53 | 0.55 | 0.50 | 8.95 | 0.00 |
| 1987 | 4462.19 | 8760 | 500 | 100.00 | 100.00 | 101.88 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1988 | 3886.16 | 7773 | 500 | 88.24 | 88.24 | 88.48 | 88.49 | 1.19 | 1.07 | 10.70 | 0.00 |
| 1989 | 3887.19 | 7798 | 500 | 96.86 | 96.86 | 88.75 | 89.02 | 2.30 | 2.28 | 0.86 | 0.00 |
| 1990 | 3803.70 | 7602 | 500 | 83.31 | 83.31 | 86.84 | 86.78 | 8.79 | 8.03 | 8.65 | 0.00 |
| 1991 | 4480.40 | 8760 | 502 | 100.00 | 100.00 | 101.82 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1992 | 3223.51 | 6516 | 500 | 73.51 | 73.51 | 73.40 | 74.18 | 0.00 | 0.00 | 26.49 | 0.00 |
| 1993 | 3746.24 | 7338 | 503 | 83.53 | 83.53 | 85.02 | 83.77 | 0.00 | 0.00 | 16.47 | 0.00 |
| 1994 | 4552.96 | 8734 | 512 | 99.71 | 99.71 | 101.51 | 99.70 | 0.23 | 0.23 | 0.06 | 0.00 |
| 1995 | 3968.17 | 7666 | 512 | 87.51 | 87.51 | 88.47 | 87.51 | 0.00 | 0.00 | 12.49 | 0.00 |
| 1996 | 4485.11 | 8653 | 512 | 98.55 | 99.20 | 99.73 | 98.51 | 0.80 | 0.80 | 0.00 | 0.65 |
| 1997 | 3642.86 | 7180 | 512 | 82.00 | 82.00 | 81.22 | 81.96 | 7.91 | 7.05 | 10.95 | 0.00 |
| 1998 | 3333.71 | 6555 | 512 | 74.84 | 74.84 | 74.33 | 74.83 | 12.44 | 10.64 | 14.52 | 0.00 |
| 1999 | 4597.44 | 8690 | 522 | 99.21 | 99.21 | 100.48 | 99.20 | 0.00 | 0.00 | 0.79 | 0.00 |
| 2000 | 4182.26 | 7820 | 522 | 89.03 | 89.03 | 91.21 | 89.03 | 0.00 | 0.00 | 10.97 | 0.00 |
| 2001 | 4270.96 | 8031 | 522 | 91.67 | 91.67 | 93.40 | 91.68 | 8.33 | 8.33 | 0.00 | 0.00 |
| 2002 | 4296.03 | 8082 | 522 | 92.43 | 92.43 | 93.95 | 92.26 | 0.00 | 0.00 | 7.57 | 0.00 |
| 2003 | 4240.97 | 8058 | 522 | 91.97 | 91.97 | 92.75 | 91.99 | 0.55 | 0.51 | 7.52 | 0.00 |
| 2004 | 4660.26 | 8737 | 522 | 99.47 | 99.47 | 101.64 | 99.46 | 0.53 | 0.53 | 0.00 | 0.00 |
| 2005 | 3848.63 | 7296 | 522 | 83.30 | 83.30 | 84.16 | 83.28 | 7.72 | 6.97 | 9.73 | 0.00 |
| 2006 | 4012.40 | 7665 | 522 | 87.52 | 87.52 | 87.75 | 87.50 | 4.53 | 4.15 | 8.33 | 0.00 |
| 2007 | 4456.64 | 8488 | 545 | 96.91 | 96.91 | 93.35 | 96.89 | 0.82 | 0.81 | 2.28 | 0.00 |
| 2008 | 4059.36 | 7768 | 545 | 88.45 | 88.45 | 84.79 | 88.43 | 0.00 | 0.00 | 11.55 | 0.00 |
| 2009 | 4653.35 | 8760 | 545 | 100.00 | 100.00 | 97.47 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 4128.07 | 7817 | 554 | 89.30 | 89.30 | 86.11 | 89.24 | 0.35 | 0.31 | 10.39 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|-------|-------|-------|------|
| 2011 | 4477.65 | 8354 | 519 | 95.07 | 95.07 | 98.49 | 95.37 | 4.93 | 4.93 | 0.00 | 0.00 |
| 2012 | 3354.75 | 6453 | 518 | 73.49 | 73.49 | 73.73 | 73.46 | 0.00 | 0.00 | 26.51 | 0.00 |
| 2013 | 3069.71 | 6311 | 519 | 72.11 | 72.11 | 67.51 | 72.04 | 0.00 | 0.00 | 27.89 | 0.00 |
| 2014 | 4570.74 | 8556 | 518 | 97.67 | 97.67 | 100.73 | 97.67 | 0.00 | 0.00 | 2.33 | 0.00 |
| 2015 | 3386.74 | 6531 | 518 | 74.56 | 74.56 | 74.64 | 74.55 | 13.40 | 11.54 | 13.91 | 0.00 |
| 2016 | 4066.08 | 7500 | 518 | 85.38 | 85.38 | 89.36 | 85.38 | 14.62 | 14.62 | 0.00 | 0.00 |
| 2017 | 4179.73 | 7767 | 519 | 88.68 | 88.68 | 91.93 | 88.66 | 0.91 | 0.82 | 10.50 | 0.00 |
| 2018 | 4792.83 | 8760 | 519 | 100.00 | 100.00 | 105.42 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 4367.41 | 8183 | 519 | 93.42 | 93.42 | 96.06 | 93.41 | 0.00 | 0.00 | 6.58 | 0.00 |
| 2020 | 4746.40 | 8783 | 519 | 100.00 | 100.00 | 104.11 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 4299.59 | 8066 | 519 | 92.08 | 92.08 | 94.57 | 92.08 | 0.00 | 0.00 | 7.92 | 0.00 |
| 2022 | 4782.23 | 8760 | 519 | 100.00 | 100.00 | 105.19 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 3349.16 | 6326 | 519 | 75.85 | 75.85 | 73.67 | 72.21 | 0.51 | 0.45 | 23.70 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1974 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 204 | |
| B. Refuelling without maintenance | | | | 14 | | |
| C. Inspection, maintenance or repair combined with refuelling | 2077 | | | 652 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 66 | | |
| E. Testing of plant systems or components | | | | 3 | | |
| H. Nuclear regulatory requirements | | | | | 10 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 1 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 11 |
| Z. Other | | | | | 2 | 1 |
| Subtotal | 2077 | 24 | | 735 | 217 | 12 |
| Total | | 2101 | | | 964 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1974 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 24 | 1 |
| 12. Reactor I&C Systems | | 31 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 34 |
| 16. Steam generation systems | | 5 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 10 |
| 31. Turbine and auxiliaries | | 60 |
| 32. Feedwater and Main Steam System | | 4 |
| 33. Circulating Water System | | 12 |
| 34. Miscellaneous Systems | | 4 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 38 |
| 42. Electrical Power Supply Systems | | 22 |
| Total | 24 | 226 |

2023 Operating Experience

US-254

QUAD CITIES-1

UNITED STATES OF AMERICA

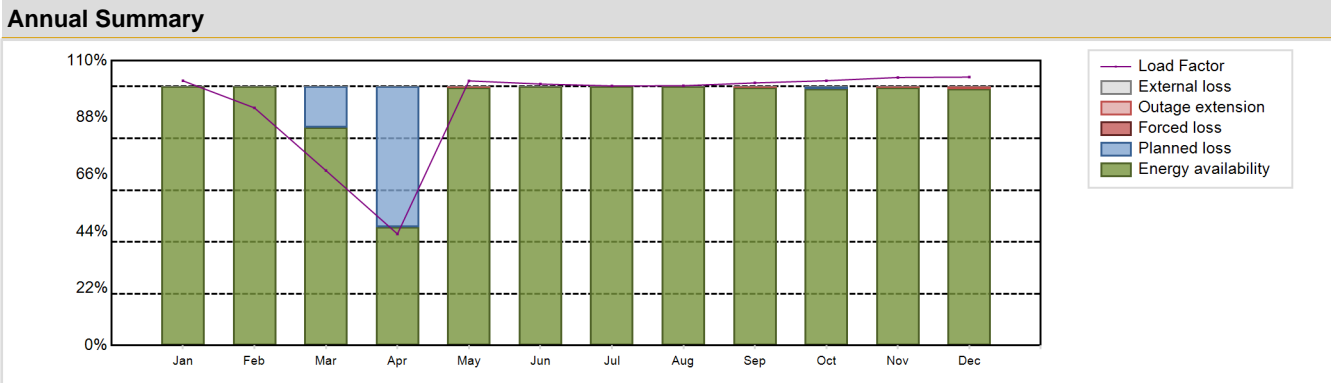
Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXE/MIDA (Exelon (75%), MidAmerican Energy (25%))
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-3 (Mark 1) | Construction Date | : 1967-02-15 |
| Thermal power | : 2957 MWth | Grid Date | : 1972-04-12 |
| Gross electrical power | : 940 MWe | Commercial Date | : 1973-02-18 |
| Reference unit power (net) | : 908 MWe | Age at end of year | : 51 years |

| Design Characteristics | | | |
|---|------------|--|------------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.1 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 286 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : Confinement |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.43 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 35 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 47000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.55 | HP cylinder inlet steam pressure [MPa] | : 6.57 |
| Active core height/length [m] | : 3.6 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 724 | Primary means of condenser cooling | : River (once-through) |
| Fuel linear heat generation rate [kW/m] | : 43.96 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 177 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 7425.73 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 93.95 % | Unplanned Capability Loss Factor (UCL) | : 0.18 % |
| Unit Capability Factor (UCF) | : 93.95 % | Planned Unavailability Factor (PUF) | : 5.87 % |
| Load Factor (LF) | : 93.36 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 94.08 % | Total off-line time | : 519 hours |

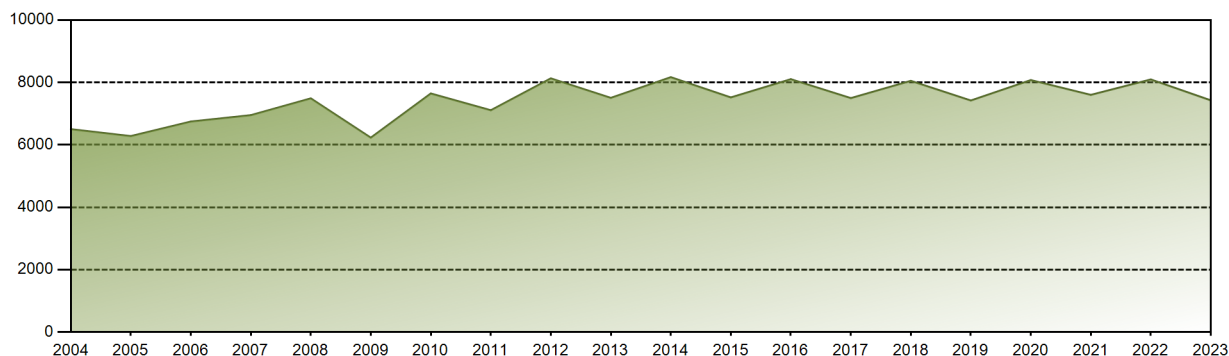


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 690.63 | 560.02 | 455.80 | 281.69 | 690.53 | 660.16 | 677.25 | 677.85 | 663.00 | 690.87 | 677.63 | 700.31 | 7425.73 |
| EAF [%] | 100.00 | 100.00 | 84.22 | 45.85 | 99.59 | 100.00 | 100.00 | 100.00 | 99.58 | 99.09 | 99.54 | 99.12 | 93.95 |
| UCF [%] | 100.00 | 100.00 | 84.22 | 45.85 | 99.59 | 100.00 | 100.00 | 100.00 | 99.58 | 99.09 | 99.54 | 99.12 | 93.95 |
| LF [%] | 102.23 | 91.78 | 67.56 | 43.09 | 102.22 | 100.98 | 100.25 | 100.34 | 101.41 | 102.27 | 103.51 | 103.66 | 93.36 |
| OF [%] | 100.00 | 100.00 | 83.85 | 44.58 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 94.08 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.41 | 0.00 | 0.00 | 0.00 | 0.42 | 0.00 | 0.46 | 0.88 | 0.18 |
| PUF [%] | 0.00 | 0.00 | 15.78 | 54.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.91 | 0.00 | 0.00 | 5.87 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 295775.98 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.36 % |
| Cumulative Energy Availability Factor (EAF) | : 83.21 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.75 % |
| Cumulative Unit Capability Factor (UCF) | : 83.24 % | Cumulative Planned Unavailability Factor (PUF) | : 12.01 % |
| Cumulative Load Factor (LF) | : 79.87 % | Cumulative Externally cause unavailability (XUF) | : 0.03 % |
| Cumulative Operating Factor (OF) | : 84.06 % | | |

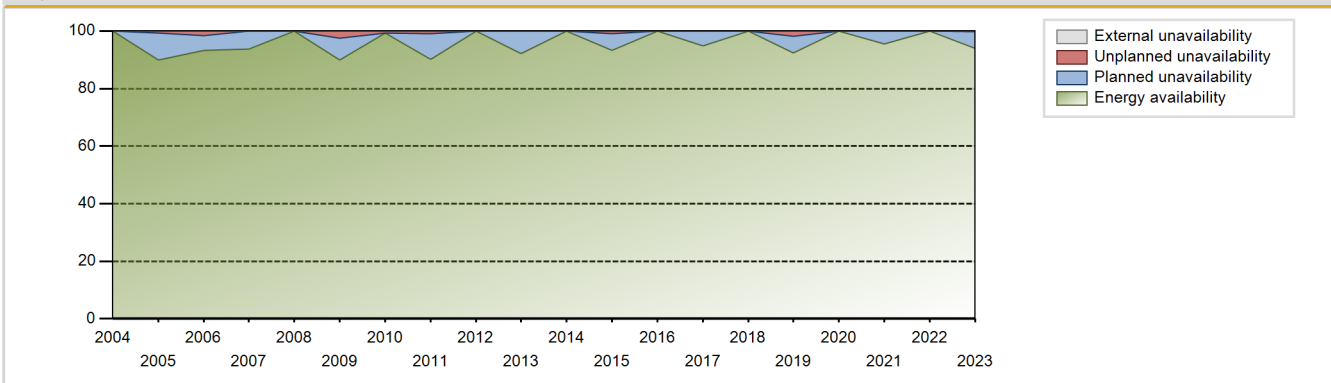
Electricity Production (net) [GWh]



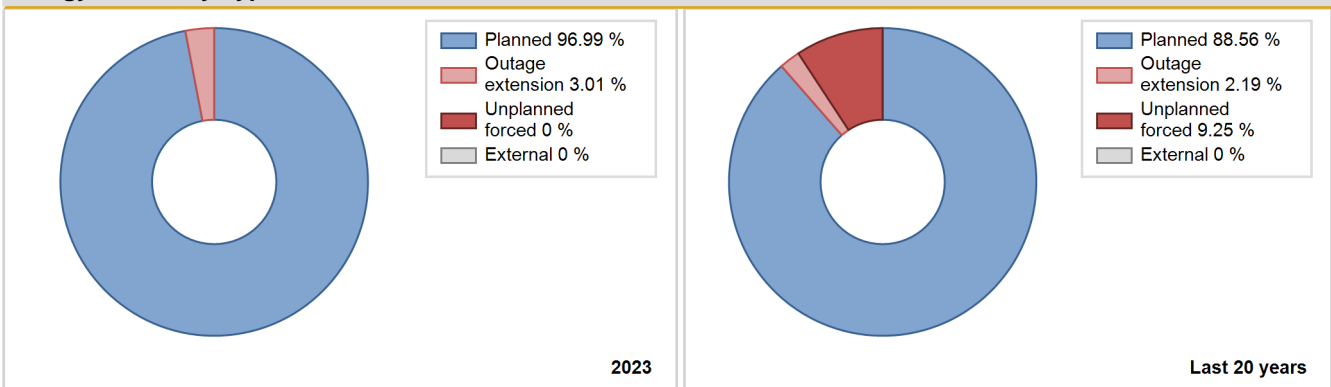
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1973 | 4908.50 | 7382 | 800 | 86.81 | 86.81 | 69.05 | 82.79 | 4.33 | 3.93 | 9.26 | 0.00 |
| 1974 | 3464.10 | 5365 | 800 | 61.37 | 61.37 | 49.43 | 61.24 | 17.84 | 13.33 | 25.31 | 0.00 |
| 1975 | 4413.40 | 7531 | 800 | 61.04 | 61.04 | 62.98 | 85.97 | 38.96 | 38.96 | 0.00 | 0.00 |
| 1976 | 3401.70 | 5699 | 769 | 50.44 | 50.44 | 50.36 | 64.88 | 14.61 | 8.63 | 40.92 | 0.00 |
| 1977 | 3527.40 | 6176 | 769 | 52.42 | 52.42 | 52.36 | 70.50 | 21.19 | 14.10 | 33.49 | 0.00 |
| 1978 | 4782.00 | 8315 | 769 | 71.04 | 71.04 | 70.99 | 94.92 | 11.08 | 8.85 | 20.11 | 0.00 |
| 1979 | 4786.50 | 7096 | 769 | 71.05 | 71.05 | 71.05 | 81.00 | 9.44 | 7.41 | 21.54 | 0.00 |
| 1980 | 3468.80 | 5840 | 769 | 66.68 | 67.43 | 51.35 | 66.48 | 2.92 | 2.03 | 30.54 | 0.75 |
| 1981 | 5726.80 | 8244 | 769 | 94.33 | 94.33 | 85.01 | 94.11 | 2.05 | 1.97 | 3.70 | 0.00 |
| 1982 | 3258.00 | 5951 | 769 | 68.48 | 68.48 | 48.36 | 67.93 | 1.18 | 0.82 | 30.70 | 0.00 |
| 1983 | 5776.40 | 8258 | 769 | 94.65 | 94.65 | 85.75 | 94.27 | 1.00 | 0.96 | 4.39 | 0.00 |
| 1984 | 3358.48 | 4687 | 769 | 53.37 | 53.37 | 49.72 | 53.36 | 2.65 | 1.45 | 45.17 | 0.00 |
| 1985 | 6072.32 | 8242 | 769 | 94.11 | 94.11 | 90.14 | 94.09 | 3.80 | 3.72 | 2.17 | 0.00 |
| 1986 | 4426.18 | 6035 | 769 | 68.92 | 68.92 | 65.71 | 68.89 | 3.37 | 2.40 | 28.67 | 0.00 |
| 1987 | 4456.09 | 6141 | 769 | 70.11 | 70.11 | 66.15 | 70.10 | 0.71 | 0.50 | 29.38 | 0.00 |
| 1988 | 5661.98 | 8199 | 769 | 93.36 | 93.36 | 83.82 | 93.34 | 4.22 | 4.11 | 2.53 | 0.00 |
| 1989 | 4280.44 | 6428 | 769 | 73.43 | 73.43 | 63.54 | 73.38 | 6.13 | 4.79 | 21.78 | 0.00 |
| 1990 | 5345.56 | 7276 | 769 | 83.08 | 83.08 | 79.35 | 83.06 | 1.48 | 1.24 | 15.67 | 0.00 |
| 1991 | 3549.53 | 4882 | 769 | 55.79 | 56.61 | 52.69 | 55.73 | 16.08 | 10.84 | 32.55 | 0.82 |
| 1992 | 4166.14 | 6158 | 769 | 70.12 | 70.12 | 61.68 | 70.10 | 7.88 | 6.00 | 23.88 | 0.00 |
| 1993 | 5042.49 | 6902 | 769 | 78.81 | 78.81 | 74.85 | 78.79 | 15.10 | 14.02 | 7.17 | 0.00 |
| 1994 | 1670.17 | 2526 | 769 | 28.87 | 28.87 | 24.79 | 28.84 | 46.41 | 25.00 | 46.13 | 0.00 |
| 1995 | 5886.21 | 7934 | 769 | 90.59 | 90.59 | 87.38 | 90.57 | 9.41 | 9.41 | 0.00 | 0.00 |
| 1996 | 2680.59 | 3769 | 769 | 42.94 | 42.94 | 39.68 | 42.91 | 2.98 | 1.32 | 55.74 | 0.00 |
| 1997 | 5565.46 | 7764 | 769 | 88.69 | 88.69 | 82.62 | 88.63 | 11.31 | 11.31 | 0.00 | 0.00 |
| 1998 | 3142.88 | 4299 | 769 | 49.12 | 49.12 | 46.65 | 49.08 | 41.59 | 34.98 | 15.90 | 0.00 |
| 1999 | 6337.59 | 8210 | 769 | 93.72 | 93.72 | 94.08 | 93.72 | 0.55 | 0.52 | 5.75 | 0.00 |
| 2000 | 6168.07 | 8242 | 769 | 93.83 | 93.83 | 91.31 | 93.83 | 0.56 | 0.52 | 5.65 | 0.00 |
| 2001 | 6710.87 | 8691 | 769 | 99.22 | 99.22 | 99.62 | 99.21 | 0.00 | 0.00 | 0.78 | 0.00 |
| 2002 | 5709.52 | 7564 | 855 | 86.60 | 86.60 | 83.96 | 86.35 | 7.61 | 7.14 | 6.26 | 0.00 |
| 2003 | 6810.25 | 8013 | 855 | 92.41 | 92.41 | 90.93 | 91.47 | 4.96 | 4.82 | 2.77 | 0.00 |
| 2004 | 6502.77 | 8784 | 855 | 100.00 | 100.00 | 86.58 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 6281.05 | 7875 | 864 | 89.92 | 89.92 | 82.98 | 89.89 | 0.69 | 0.62 | 9.46 | 0.00 |
| 2006 | 6747.25 | 8161 | 867 | 93.18 | 93.18 | 88.84 | 93.16 | 1.77 | 1.68 | 5.14 | 0.00 |
| 2007 | 6951.04 | 8212 | 867 | 93.75 | 93.75 | 91.52 | 93.74 | 0.00 | 0.00 | 6.25 | 0.00 |
| 2008 | 7490.09 | 8784 | 867 | 100.00 | 100.00 | 98.35 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 6230.78 | 7879 | 867 | 89.96 | 89.96 | 82.04 | 89.94 | 0.98 | 2.53 | 7.52 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|------|------|
| 2010 | 7646.11 | 8698 | 882 | 99.31 | 99.31 | 98.96 | 99.29 | 0.69 | 0.69 | 0.00 | 0.00 |
| 2011 | 7109.23 | 7898 | 882 | 90.18 | 90.18 | 92.01 | 90.16 | 1.13 | 1.03 | 8.79 | 0.00 |
| 2012 | 8130.41 | 8784 | 908 | 100.00 | 100.00 | 101.94 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 7505.99 | 8073 | 908 | 92.16 | 92.16 | 94.36 | 92.15 | 0.00 | 0.00 | 7.84 | 0.00 |
| 2014 | 8168.26 | 8760 | 908 | 100.00 | 100.00 | 102.69 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 7519.60 | 8170 | 908 | 93.26 | 93.26 | 94.54 | 93.26 | 0.87 | 0.82 | 5.91 | 0.00 |
| 2016 | 8104.18 | 8784 | 908 | 100.00 | 100.00 | 101.61 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 7498.16 | 8305 | 908 | 94.81 | 94.81 | 94.27 | 94.81 | 0.00 | 0.00 | 5.19 | 0.00 |
| 2018 | 8051.91 | 8668 | 908 | 100.00 | 100.00 | 101.23 | 98.95 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 7421.05 | 8101 | 908 | 92.49 | 92.49 | 93.30 | 92.48 | 1.95 | 1.84 | 5.67 | 0.00 |
| 2020 | 8075.97 | 8783 | 908 | 100.00 | 100.00 | 101.25 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 7601.76 | 8360 | 908 | 95.44 | 95.44 | 95.57 | 95.43 | 0.00 | 0.00 | 4.56 | 0.00 |
| 2022 | 8095.80 | 8760 | 908 | 100.00 | 100.00 | 101.78 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 7425.73 | 8241 | 908 | 93.95 | 93.95 | 93.36 | 94.08 | 0.00 | 0.18 | 5.87 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1973 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 248 | |
| B. Refuelling without maintenance | | | | 8 | | |
| C. Inspection, maintenance or repair combined with refuelling | 519 | | | 873 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 117 | 57 | |
| E. Testing of plant systems or components | | | | 7 | 6 | |
| H. Nuclear regulatory requirements | | | | | 6 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 10 |
| L. Human factor related | | | | | 51 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 2 |
| P. Fire | | | | | 6 | |
| Z. Other | | | | 2 | 6 | 1 |
| Subtotal | 519 | | | 1007 | 380 | 13 |
| Total | | 519 | | | 1400 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1973 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 6 |
| 12. Reactor I&C Systems | | 17 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 6 |
| 15. Reactor Cooling Systems | | 74 |
| 31. Turbine and auxiliaries | | 68 |
| 32. Feedwater and Main Steam System | | 18 |
| 34. Miscellaneous Systems | | 22 |
| 41. Main Generator Systems | | 15 |
| 42. Electrical Power Supply Systems | | 31 |
| Total | | 259 |

2023 Operating Experience

US-265

QUAD CITIES-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : EXELON (Exelon Generation Co., LLC)
 Owner : EXE/MIDA (Exelon (75%), MidAmerican Energy (25%))
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : BWR / BWR-3 (Mark 1)
 Thermal power : 2957 MWth
 Gross electrical power : 940 MWe
 Reference unit power (net) : 911 MWe

Key Dates

Construction Date : 1967-02-15
 Grid Date : 1972-05-23
 Commercial Date : 1973-03-10
 Age at end of year : 51 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 24
 Part of the core refuelled [%] : 35
 Average discharge burnup [MWd/t] : 47000
 Active core diameter [m] : 4.55
 Active core height/length [m] : 3.6
 Number of fissile fuel assemblies/bundles : 724
 Fuel linear heat generation rate [kW/m] : 43.96
 Number of control rod assemblies : 177
 Number of external reactor coolant loops : 2
 Coolant type : H2O

Operating coolant pressure [MPa] : 7.1
 Reactor outlet temperature [°C] : 286
 Number of SG : NA
 Containment type : Confinement
 Containment design pressure [MPa] : 0.43

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.57
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

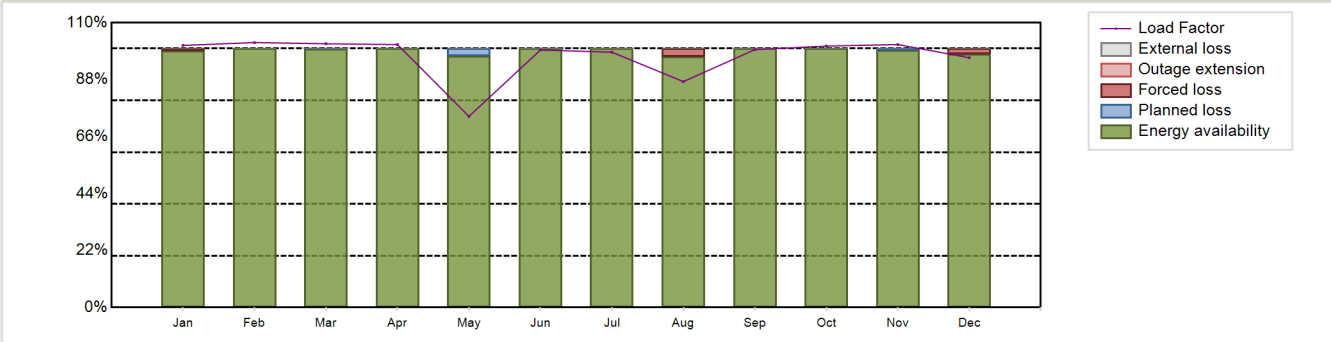
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7739.24 GW(e).h
 Energy Availability Factor (EAF) : 99.15 %
 Unit Capability Factor (UCF) : 99.15 %
 Load Factor (LF) : 96.98 %
 Operating Factor (OF) : 97.17 %

Forced Loss Rate (FLR) : 0.53 %
 Unplanned Capability Loss Factor (UCL) : 0.53 %
 Planned Unavailability Factor (PUF) : 0.32 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 248 hours

Annual Summary

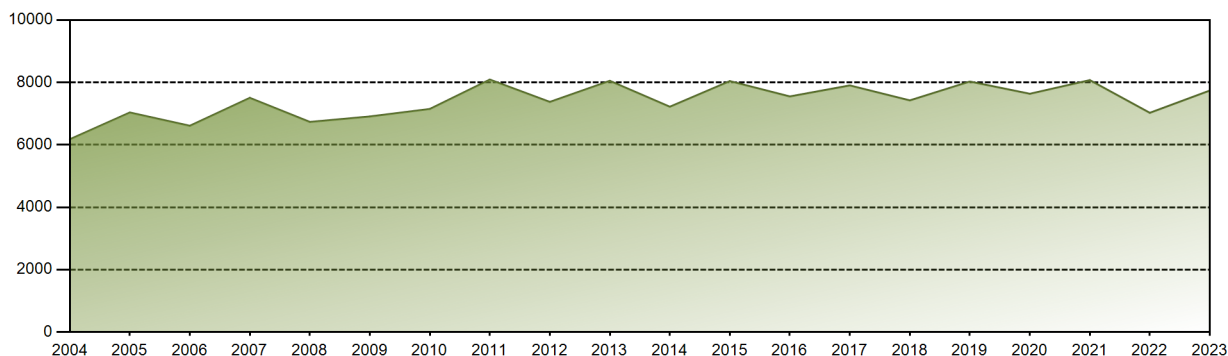


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 686.11 | 626.46 | 689.42 | 666.20 | 500.26 | 652.33 | 668.37 | 591.37 | 653.40 | 684.40 | 667.09 | 653.84 | 7739.24 |
| EAF [%] | 99.12 | 100.00 | 99.75 | 100.00 | 97.14 | 100.00 | 100.00 | 96.86 | 100.00 | 100.00 | 99.32 | 97.83 | 99.15 |
| UCF [%] | 99.12 | 100.00 | 99.75 | 100.00 | 97.14 | 100.00 | 100.00 | 96.86 | 100.00 | 100.00 | 99.32 | 97.83 | 99.15 |
| LF [%] | 101.23 | 102.33 | 101.85 | 101.57 | 73.81 | 99.45 | 98.61 | 87.25 | 99.62 | 100.98 | 101.56 | 96.47 | 96.98 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 76.21 | 100.00 | 100.00 | 90.46 | 100.00 | 100.00 | 100.00 | 100.00 | 97.17 |
| FLR [%] | 0.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.14 | 0.00 | 0.00 | 0.00 | 2.17 | 0.53 |
| UCL [%] | 0.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.14 | 0.00 | 0.00 | 0.00 | 2.17 | 0.53 |
| PUF [%] | 0.00 | 0.00 | 0.25 | 0.00 | 2.86 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.68 | 0.00 | 0.32 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 291487.9 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.99 % |
| Cumulative Energy Availability Factor (EAF) | : 82.04 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.28 % |
| Cumulative Unit Capability Factor (UCF) | : 82.55 % | Cumulative Planned Unavailability Factor (PUF) | : 12.18 % |
| Cumulative Load Factor (LF) | : 78.56 % | Cumulative Externally cause unavailability (XUF) | : 0.51 % |
| Cumulative Operating Factor (OF) | : 82.85 % | | |

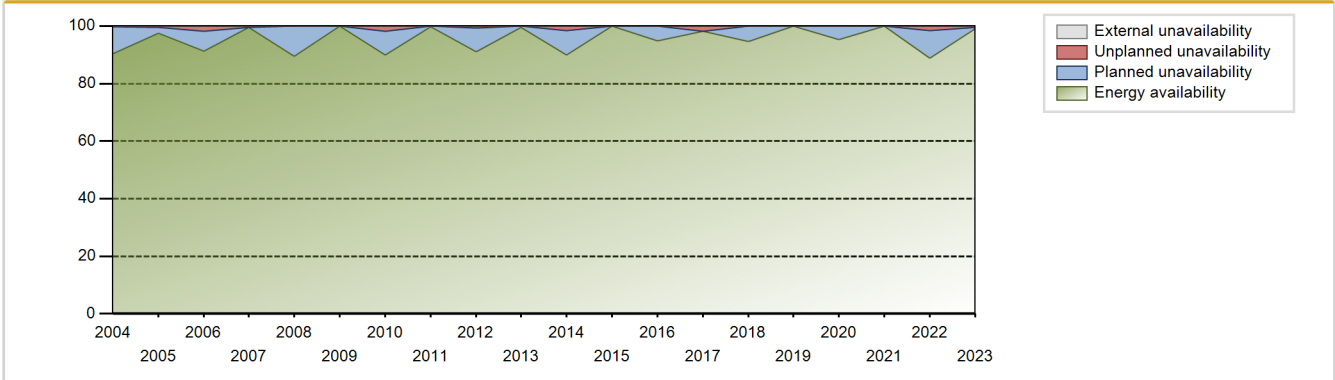
Electricity Production (net) [GWh]



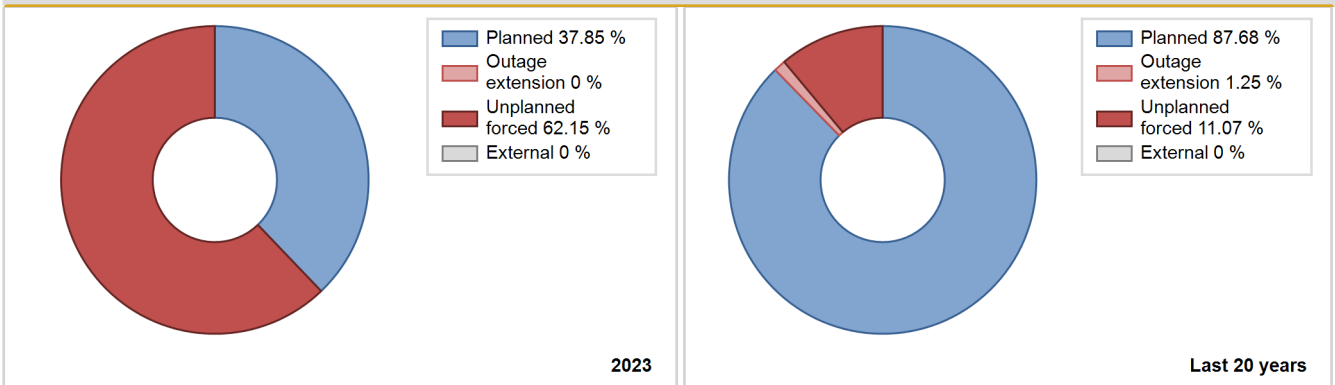
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|-------|--------|-------|-------|-------|-------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1973 | 5208.90 | 7405 | 800 | 86.42 | 86.42 | 74.76 | 84.94 | 4.05 | 3.64 | 9.94 | 0.00 |
| 1974 | 4643.80 | 7232 | 800 | 82.56 | 82.56 | 66.26 | 82.56 | 11.84 | 11.08 | 6.36 | 0.00 |
| 1975 | 2490.90 | 4555 | 798 | 35.73 | 35.73 | 35.63 | 52.00 | 31.66 | 16.55 | 47.72 | 0.00 |
| 1976 | 4320.00 | 7143 | 769 | 64.02 | 64.02 | 63.95 | 81.32 | 9.71 | 6.88 | 29.10 | 0.00 |
| 1977 | 4369.30 | 7118 | 769 | 64.92 | 64.92 | 64.86 | 81.26 | 12.32 | 9.12 | 25.96 | 0.00 |
| 1978 | 4429.10 | 7022 | 769 | 65.74 | 65.74 | 65.75 | 80.16 | 6.60 | 4.64 | 29.62 | 0.00 |
| 1979 | 3993.60 | 7686 | 769 | 59.28 | 59.28 | 59.28 | 87.74 | 13.92 | 9.59 | 31.13 | 0.00 |
| 1980 | 3651.60 | 5486 | 769 | 62.47 | 62.79 | 54.06 | 62.45 | 8.26 | 5.65 | 31.56 | 0.32 |
| 1981 | 3770.70 | 5957 | 769 | 68.07 | 68.07 | 55.97 | 68.00 | 1.08 | 0.74 | 31.19 | 0.00 |
| 1982 | 5062.30 | 7343 | 769 | 83.98 | 83.98 | 75.15 | 83.82 | 14.50 | 14.24 | 1.78 | 0.00 |
| 1983 | 3158.50 | 5620 | 769 | 64.18 | 64.18 | 46.89 | 64.16 | 0.50 | 0.32 | 35.50 | 0.00 |
| 1984 | 4984.45 | 6837 | 769 | 77.87 | 77.87 | 73.79 | 77.83 | 10.15 | 8.79 | 13.34 | 0.00 |
| 1985 | 4560.69 | 6247 | 769 | 71.33 | 71.33 | 67.70 | 71.31 | 2.97 | 2.19 | 26.49 | 0.00 |
| 1986 | 4727.96 | 6399 | 769 | 74.24 | 74.24 | 70.18 | 73.05 | 0.88 | 0.66 | 25.10 | 0.00 |
| 1987 | 4952.99 | 6832 | 769 | 78.06 | 78.06 | 73.53 | 77.99 | 17.05 | 16.05 | 5.90 | 0.00 |
| 1988 | 4178.87 | 6193 | 769 | 70.55 | 70.55 | 61.86 | 70.50 | 10.03 | 7.86 | 21.59 | 0.00 |
| 1989 | 5743.07 | 8363 | 769 | 95.51 | 95.51 | 85.25 | 95.47 | 3.85 | 3.82 | 0.67 | 0.00 |
| 1990 | 4373.60 | 6186 | 769 | 70.38 | 70.38 | 64.92 | 70.62 | 27.74 | 27.02 | 2.60 | 0.00 |
| 1991 | 5285.18 | 7731 | 769 | 88.26 | 88.26 | 78.46 | 88.25 | 11.74 | 11.74 | 0.00 | 0.00 |
| 1992 | 3464.19 | 5621 | 769 | 63.99 | 63.99 | 51.28 | 63.99 | 0.00 | 0.00 | 36.01 | 0.00 |
| 1993 | 3111.82 | 4538 | 769 | 51.84 | 51.84 | 46.19 | 51.80 | 26.46 | 18.65 | 29.51 | 0.00 |
| 1994 | 4013.35 | 5745 | 769 | 65.66 | 65.66 | 59.58 | 65.58 | 34.26 | 34.21 | 0.13 | 0.00 |
| 1995 | 2496.98 | 3966 | 769 | 45.33 | 45.33 | 37.07 | 45.27 | 22.14 | 12.89 | 41.78 | 0.00 |
| 1996 | 4666.84 | 6348 | 769 | 72.31 | 98.78 | 69.09 | 72.27 | 1.22 | 1.22 | 0.00 | 26.47 |
| 1997 | 2627.74 | 3718 | 769 | 42.34 | 42.34 | 39.01 | 42.44 | 38.44 | 26.44 | 31.22 | 0.00 |
| 1998 | 3819.59 | 5095 | 769 | 58.20 | 59.00 | 56.70 | 58.16 | 2.12 | 1.28 | 39.73 | 0.79 |
| 1999 | 6596.69 | 8537 | 769 | 97.47 | 97.47 | 97.93 | 97.45 | 0.00 | 0.00 | 2.53 | 0.00 |
| 2000 | 6220.62 | 8156 | 769 | 92.87 | 92.87 | 92.09 | 92.85 | 1.21 | 1.14 | 5.99 | 0.00 |
| 2001 | 6273.82 | 8058 | 769 | 91.92 | 91.92 | 93.13 | 91.99 | 7.30 | 7.24 | 0.84 | 0.00 |
| 2002 | 6556.83 | 7852 | 855 | 90.37 | 90.37 | 89.77 | 89.63 | 3.56 | 3.33 | 6.30 | 0.00 |
| 2003 | 6975.11 | 8181 | 855 | 94.01 | 94.01 | 93.13 | 93.39 | 5.99 | 5.99 | 0.00 | 0.00 |
| 2004 | 6179.39 | 7955 | 855 | 90.48 | 90.48 | 82.28 | 90.56 | 0.32 | 0.29 | 9.23 | 0.00 |
| 2005 | 7036.91 | 8533 | 864 | 97.42 | 97.42 | 92.96 | 97.40 | 0.44 | 0.43 | 2.15 | 0.00 |
| 2006 | 6611.02 | 8000 | 867 | 91.34 | 91.34 | 87.05 | 91.32 | 1.84 | 1.71 | 6.94 | 0.00 |
| 2007 | 7505.84 | 8720 | 867 | 99.55 | 99.55 | 98.83 | 99.54 | 0.45 | 0.45 | 0.00 | 0.00 |
| 2008 | 6734.60 | 7852 | 867 | 89.40 | 89.40 | 88.43 | 89.39 | 0.00 | 0.00 | 10.60 | 0.00 |
| 2009 | 6909.37 | 8760 | 867 | 100.00 | 100.00 | 90.97 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|------|------|
| 2010 | 7150.14 | 7849 | 892 | 89.90 | 89.90 | 91.51 | 89.60 | 0.88 | 1.93 | 8.17 | 0.00 |
| 2011 | 8092.34 | 8743 | 892 | 99.81 | 99.81 | 103.56 | 99.81 | 0.00 | 0.00 | 0.19 | 0.00 |
| 2012 | 7375.56 | 8004 | 911 | 91.14 | 91.14 | 92.17 | 91.12 | 0.67 | 0.61 | 8.25 | 0.00 |
| 2013 | 8051.85 | 8723 | 911 | 99.58 | 99.58 | 100.88 | 99.57 | 0.00 | 0.00 | 0.42 | 0.00 |
| 2014 | 7220.77 | 7886 | 911 | 90.03 | 90.03 | 90.48 | 90.02 | 1.84 | 1.69 | 8.28 | 0.00 |
| 2015 | 8042.55 | 8760 | 911 | 100.00 | 100.00 | 100.78 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 7550.87 | 8336 | 911 | 94.90 | 94.90 | 94.36 | 94.90 | 0.00 | 0.00 | 5.10 | 0.00 |
| 2017 | 7903.72 | 8604 | 911 | 98.22 | 98.22 | 99.04 | 98.22 | 1.78 | 1.78 | 0.00 | 0.00 |
| 2018 | 7424.55 | 8282 | 911 | 94.68 | 94.68 | 93.04 | 94.54 | 0.00 | 0.00 | 5.32 | 0.00 |
| 2019 | 8029.05 | 8760 | 911 | 100.00 | 100.00 | 100.61 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 7636.48 | 8376 | 911 | 95.37 | 95.37 | 95.43 | 95.36 | 0.00 | 0.00 | 4.63 | 0.00 |
| 2021 | 8073.93 | 8760 | 911 | 100.00 | 100.00 | 101.17 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 7026.45 | 7782 | 911 | 88.84 | 88.84 | 88.05 | 88.84 | 1.84 | 1.66 | 9.50 | 0.00 |
| 2023 | 7739.24 | 8512 | 911 | 99.15 | 99.15 | 96.98 | 97.17 | 0.53 | 0.53 | 0.32 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1973 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 379 | |
| B. Refuelling without maintenance | | | | 34 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 817 | | |
| D. Inspection, maintenance or repair without refuelling | 24 | | | 105 | | |
| E. Testing of plant systems or components | | | | 3 | 1 | |
| H. Nuclear regulatory requirements | | | | | 8 | |
| K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power) | | | | | | 11 |
| L. Human factor related | | | | | 11 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| P. Fire | | | | | 6 | |
| Z. Other | | | | 69 | 33 | 46 |
| Subtotal | 24 | 24 | | 1028 | 438 | 58 |
| Total | | 48 | | | 1524 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1973 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 24 | 20 |
| 12. Reactor I&C Systems | | 11 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 13 |
| 15. Reactor Cooling Systems | | 53 |
| 16. Steam generation systems | | 8 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 5 |
| 31. Turbine and auxiliaries | | 67 |
| 32. Feedwater and Main Steam System | | 37 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | | 68 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 28 |
| 42. Electrical Power Supply Systems | | 61 |
| Total | 24 | 381 |

2023 Operating Experience

US-458 **RIVER BEND-1** **UNITED STATES OF AMERICA**

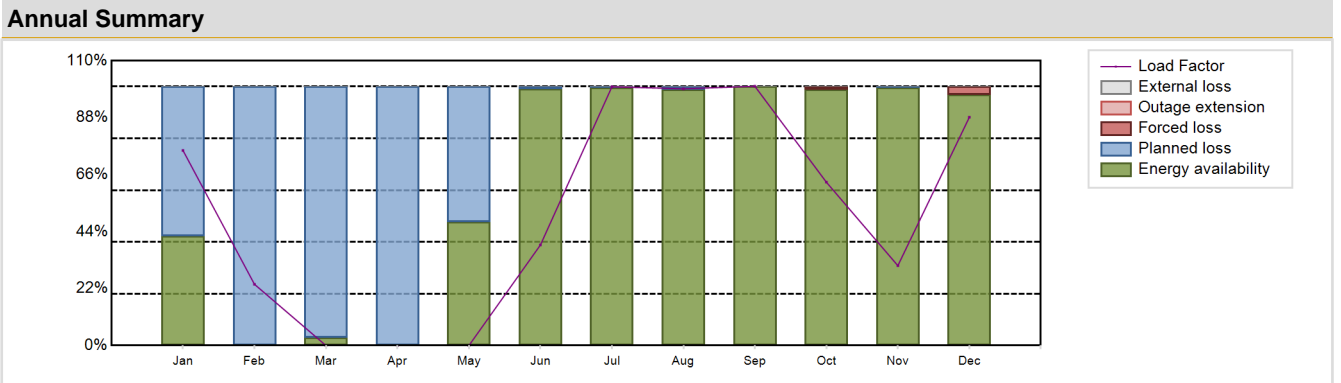
Status at end of year : **Operational**
 Operator : ENTERGY (Entergy Nuclear Operations, Inc.)
 Owner : ENTGS (ENTERGY GULF STATES, INC.)
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-6 (Mark 3) | Construction Date | : 1977-03-25 |
| Thermal power | : 3091 MWth | Grid Date | : 1985-12-03 |
| Gross electrical power | : 1016 MWe | Commercial Date | : 1986-06-16 |
| Reference unit power (net) | : 967 MWe | Age at end of year | : 38 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.56 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 288 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.105 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 25 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 29600 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.29 | HP cylinder inlet steam pressure [MPa] | : 6.78 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 624 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 18.86 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 145 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|--------------|
| Net Energy Production | : 4398.62 GW(e).h | Forced Loss Rate (FLR) | : 0.56 % |
| Energy Availability Factor (EAF) | : 65.92 % | Unplanned Capability Loss Factor (UCL) | : 0.37 % |
| Unit Capability Factor (UCF) | : 65.92 % | Planned Unavailability Factor (PUF) | : 33.71 % |
| Load Factor (LF) | : 51.93 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 59.32 % | Total off-line time | : 3564 hours |

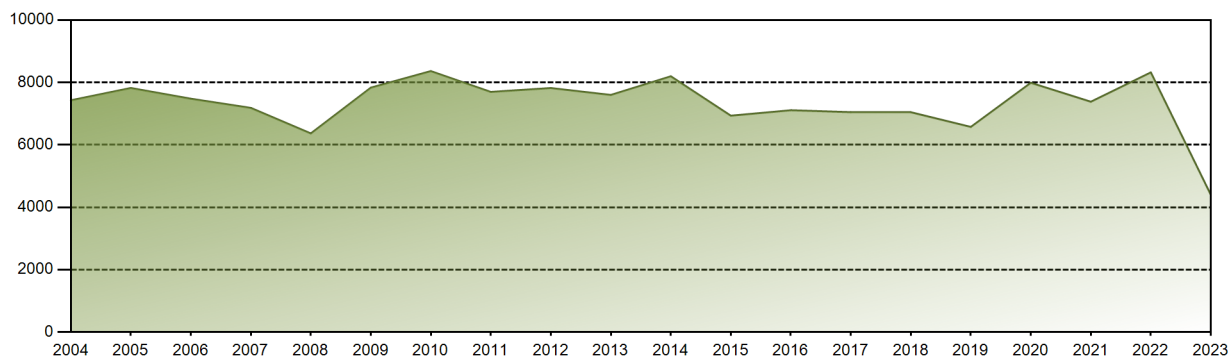


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|-------|--------|-------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 542.06 | 153.64 | 0.00 | 0.00 | 0.00 | 270.39 | 718.94 | 713.41 | 697.00 | 453.90 | 215.04 | 634.23 | 4398.62 |
| EAF [%] | 42.20 | 0.00 | 3.10 | 0.00 | 47.76 | 99.10 | 99.52 | 98.81 | 100.00 | 98.87 | 99.50 | 96.77 | 65.92 |
| UCF [%] | 42.20 | 0.00 | 3.10 | 0.00 | 47.76 | 99.10 | 99.52 | 98.81 | 100.00 | 98.87 | 99.50 | 96.77 | 65.92 |
| LF [%] | 75.34 | 23.64 | 0.00 | 0.00 | 0.00 | 38.84 | 99.93 | 99.16 | 100.11 | 63.09 | 30.84 | 88.15 | 51.93 |
| OF [%] | 100.00 | 36.01 | 0.00 | 0.00 | 0.00 | 45.97 | 100.00 | 100.00 | 100.00 | 90.73 | 46.32 | 88.98 | 59.32 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.13 | 0.00 | 3.23 | 0.56 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.13 | 0.00 | 3.23 | 0.37 |
| PUF [%] | 57.80 | 100.00 | 96.90 | 100.00 | 52.24 | 0.90 | 0.48 | 1.19 | 0.00 | 0.00 | 0.50 | 0.00 | 33.71 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 258350.8 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.39 % |
| Cumulative Energy Availability Factor (EAF) | : 84.82 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.84 % |
| Cumulative Unit Capability Factor (UCF) | : 84.98 % | Cumulative Planned Unavailability Factor (PUF) | : 10.18 % |
| Cumulative Load Factor (LF) | : 81.91 % | Cumulative Externally cause unavailability (XUF) | : 0.16 % |
| Cumulative Operating Factor (OF) | : 84.53 % | | |

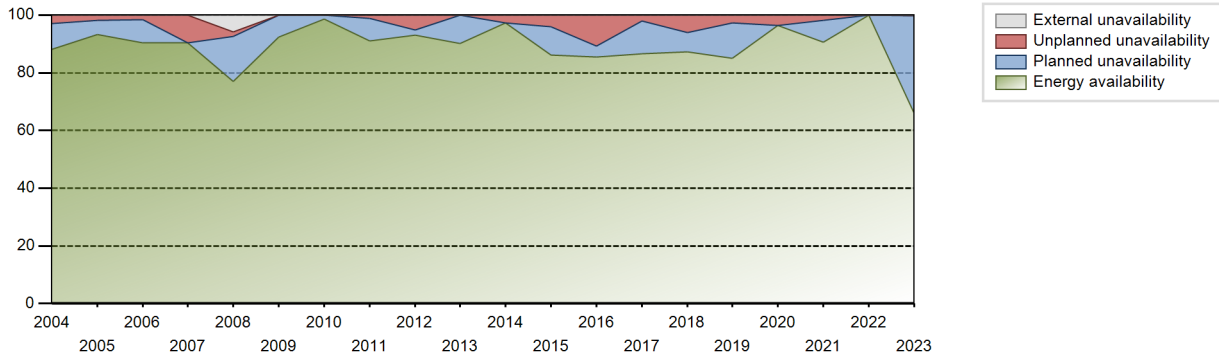
Electricity Production (net) [GWh]



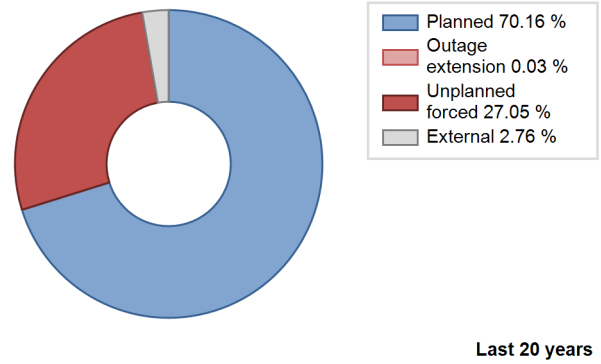
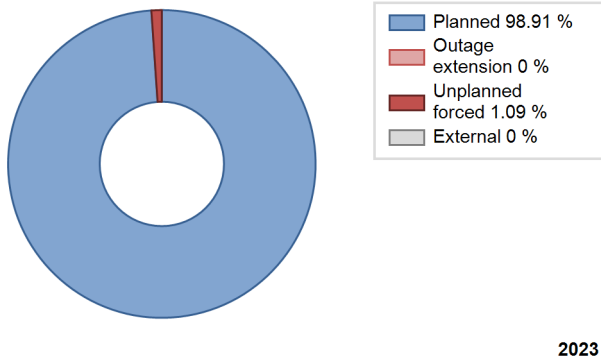
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1986 | 2995.44 | 4221 | 936 | 51.92 | 51.92 | 47.08 | 51.73 | 18.86 | 12.07 | 36.01 | 0.00 |
| 1987 | 4964.44 | 5836 | 936 | 66.65 | 66.65 | 60.55 | 66.62 | 5.69 | 4.02 | 29.33 | 0.00 |
| 1988 | 7248.98 | 8149 | 936 | 92.80 | 92.80 | 88.17 | 92.77 | 4.26 | 4.13 | 3.06 | 0.00 |
| 1989 | 4785.01 | 5853 | 936 | 66.88 | 66.88 | 58.36 | 66.82 | 11.31 | 8.53 | 24.60 | 0.00 |
| 1990 | 5592.55 | 6642 | 936 | 75.83 | 75.83 | 68.21 | 75.82 | 2.27 | 1.76 | 22.41 | 0.00 |
| 1991 | 6687.20 | 7507 | 936 | 85.72 | 85.72 | 81.56 | 85.70 | 11.54 | 11.19 | 3.09 | 0.00 |
| 1992 | 2762.68 | 3210 | 936 | 36.54 | 36.54 | 33.60 | 36.54 | 25.78 | 12.69 | 50.76 | 0.00 |
| 1993 | 5257.87 | 6076 | 936 | 69.37 | 69.37 | 64.13 | 69.36 | 28.70 | 27.92 | 2.71 | 0.00 |
| 1994 | 4886.23 | 5455 | 936 | 62.34 | 62.34 | 59.59 | 62.27 | 19.70 | 15.30 | 22.36 | 0.00 |
| 1995 | 7930.81 | 8704 | 936 | 99.37 | 99.37 | 96.72 | 99.36 | 0.63 | 0.63 | 0.00 | 0.00 |
| 1996 | 6860.33 | 7391 | 936 | 84.20 | 84.20 | 83.44 | 84.14 | 5.65 | 5.04 | 10.76 | 0.00 |
| 1997 | 6822.66 | 7427 | 936 | 84.82 | 84.82 | 83.21 | 84.78 | 5.08 | 4.54 | 10.64 | 0.00 |
| 1998 | 7833.50 | 8404 | 936 | 95.94 | 95.94 | 95.54 | 95.94 | 4.06 | 4.06 | 0.00 | 0.00 |
| 1999 | 5704.78 | 6476 | 936 | 74.01 | 74.01 | 69.58 | 73.93 | 16.83 | 14.98 | 11.02 | 0.00 |
| 2000 | 7352.74 | 7795 | 936 | 88.76 | 88.76 | 89.43 | 88.74 | 1.65 | 1.49 | 9.76 | 0.00 |
| 2001 | 7811.78 | 8120 | 936 | 92.36 | 92.36 | 95.27 | 92.69 | 0.77 | 0.72 | 6.92 | 0.00 |
| 2002 | 8472.43 | 8579 | 966 | 97.92 | 97.92 | 100.12 | 97.93 | 1.03 | 1.01 | 1.06 | 0.00 |
| 2003 | 7653.23 | 8050 | 966 | 91.81 | 91.81 | 90.44 | 91.89 | 1.24 | 1.16 | 7.03 | 0.00 |
| 2004 | 7427.37 | 7758 | 966 | 88.20 | 88.20 | 87.53 | 88.32 | 3.27 | 2.98 | 8.83 | 0.00 |
| 2005 | 7822.48 | 8162 | 978 | 93.21 | 93.21 | 91.30 | 93.16 | 2.03 | 1.93 | 4.86 | 0.00 |
| 2006 | 7478.26 | 7921 | 966 | 90.44 | 90.44 | 88.37 | 90.42 | 1.71 | 1.58 | 7.98 | 0.00 |
| 2007 | 7184.57 | 7916 | 970 | 90.46 | 90.46 | 84.55 | 90.37 | 9.54 | 9.54 | 0.00 | 0.00 |
| 2008 | 6366.63 | 6771 | 970 | 77.09 | 82.99 | 74.72 | 77.08 | 1.74 | 1.47 | 15.54 | 5.90 |
| 2009 | 7833.37 | 8085 | 978 | 92.39 | 92.39 | 91.43 | 92.29 | 0.00 | 0.00 | 7.61 | 0.00 |
| 2010 | 8363.16 | 8642 | 974 | 98.67 | 98.67 | 98.02 | 98.65 | 0.00 | 0.00 | 1.33 | 0.00 |
| 2011 | 7696.44 | 7988 | 967 | 91.15 | 91.15 | 90.86 | 91.19 | 1.21 | 1.12 | 7.73 | 0.00 |
| 2012 | 7819.86 | 8172 | 967 | 93.06 | 93.06 | 92.06 | 93.03 | 5.19 | 5.09 | 1.85 | 0.00 |
| 2013 | 7599.84 | 7898 | 967 | 90.16 | 90.16 | 89.71 | 90.15 | 0.09 | 0.08 | 9.76 | 0.00 |
| 2014 | 8197.47 | 8525 | 967 | 97.31 | 97.31 | 96.77 | 97.32 | 2.69 | 2.69 | 0.00 | 0.00 |
| 2015 | 6934.81 | 7556 | 967 | 86.24 | 86.24 | 81.87 | 86.26 | 4.42 | 3.99 | 9.77 | 0.00 |
| 2016 | 7108.86 | 7501 | 967 | 85.39 | 85.39 | 83.69 | 85.39 | 11.23 | 10.80 | 3.81 | 0.00 |
| 2017 | 7047.56 | 7586 | 967 | 86.61 | 86.61 | 83.20 | 86.60 | 2.39 | 2.12 | 11.27 | 0.00 |
| 2018 | 7045.93 | 7650 | 967 | 87.34 | 87.34 | 83.18 | 87.33 | 6.53 | 6.10 | 6.56 | 0.00 |
| 2019 | 6574.77 | 7448 | 967 | 85.04 | 85.04 | 77.62 | 85.02 | 3.17 | 2.78 | 12.17 | 0.00 |
| 2020 | 7988.37 | 8467 | 967 | 96.40 | 96.40 | 94.05 | 96.39 | 3.54 | 3.60 | 0.00 | 0.00 |
| 2021 | 7381.59 | 7933 | 967 | 90.56 | 90.56 | 87.14 | 90.56 | 1.96 | 1.81 | 7.63 | 0.00 |
| 2022 | 8321.81 | 8760 | 967 | 100.00 | 100.00 | 98.24 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

2023 4398.62 5196 967 65.92 65.92 51.93 59.32 0.56 0.37 33.71 0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1986 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 331 | |
| B. Refuelling without maintenance | | | | 18 | | |
| C. Inspection, maintenance or repair combined with refuelling | 3025 | | | 736 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 140 | | |
| E. Testing of plant systems or components | | | | 8 | 14 | |
| L. Human factor related | | | | | 15 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 14 |
| P. Fire | | | | | 0 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 9 | | |
| Z. Other | | | | 7 | 92 | 0 |
| Subtotal | 3025 | 24 | | 918 | 452 | 14 |
| Total | | 3049 | | | 1384 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1986 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 24 | 33 |
| 12. Reactor I&C Systems | | 54 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 7 |
| 15. Reactor Cooling Systems | | 66 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 13 |
| 31. Turbine and auxiliaries | | 62 |
| 32. Feedwater and Main Steam System | | 62 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 13 |
| 35. All other I&C Systems | | 7 |
| 41. Main Generator Systems | | 39 |
| 42. Electrical Power Supply Systems | | 31 |
| Total | 24 | 391 |

2023 Operating Experience

US-261 **ROBINSON-2** **UNITED STATES OF AMERICA**

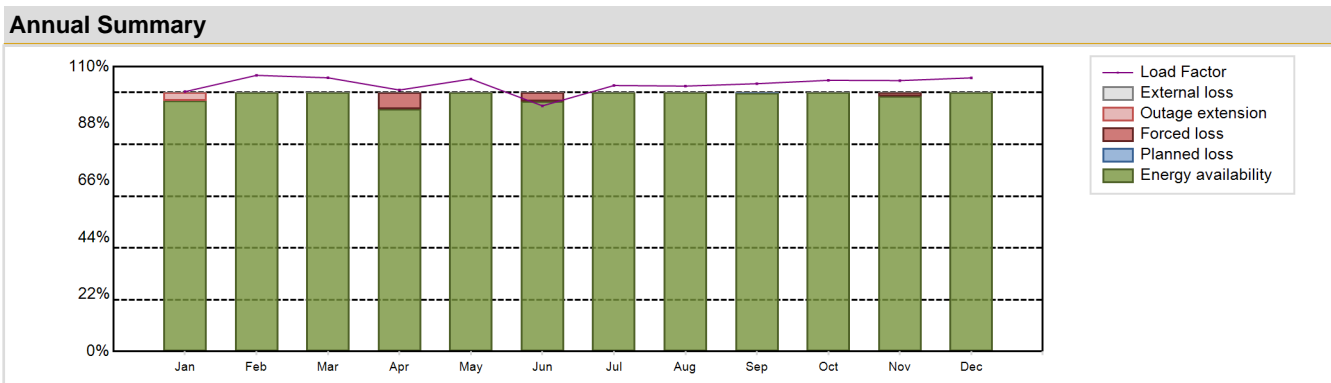
Status at end of year : **Operational**
 Operator : PROGRESS (Progress Energy)
 Owner : PROG_E_C (PROGRESS ENERGY Carolinas, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP (DRYAMB) | Construction Date | : 1967-04-13 |
| Thermal power | : 2339 MWth | Grid Date | : 1970-09-26 |
| Gross electrical power | : 780 MWe | Commercial Date | : 1971-03-07 |
| Reference unit power (net) | : 741 MWe | Age at end of year | : 53 years |

| Design Characteristics | | | |
|---|------------|--|-----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.71 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 318 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.295 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 30000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.4 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Lake (once-through) |
| Fuel linear heat generation rate [kW/m] | : 43.96 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 45 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|------------|
| Net Energy Production | : 6693.97 GW(e).h | Forced Loss Rate (FLR) | : 0.93 % |
| Energy Availability Factor (EAF) | : 98.81 % | Unplanned Capability Loss Factor (UCL) | : 1.19 % |
| Unit Capability Factor (UCF) | : 98.81 % | Planned Unavailability Factor (PUF) | : 0.01 % |
| Load Factor (LF) | : 103.12 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 99.19 % | Total off-line time | : 71 hours |

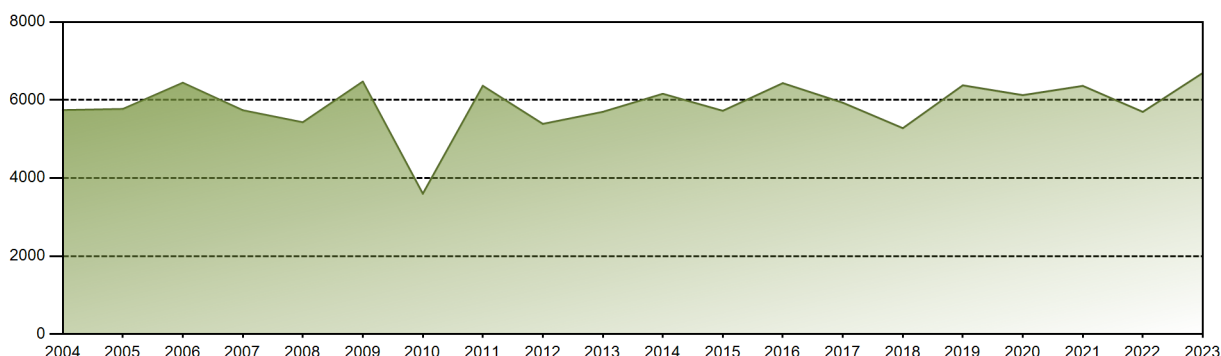


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 553.31 | 531.11 | 582.02 | 538.80 | 580.16 | 506.23 | 566.36 | 565.11 | 551.84 | 577.42 | 558.97 | 582.62 | 6693.97 |
| EAF [%] | 96.96 | 100.00 | 100.00 | 93.55 | 100.00 | 96.59 | 100.00 | 100.00 | 99.93 | 100.00 | 98.57 | 100.00 | 98.81 |
| UCF [%] | 96.96 | 100.00 | 100.00 | 93.55 | 100.00 | 96.59 | 100.00 | 100.00 | 99.93 | 100.00 | 98.57 | 100.00 | 98.81 |
| LF [%] | 100.36 | 106.66 | 105.71 | 100.99 | 105.23 | 94.89 | 102.73 | 102.50 | 103.43 | 104.74 | 104.62 | 105.68 | 103.12 |
| OF [%] | 97.98 | 100.00 | 100.00 | 100.00 | 100.00 | 92.22 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.19 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 6.45 | 0.00 | 3.41 | 0.00 | 0.00 | 0.00 | 0.00 | 1.43 | 0.00 | 0.93 |
| UCL [%] | 3.04 | 0.00 | 0.00 | 6.45 | 0.00 | 3.41 | 0.00 | 0.00 | 0.00 | 0.00 | 1.43 | 0.00 | 1.19 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 259795.8 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.43 % |
| Cumulative Energy Availability Factor (EAF) | : 81.66 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.63 % |
| Cumulative Unit Capability Factor (UCF) | : 81.81 % | Cumulative Planned Unavailability Factor (PUF) | : 12.56 % |
| Cumulative Load Factor (LF) | : 80.39 % | Cumulative Externally cause unavailability (XUF) | : 0.15 % |
| Cumulative Operating Factor (OF) | : 80.47 % | | |

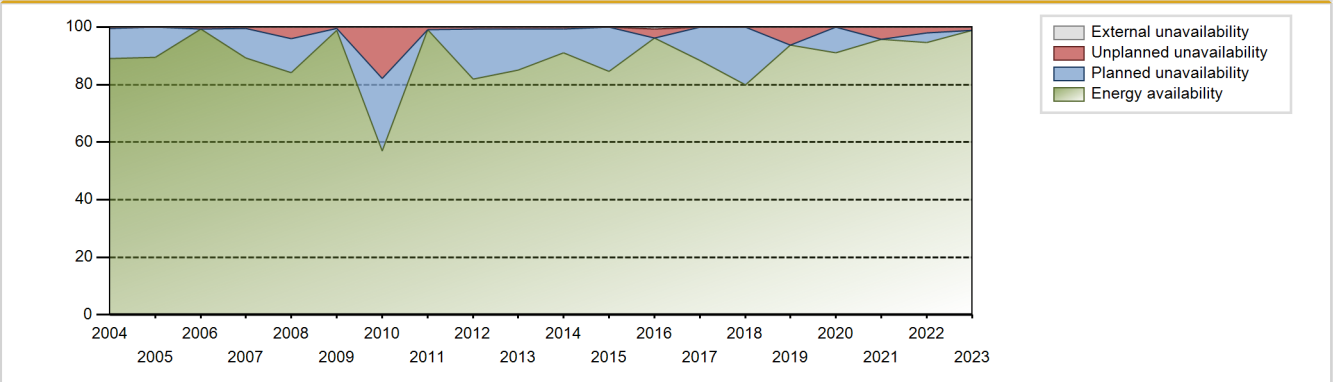
Electricity Production (net) [GWh]



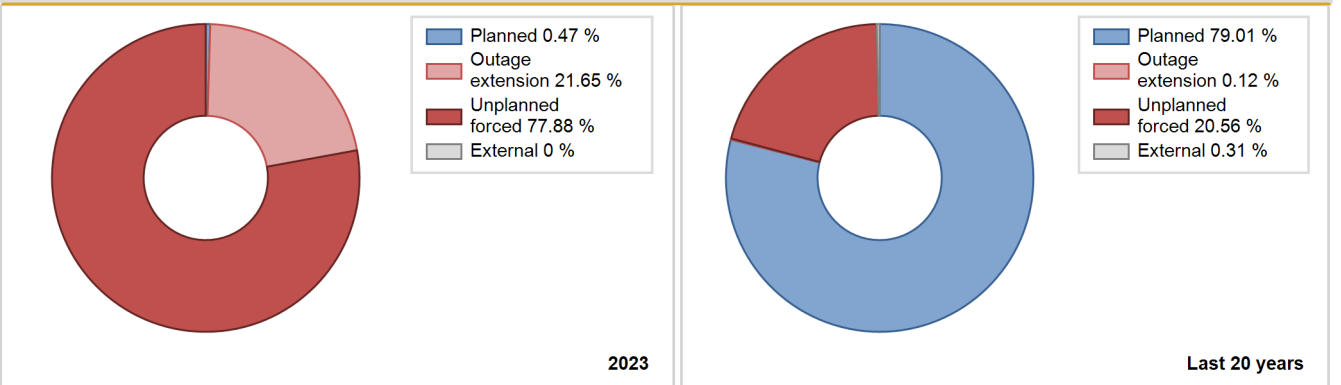
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1971 | 2538.60 | 4078 | 739 | 100.00 | 100.00 | 43.07 | 48.12 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1972 | 5082.40 | 7487 | 739 | 100.00 | 100.00 | 78.29 | 85.23 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | 3765.50 | 6591 | 715 | 75.70 | 75.70 | 60.12 | 75.24 | 9.44 | 7.89 | 16.41 | 0.00 |
| 1974 | 4813.10 | 7297 | 700 | 83.30 | 83.30 | 78.49 | 83.30 | 3.03 | 2.60 | 14.10 | 0.00 |
| 1975 | 4170.90 | 6316 | 665 | 71.05 | 71.05 | 71.60 | 72.10 | 13.68 | 11.26 | 17.69 | 0.00 |
| 1976 | 4874.20 | 7435 | 667 | 82.54 | 82.54 | 83.19 | 84.64 | 3.46 | 2.95 | 14.50 | 0.00 |
| 1977 | 4130.20 | 7462 | 665 | 70.81 | 70.81 | 70.90 | 85.18 | 23.86 | 22.18 | 7.01 | 0.00 |
| 1978 | 3980.00 | 6307 | 665 | 68.21 | 68.21 | 68.32 | 72.00 | 9.62 | 7.26 | 24.53 | 0.00 |
| 1979 | 4005.10 | 6172 | 665 | 68.72 | 68.72 | 68.75 | 70.46 | 5.18 | 3.75 | 27.53 | 0.00 |
| 1980 | 3210.90 | 5464 | 665 | 61.85 | 61.85 | 54.97 | 62.20 | 21.08 | 16.52 | 21.63 | 0.00 |
| 1981 | 3510.80 | 6391 | 665 | 73.41 | 81.06 | 60.27 | 72.96 | 18.94 | 18.94 | 0.00 | 7.65 |
| 1982 | 2268.40 | 4278 | 665 | 47.89 | 47.89 | 38.94 | 48.84 | 7.11 | 3.66 | 48.44 | 0.00 |
| 1983 | 3347.50 | 6609 | 665 | 75.54 | 75.54 | 57.46 | 75.45 | 17.74 | 16.30 | 8.16 | 0.00 |
| 1984 | 224.28 | 615 | 665 | 6.97 | 6.97 | 3.84 | 7.00 | 17.70 | 1.50 | 91.53 | 0.00 |
| 1985 | 5239.91 | 7697 | 665 | 87.64 | 87.64 | 89.95 | 87.87 | 9.76 | 9.48 | 2.89 | 0.00 |
| 1986 | 4799.60 | 7028 | 665 | 79.72 | 79.72 | 82.39 | 80.23 | 20.23 | 20.22 | 0.06 | 0.00 |
| 1987 | 4235.47 | 6224 | 665 | 70.31 | 70.31 | 72.71 | 71.05 | 9.25 | 7.17 | 22.52 | 0.00 |
| 1988 | 3182.43 | 5717 | 665 | 64.23 | 64.23 | 54.48 | 65.08 | 25.18 | 21.62 | 14.15 | 0.00 |
| 1989 | 2790.53 | 4107 | 665 | 45.49 | 45.49 | 47.90 | 46.88 | 46.11 | 38.93 | 15.58 | 0.00 |
| 1990 | 3319.19 | 5614 | 665 | 63.15 | 63.15 | 56.98 | 64.09 | 1.77 | 1.14 | 35.71 | 0.00 |
| 1991 | 4792.24 | 7048 | 672 | 80.15 | 80.15 | 81.34 | 80.46 | 1.30 | 1.05 | 18.79 | 0.00 |
| 1992 | 4062.91 | 5812 | 683 | 66.17 | 66.17 | 67.72 | 66.17 | 12.75 | 9.67 | 24.17 | 0.00 |
| 1993 | 4193.27 | 6137 | 683 | 70.07 | 70.07 | 70.09 | 70.06 | 14.94 | 12.31 | 17.63 | 0.00 |
| 1994 | 4655.06 | 6845 | 683 | 78.20 | 78.20 | 77.80 | 78.14 | 21.80 | 21.80 | 0.00 | 0.00 |
| 1995 | 5033.83 | 7356 | 683 | 84.01 | 84.01 | 84.13 | 83.97 | 1.64 | 1.40 | 14.59 | 0.00 |
| 1996 | 5460.10 | 7745 | 683 | 88.19 | 88.19 | 91.01 | 88.17 | 0.21 | 0.18 | 11.62 | 0.00 |
| 1997 | 6197.59 | 8662 | 683 | 98.89 | 98.89 | 103.59 | 98.88 | 1.11 | 1.11 | 0.00 | 0.00 |
| 1998 | 5505.56 | 7751 | 683 | 88.50 | 88.50 | 92.02 | 88.48 | 0.99 | 0.88 | 10.62 | 0.00 |
| 1999 | 5684.48 | 8009 | 683 | 91.45 | 91.45 | 95.01 | 91.43 | 0.00 | 0.00 | 8.55 | 0.00 |
| 2000 | 6237.08 | 8750 | 683 | 99.62 | 99.62 | 103.96 | 99.61 | 0.38 | 0.38 | 0.00 | 0.00 |
| 2001 | 5515.04 | 7919 | 683 | 90.41 | 90.41 | 92.18 | 90.40 | 0.00 | 0.00 | 9.59 | 0.00 |
| 2002 | 5606.11 | 7960 | 683 | 90.88 | 90.88 | 93.70 | 90.87 | 0.00 | 0.00 | 9.12 | 0.00 |
| 2003 | 6439.90 | 8760 | 710 | 100.00 | 100.00 | 103.54 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 5742.21 | 7811 | 710 | 88.94 | 88.94 | 92.07 | 88.92 | 0.60 | 0.54 | 10.52 | 0.00 |
| 2005 | 5770.14 | 7839 | 710 | 89.50 | 89.50 | 92.77 | 89.49 | 0.00 | 0.00 | 10.50 | 0.00 |
| 2006 | 6442.70 | 8705 | 710 | 99.38 | 99.38 | 103.59 | 99.37 | 0.62 | 0.62 | 0.00 | 0.00 |
| 2007 | 5737.92 | 7825 | 710 | 89.34 | 89.34 | 92.26 | 89.33 | 0.62 | 0.56 | 10.10 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|--------|-------|-------|-------|-------|------|
| 2008 | 5429.26 | 7380 | 710 | 84.03 | 84.03 | 87.05 | 84.02 | 4.50 | 3.96 | 12.01 | 0.00 |
| 2009 | 6473.19 | 8667 | 710 | 98.95 | 98.95 | 104.08 | 98.94 | 0.52 | 0.52 | 0.54 | 0.00 |
| 2010 | 3598.36 | 4902 | 724 | 56.85 | 56.85 | 56.74 | 55.96 | 23.96 | 17.91 | 25.24 | 0.00 |
| 2011 | 6363.80 | 8677 | 724 | 99.06 | 99.06 | 100.34 | 99.05 | 0.94 | 0.94 | 0.00 | 0.00 |
| 2012 | 5388.11 | 7165 | 741 | 81.90 | 81.90 | 83.25 | 81.57 | 0.93 | 0.77 | 17.33 | 0.00 |
| 2013 | 5696.46 | 7446 | 741 | 85.00 | 85.00 | 87.75 | 84.99 | 0.70 | 0.60 | 14.40 | 0.00 |
| 2014 | 6159.41 | 7975 | 741 | 91.03 | 91.03 | 94.89 | 91.04 | 0.66 | 0.60 | 8.37 | 0.00 |
| 2015 | 5723.72 | 7413 | 741 | 84.62 | 84.62 | 88.18 | 84.62 | 0.00 | 0.00 | 15.38 | 0.00 |
| 2016 | 6432.19 | 8441 | 741 | 96.09 | 96.73 | 98.82 | 96.10 | 3.27 | 3.27 | 0.00 | 0.64 |
| 2017 | 5930.08 | 7752 | 741 | 88.48 | 88.48 | 91.36 | 88.49 | 0.00 | 0.00 | 11.52 | 0.00 |
| 2018 | 5278.14 | 7009 | 741 | 80.01 | 80.01 | 81.31 | 80.01 | 0.00 | 0.00 | 19.99 | 0.00 |
| 2019 | 6376.32 | 8207 | 741 | 93.70 | 93.70 | 98.23 | 93.69 | 6.30 | 6.30 | 0.00 | 0.00 |
| 2020 | 6124.63 | 8001 | 741 | 91.08 | 91.08 | 94.10 | 91.09 | 0.00 | 0.00 | 8.92 | 0.00 |
| 2021 | 6361.89 | 8395 | 741 | 95.83 | 95.83 | 98.01 | 95.83 | 4.17 | 4.17 | 0.00 | 0.00 |
| 2022 | 5695.94 | 7339 | 741 | 94.64 | 94.64 | 87.75 | 83.78 | 2.17 | 2.10 | 3.26 | 0.00 |
| 2023 | 6693.97 | 8689 | 741 | 98.81 | 98.81 | 103.12 | 99.19 | 0.93 | 1.19 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1971 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 425 | |
| B. Refuelling without maintenance | | | | 34 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 1015 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 53 | | |
| E. Testing of plant systems or components | | | | 0 | 0 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 93 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 47 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 33 | |
| Subtotal | | 24 | | 1103 | 598 | 2 |
| Total | | 24 | | | 1703 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1971 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 24 | | 1 |
| 12. Reactor I&C Systems | | | | 47 |
| 13. Reactor Auxiliary Systems | | | | 2 |
| 14. Safety Systems | | | | 42 |
| 15. Reactor Cooling Systems | | | | 66 |
| 16. Steam generation systems | | | | 98 |
| 31. Turbine and auxiliaries | | | | 80 |
| 32. Feedwater and Main Steam System | | | | 32 |
| 34. Miscellaneous Systems | | | | 69 |
| 35. All other I&C Systems | | | | 0 |
| 41. Main Generator Systems | | | | 19 |
| 42. Electrical Power Supply Systems | | | | 83 |
| Total | | 24 | | 539 |

2023 Operating Experience

US-272

SALEM-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : PSEG (PSEG Nuclear, LLC)
 Owner : PSEGPOWER (PSEG Power, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 4LP (DRYAMB) | Construction Date | : 1968-09-25 |
| Thermal power | : 3459 MWth | Grid Date | : 1976-12-25 |
| Gross electrical power | : 1254 MWe | Commercial Date | : 1977-06-30 |
| Reference unit power (net) | : 1169 MWe | Age at end of year | : 47 years |

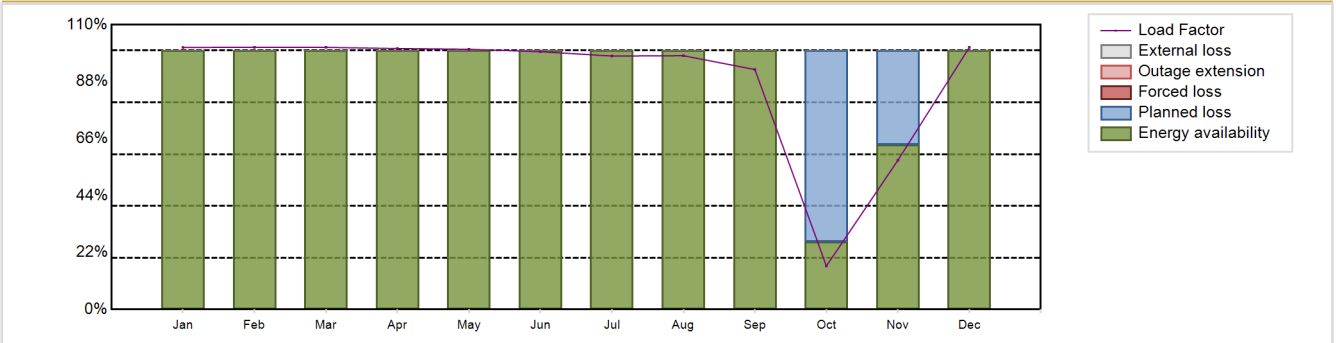
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|------------|--|------------------------|
| Reactor vessel centreline orientation | : Vertical | Operating coolant pressure [MPa] | : 15.8 |
| Fuel material | : UO2 | Reactor outlet temperature [°C] | : 322 |
| Refuelling type | : OFF-line | Number of SG | : 4 |
| Moderator material | : H2O | Containment type | : - |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : 0.42 |
| Refuelling frequency [month] | : 18 | Secondary systems | |
| Part of the core refuelled [%] | : 33 | Number of turbine-generators per unit/reactor | : 1 |
| Average discharge burnup [MWd/t] | : 40000 | Turbine speed [rpm] | : 1800 |
| Active core diameter [m] | : 3.4 | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : 3.66 | HP cylinder inlet steam pressure [MPa] | : 5.38 |
| Number of fissile fuel assemblies/bundles | : 193 | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : 17.85 | Primary means of condenser cooling | : River (once-through) |
| Number of control rod assemblies | : 29 | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : 4 | Number of FW pumps for full power operation | : - |
| Coolant type | : H2O | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 9112.43 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 90.73 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 90.73 % | Planned Unavailability Factor (PUF) | : 9.27 % |
| Load Factor (LF) | : 88.98 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 90.29 % | Total off-line time | : 851 hours |

Annual Summary

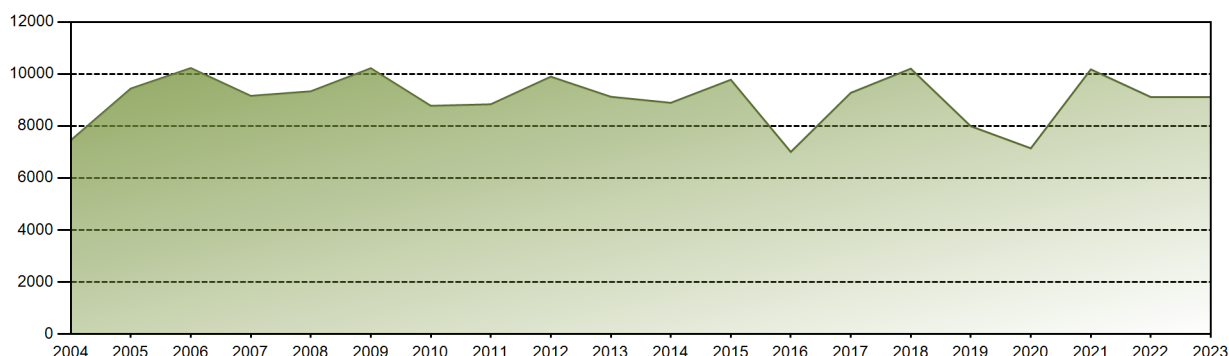


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 880.17 | 795.61 | 879.39 | 848.41 | 874.11 | 838.13 | 851.49 | 852.60 | 780.16 | 146.24 | 485.67 | 880.45 | 9112.43 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 26.09 | 63.59 | 100.00 | 90.73 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 26.09 | 63.59 | 100.00 | 90.73 |
| LF [%] | 101.20 | 101.28 | 101.25 | 100.80 | 100.50 | 99.58 | 97.90 | 98.03 | 92.69 | 16.81 | 57.62 | 101.23 | 88.98 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 22.58 | 61.86 | 100.00 | 90.29 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 73.91 | 36.41 | 0.00 | 9.27 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 330261.22 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 15.37 % |
| Cumulative Energy Availability Factor (EAF) | : 74.39 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 13.54 % |
| Cumulative Unit Capability Factor (UCF) | : 74.53 % | Cumulative Planned Unavailability Factor (PUF) | : 11.93 % |
| Cumulative Load Factor (LF) | : 72.05 % | Cumulative Externally cause unavailability (XUF) | : 0.15 % |
| Cumulative Operating Factor (OF) | : 74.33 % | | |

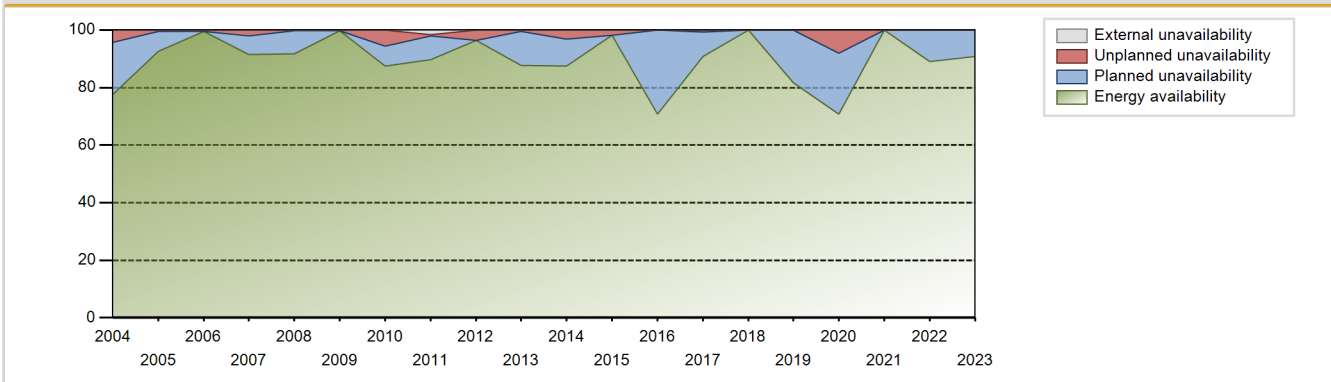
Electricity Production (net) [GWh]



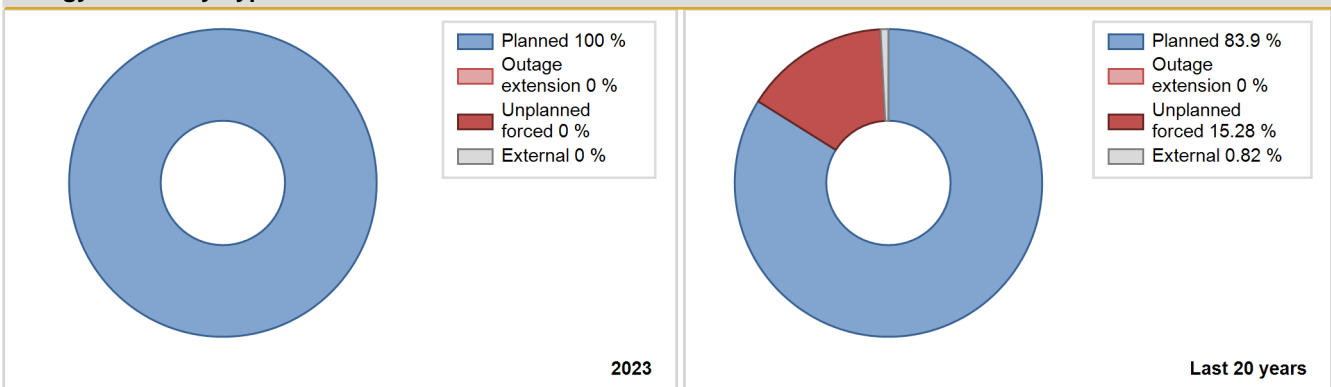
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|-------|-------|-------|--------|--------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1977 | 3398.20 | 2432 | 1079 | 42.77 | 42.77 | 42.79 | 54.53 | 56.99 | 56.66 | 0.57 | 0.00 |
| 1978 | 4537.00 | 4862 | 1079 | 48.00 | 48.00 | 48.00 | 55.50 | 51.90 | 51.80 | 0.20 | 0.00 |
| 1979 | 2084.30 | 2231 | 1079 | 22.05 | 22.05 | 22.05 | 25.47 | 65.71 | 42.25 | 35.70 | 0.00 |
| 1980 | 5689.80 | 6075 | 1079 | 69.47 | 74.22 | 60.03 | 69.16 | 5.09 | 3.98 | 21.81 | 4.74 |
| 1981 | 6191.30 | 6839 | 1079 | 78.47 | 78.47 | 65.50 | 78.07 | 21.53 | 21.53 | 0.00 | 0.00 |
| 1982 | 4107.40 | 4192 | 1079 | 46.96 | 46.96 | 43.46 | 47.85 | 6.50 | 3.27 | 49.78 | 0.00 |
| 1983 | 5408.80 | 5127 | 1079 | 57.61 | 57.61 | 57.22 | 58.53 | 42.39 | 42.39 | 0.00 | 0.00 |
| 1984 | 2160.15 | 2378 | 1079 | 27.08 | 27.08 | 22.79 | 27.07 | 61.84 | 43.88 | 29.05 | 0.00 |
| 1985 | 9007.51 | 8345 | 1079 | 95.16 | 95.16 | 95.30 | 95.26 | 4.84 | 4.84 | 0.00 | 0.00 |
| 1986 | 7084.01 | 6921 | 1083 | 78.61 | 78.61 | 74.63 | 79.01 | 9.85 | 8.59 | 12.81 | 0.00 |
| 1987 | 6216.61 | 6362 | 1106 | 72.64 | 73.08 | 64.16 | 72.63 | 2.96 | 2.23 | 24.69 | 0.44 |
| 1988 | 7418.56 | 6841 | 1106 | 77.92 | 77.92 | 76.36 | 77.88 | 3.06 | 2.46 | 19.62 | 0.00 |
| 1989 | 6213.35 | 6059 | 1106 | 69.18 | 69.18 | 64.13 | 69.17 | 10.69 | 8.28 | 22.53 | 0.00 |
| 1990 | 5999.21 | 5868 | 1106 | 67.01 | 67.01 | 61.92 | 66.99 | 32.99 | 32.99 | 0.00 | 0.00 |
| 1991 | 6810.28 | 6479 | 1106 | 73.96 | 73.96 | 70.29 | 73.96 | 4.23 | 3.26 | 22.77 | 0.00 |
| 1992 | 5307.84 | 5090 | 1106 | 57.99 | 57.99 | 54.63 | 57.95 | 24.21 | 18.52 | 23.49 | 0.00 |
| 1993 | 5870.60 | 5746 | 1106 | 65.61 | 65.61 | 60.59 | 65.59 | 12.61 | 9.46 | 24.93 | 0.00 |
| 1994 | 5779.31 | 5865 | 1106 | 67.04 | 67.04 | 59.65 | 66.95 | 25.86 | 23.38 | 9.58 | 0.00 |
| 1995 | 2554.43 | 2632 | 1106 | 30.07 | 30.07 | 26.37 | 30.05 | 59.80 | 44.73 | 25.21 | 0.00 |
| 1996 | 0.00 | 0 | 1106 | 0.01 | 0.01 | 0.00 | 0.00 | 99.98 | 66.94 | 33.05 | 0.00 |
| 1997 | 0.00 | 0 | 1106 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1998 | 6475.62 | 6199 | 1106 | 70.76 | 70.76 | 66.84 | 70.76 | 29.24 | 29.24 | 0.00 | 0.00 |
| 1999 | 8009.17 | 7663 | 1106 | 87.48 | 87.48 | 82.67 | 87.48 | 2.21 | 1.97 | 10.55 | 0.00 |
| 2000 | 8952.64 | 8328 | 1106 | 94.81 | 94.81 | 92.15 | 94.81 | 4.84 | 4.83 | 0.36 | 0.00 |
| 2001 | 7709.42 | 7116 | 1096 | 80.94 | 80.94 | 80.83 | 81.23 | 8.04 | 7.07 | 11.99 | 0.00 |
| 2002 | 8620.57 | 7855 | 1096 | 89.53 | 89.53 | 89.79 | 89.67 | 3.23 | 2.99 | 7.49 | 0.00 |
| 2003 | 9096.68 | 8401 | 1096 | 95.85 | 95.85 | 94.75 | 95.90 | 4.15 | 4.15 | 0.00 | 0.00 |
| 2004 | 7452.71 | 6766 | 1159 | 77.61 | 77.61 | 75.24 | 77.03 | 5.21 | 4.27 | 18.13 | 0.00 |
| 2005 | 9440.58 | 8105 | 1111 | 92.52 | 92.52 | 97.00 | 92.52 | 0.60 | 0.56 | 6.92 | 0.00 |
| 2006 | 10228.09 | 8725 | 1174 | 99.60 | 99.60 | 99.45 | 99.60 | 0.40 | 0.40 | 0.00 | 0.00 |
| 2007 | 9158.51 | 8013 | 1174 | 91.51 | 91.51 | 89.05 | 91.47 | 2.15 | 2.01 | 6.48 | 0.00 |
| 2008 | 9333.79 | 8053 | 1174 | 91.69 | 91.69 | 90.51 | 91.68 | 0.17 | 0.16 | 8.15 | 0.00 |
| 2009 | 10221.76 | 8735 | 1174 | 99.72 | 99.72 | 99.39 | 99.71 | 0.28 | 0.28 | 0.00 | 0.00 |
| 2010 | 8776.60 | 7653 | 1174 | 87.37 | 87.37 | 85.34 | 87.36 | 6.06 | 5.63 | 6.99 | 0.00 |
| 2011 | 8835.77 | 7847 | 1174 | 89.61 | 91.30 | 85.92 | 89.58 | 0.46 | 0.43 | 8.28 | 1.69 |
| 2012 | 9896.78 | 8472 | 1168 | 96.48 | 96.48 | 96.46 | 96.45 | 3.52 | 3.52 | 0.00 | 0.00 |
| 2013 | 9124.16 | 7692 | 1168 | 87.80 | 87.80 | 89.17 | 87.80 | 0.58 | 0.52 | 11.68 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|--------|--------|-------|--------|-------|------|-------|------|
| 2014 | 8891.48 | 7657 | 1168 | 87.40 | 87.40 | 86.90 | 87.41 | 3.51 | 3.17 | 9.42 | 0.00 |
| 2015 | 9778.02 | 8593 | 1169 | 98.09 | 98.09 | 95.48 | 98.09 | 1.91 | 1.91 | 0.00 | 0.00 |
| 2016 | 7002.31 | 6214 | 1169 | 70.74 | 70.74 | 68.19 | 70.74 | 0.00 | 0.00 | 29.26 | 0.00 |
| 2017 | 9275.70 | 7964 | 1169 | 90.92 | 90.92 | 90.58 | 90.91 | 0.67 | 0.62 | 8.47 | 0.00 |
| 2018 | 10204.37 | 8760 | 1169 | 100.00 | 100.00 | 99.65 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 7990.30 | 7153 | 1169 | 81.66 | 81.66 | 78.03 | 81.66 | 0.00 | 0.00 | 18.34 | 0.00 |
| 2020 | 7142.17 | 6225 | 1169 | 70.87 | 70.87 | 69.55 | 70.87 | 10.22 | 8.07 | 21.05 | 0.00 |
| 2021 | 10176.69 | 8760 | 1169 | 100.00 | 100.00 | 99.38 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 9112.71 | 7806 | 1169 | 89.12 | 89.12 | 88.99 | 89.11 | 0.00 | 0.00 | 10.88 | 0.00 |
| 2023 | 9112.43 | 7909 | 1169 | 90.73 | 90.73 | 88.98 | 90.29 | 0.00 | 0.00 | 9.27 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1977 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 980 | |
| B. Refuelling without maintenance | | | | 60 | | |
| C. Inspection, maintenance or repair combined with refuelling | 851 | | | 910 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 70 | | |
| E. Testing of plant systems or components | | | | 1 | 1 | |
| H. Nuclear regulatory requirements | | | | | 105 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 7 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 7 |
| Z. Other | | | | 9 | 91 | |
| Subtotal | 851 | | | 1050 | 1184 | 8 |
| Total | | 851 | | | 2242 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1977 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 16 |
| 12. Reactor I&C Systems | | 65 |
| 13. Reactor Auxiliary Systems | | 8 |
| 14. Safety Systems | | 83 |
| 15. Reactor Cooling Systems | | 64 |
| 16. Steam generation systems | | 405 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 3 |
| 31. Turbine and auxiliaries | | 172 |
| 32. Feedwater and Main Steam System | | 83 |
| 33. Circulating Water System | | 43 |
| 34. Miscellaneous Systems | | 62 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 80 |
| 42. Electrical Power Supply Systems | | 46 |
| Total | | 1135 |

2023 Operating Experience

US-311

SALEM-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : PSEG (PSEG Nuclear, LLC)
 Owner : PSEGPOWER (PSEG Power, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3459 MWth
 Gross electrical power : 1200 MWe
 Reference unit power (net) : 1158 MWe

Key Dates

Construction Date : 1968-09-25
 Grid Date : 1981-06-03
 Commercial Date : 1981-10-13
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 40000
 Active core diameter [m] : 3.4
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.85
 Number of control rod assemblies : 29
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 322
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.42

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.38
 Output voltage [kV] : -
 Primary means of condenser cooling : River (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

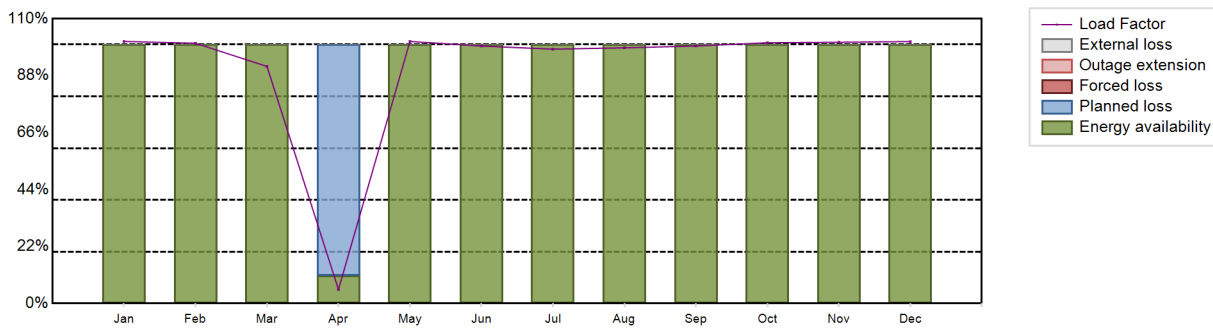
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9296.43 GW(e).h
 Energy Availability Factor (EAF) : 92.66 %
 Unit Capability Factor (UCF) : 92.66 %
 Load Factor (LF) : 91.64 %
 Operating Factor (OF) : 92.5 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 7.34 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 657 hours

Annual Summary

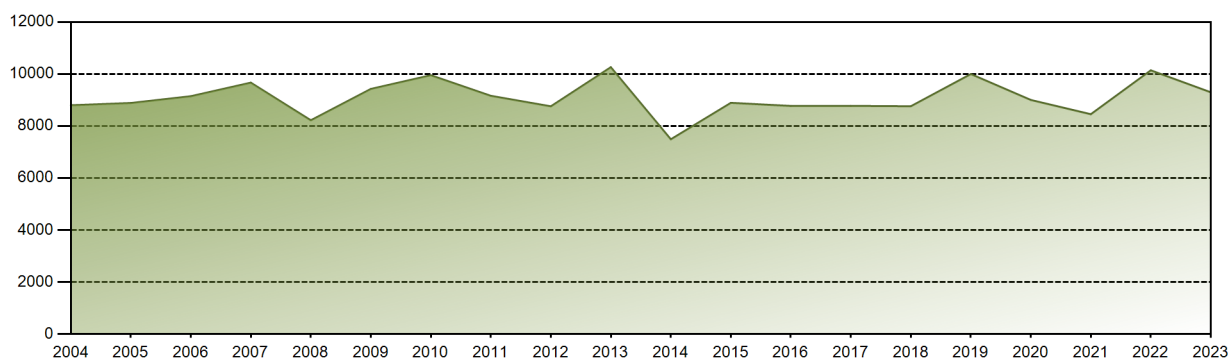


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 872.10 | 782.23 | 787.88 | 45.11 | 872.08 | 829.01 | 846.40 | 850.83 | 829.12 | 867.69 | 842.44 | 871.52 | 9296.43 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 10.68 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.66 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 10.68 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.66 |
| LF [%] | 101.22 | 100.52 | 91.57 | 5.41 | 101.22 | 99.43 | 98.24 | 98.76 | 99.44 | 100.71 | 100.90 | 101.16 | 91.64 |
| OF [%] | 100.00 | 100.00 | 100.00 | 8.75 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.50 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 89.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.34 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 309309.26 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 13.28 % |
| Cumulative Energy Availability Factor (EAF) | : 77.27 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 12.26 % |
| Cumulative Unit Capability Factor (UCF) | : 77.28 % | Cumulative Planned Unavailability Factor (PUF) | : 10.46 % |
| Cumulative Load Factor (LF) | : 74.27 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 76.67 % | | |

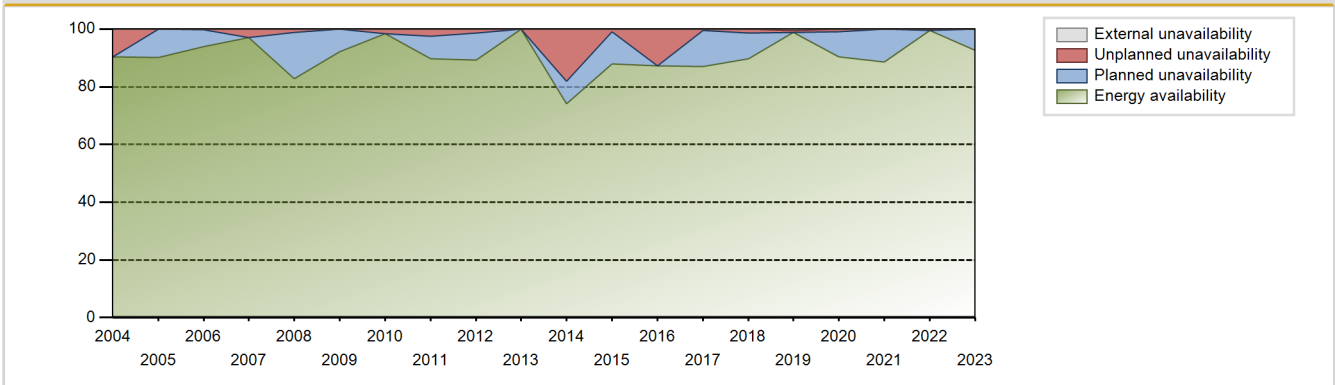
Electricity Production (net) [GWh]



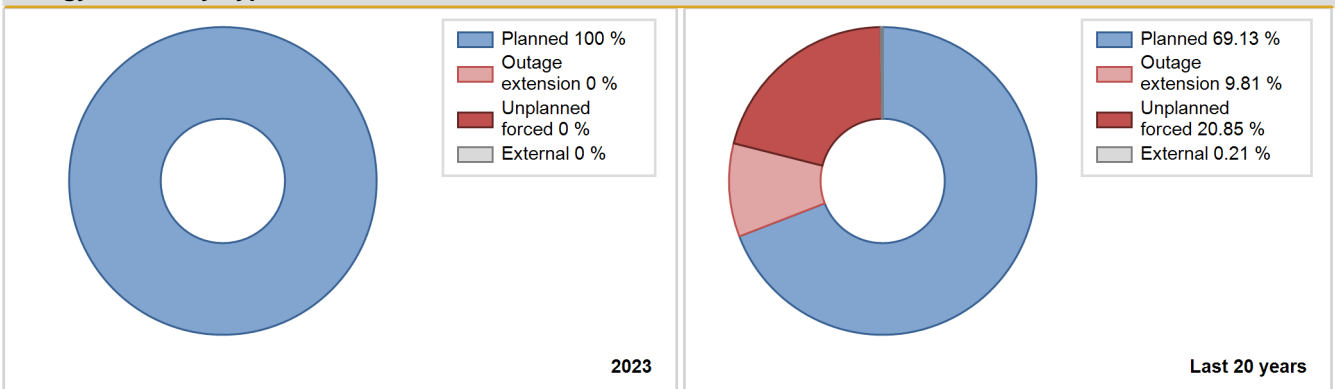
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|-------|--------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 3009.57 | 3253 | 1105 | 96.27 | 96.27 | 76.89 | 94.59 | 3.73 | 3.73 | 0.00 | 0.00 |
| 1982 | 7941.70 | 8517 | 1106 | 97.54 | 97.54 | 81.97 | 97.23 | 2.46 | 2.46 | 0.00 | 0.00 |
| 1983 | 775.20 | 1078 | 1106 | 12.65 | 12.65 | 8.00 | 12.31 | 73.49 | 35.06 | 52.29 | 0.00 |
| 1984 | 3225.70 | 3192 | 1106 | 36.40 | 36.40 | 33.20 | 36.34 | 56.61 | 47.48 | 16.12 | 0.00 |
| 1985 | 5033.76 | 4923 | 1106 | 56.22 | 56.22 | 51.96 | 56.20 | 41.70 | 40.21 | 3.56 | 0.00 |
| 1986 | 5317.72 | 5388 | 1106 | 61.59 | 61.59 | 54.89 | 61.51 | 20.69 | 16.06 | 22.35 | 0.00 |
| 1987 | 6176.55 | 6338 | 1106 | 72.42 | 72.42 | 63.75 | 72.35 | 9.33 | 7.45 | 20.12 | 0.00 |
| 1988 | 5982.17 | 5838 | 1106 | 66.50 | 66.50 | 61.58 | 66.46 | 33.47 | 33.45 | 0.05 | 0.00 |
| 1989 | 7824.60 | 7419 | 1106 | 84.74 | 84.74 | 80.76 | 84.69 | 9.76 | 9.17 | 6.10 | 0.00 |
| 1990 | 5446.10 | 5163 | 1106 | 72.16 | 72.16 | 56.21 | 58.94 | 5.68 | 4.35 | 23.49 | 0.00 |
| 1991 | 7662.34 | 7188 | 1106 | 82.05 | 82.05 | 79.09 | 82.05 | 15.40 | 14.93 | 3.01 | 0.00 |
| 1992 | 4744.64 | 4657 | 1106 | 53.05 | 53.05 | 48.84 | 53.02 | 16.80 | 10.71 | 36.24 | 0.00 |
| 1993 | 5575.50 | 5328 | 1106 | 60.87 | 60.87 | 57.55 | 60.82 | 20.37 | 15.57 | 23.56 | 0.00 |
| 1994 | 5606.78 | 6076 | 1106 | 69.43 | 69.43 | 57.87 | 69.36 | 5.75 | 4.24 | 26.34 | 0.00 |
| 1995 | 2071.74 | 2261 | 1106 | 25.83 | 25.83 | 21.38 | 25.81 | 65.33 | 48.69 | 25.48 | 0.00 |
| 1996 | 0.00 | 0 | 1106 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 91.53 | 8.47 | 0.00 |
| 1997 | 2564.28 | 2834 | 1106 | 32.37 | 32.37 | 26.47 | 32.35 | 67.63 | 67.63 | 0.00 | 0.00 |
| 1998 | 7797.25 | 7287 | 1106 | 83.18 | 83.18 | 80.48 | 83.18 | 15.42 | 15.17 | 1.64 | 0.00 |
| 1999 | 7949.39 | 7431 | 1106 | 84.83 | 84.83 | 82.05 | 84.83 | 0.00 | 0.00 | 15.17 | 0.00 |
| 2000 | 8381.72 | 7819 | 1106 | 89.01 | 89.01 | 86.28 | 89.01 | 0.00 | 0.00 | 10.99 | 0.00 |
| 2001 | 9517.60 | 8736 | 1092 | 99.72 | 99.72 | 99.97 | 99.73 | 0.28 | 0.28 | 0.00 | 0.00 |
| 2002 | 8367.43 | 7620 | 1092 | 86.77 | 86.77 | 87.47 | 86.99 | 1.68 | 1.49 | 11.74 | 0.00 |
| 2003 | 8095.61 | 7355 | 1116 | 83.73 | 83.73 | 84.47 | 83.96 | 3.24 | 2.80 | 13.47 | 0.00 |
| 2004 | 8799.76 | 7945 | 1116 | 90.34 | 90.34 | 89.77 | 90.45 | 9.60 | 9.59 | 0.07 | 0.00 |
| 2005 | 8886.03 | 7897 | 1129 | 90.15 | 90.15 | 89.84 | 90.14 | 0.00 | 0.00 | 9.85 | 0.00 |
| 2006 | 9147.38 | 8220 | 1130 | 93.86 | 93.86 | 92.41 | 93.84 | 0.29 | 0.28 | 5.87 | 0.00 |
| 2007 | 9669.39 | 8506 | 1130 | 97.12 | 97.12 | 97.68 | 97.10 | 2.88 | 2.88 | 0.00 | 0.00 |
| 2008 | 8222.00 | 7285 | 1156 | 82.82 | 82.82 | 81.58 | 82.93 | 1.50 | 1.26 | 15.92 | 0.00 |
| 2009 | 9427.50 | 8069 | 1158 | 92.15 | 92.15 | 92.94 | 92.11 | 0.00 | 0.00 | 7.85 | 0.00 |
| 2010 | 9954.77 | 8620 | 1158 | 98.41 | 98.41 | 98.13 | 98.40 | 1.59 | 1.59 | 0.00 | 0.00 |
| 2011 | 9162.79 | 7863 | 1158 | 89.78 | 89.78 | 90.33 | 89.76 | 2.62 | 2.41 | 7.81 | 0.00 |
| 2012 | 8758.57 | 7813 | 1158 | 89.19 | 89.19 | 86.11 | 88.95 | 1.49 | 1.35 | 9.46 | 0.00 |
| 2013 | 10262.83 | 8760 | 1158 | 100.00 | 100.00 | 101.16 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 7490.46 | 6488 | 1158 | 74.06 | 74.06 | 73.84 | 74.06 | 0.74 | 18.14 | 7.80 | 0.00 |
| 2015 | 8892.07 | 7710 | 1158 | 88.02 | 88.02 | 87.66 | 88.01 | 1.13 | 1.00 | 10.98 | 0.00 |
| 2016 | 8773.17 | 7661 | 1158 | 87.22 | 87.22 | 86.25 | 87.22 | 12.78 | 12.78 | 0.00 | 0.00 |
| 2017 | 8774.68 | 7617 | 1158 | 86.96 | 86.96 | 86.50 | 86.95 | 0.45 | 0.40 | 12.64 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2018 | 8761.52 | 7844 | 1158 | 89.75 | 89.75 | 86.37 | 89.54 | 1.54 | 1.40 | 8.85 | 0.00 |
| 2019 | 9999.01 | 8649 | 1158 | 98.75 | 99.13 | 98.57 | 98.73 | 0.87 | 0.87 | 0.00 | 0.38 |
| 2020 | 9003.39 | 7941 | 1158 | 90.41 | 90.41 | 88.51 | 90.40 | 1.05 | 0.96 | 8.63 | 0.00 |
| 2021 | 8454.84 | 7764 | 1158 | 88.63 | 88.63 | 83.35 | 88.63 | 0.00 | 0.00 | 11.37 | 0.00 |
| 2022 | 10142.84 | 8720 | 1158 | 99.55 | 99.55 | 99.99 | 99.54 | 0.45 | 0.45 | 0.00 | 0.00 |
| 2023 | 9296.43 | 8103 | 1158 | 92.66 | 92.66 | 91.64 | 92.50 | 0.00 | 0.00 | 7.34 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 839 | |
| B. Refuelling without maintenance | | | | 42 | | |
| C. Inspection, maintenance or repair combined with refuelling | 656 | | | 803 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 75 | | |
| E. Testing of plant systems or components | | | | 0 | 0 | |
| H. Nuclear regulatory requirements | | | | | 203 | |
| L. Human factor related | | | | | 6 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 5 |
| Z. Other | | | | 3 | 20 | |
| Subtotal | 656 | | | 923 | 1068 | 5 |
| Total | | 656 | | | 1996 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 189 |
| 12. Reactor I&C Systems | | 44 |
| 13. Reactor Auxiliary Systems | | 4 |
| 14. Safety Systems | | 37 |
| 15. Reactor Cooling Systems | | 97 |
| 16. Steam generation systems | | 140 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 73 |
| 32. Feedwater and Main Steam System | | 92 |
| 33. Circulating Water System | | 14 |
| 34. Miscellaneous Systems | | 8 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 194 |
| 42. Electrical Power Supply Systems | | 152 |
| Total | | 1047 |

2023 Operating Experience

US-443

SEABROOK-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : NEXTERA (NextEra Energy Resources, LLC)
 Owner : NEXTERA (NextEra Energy Resources, LLC)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3648 MWth
 Gross electrical power : 1296 MWe
 Reference unit power (net) : 1246 MWe

Key Dates

Construction Date : 1976-07-07
 Grid Date : 1990-05-29
 Commercial Date : 1990-08-19
 Age at end of year : 33 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.18
 Number of control rod assemblies : 57
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 326
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.37

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 7.14
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

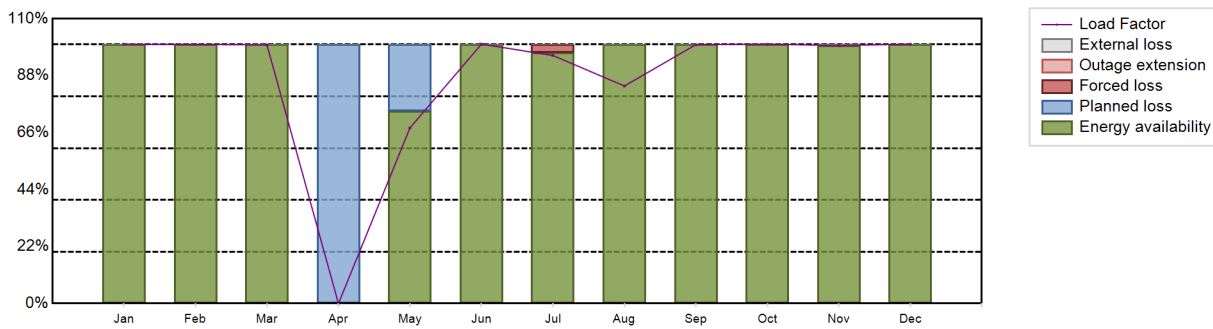
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9534.37 GW(e).h
 Energy Availability Factor (EAF) : 89.3 %
 Unit Capability Factor (UCF) : 89.3 %
 Load Factor (LF) : 87.35 %
 Operating Factor (OF) : 88.2 %

Forced Loss Rate (FLR) : 0.31 %
 Unplanned Capability Loss Factor (UCL) : 0.3 %
 Planned Unavailability Factor (PUF) : 10.4 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1034 hours

Annual Summary

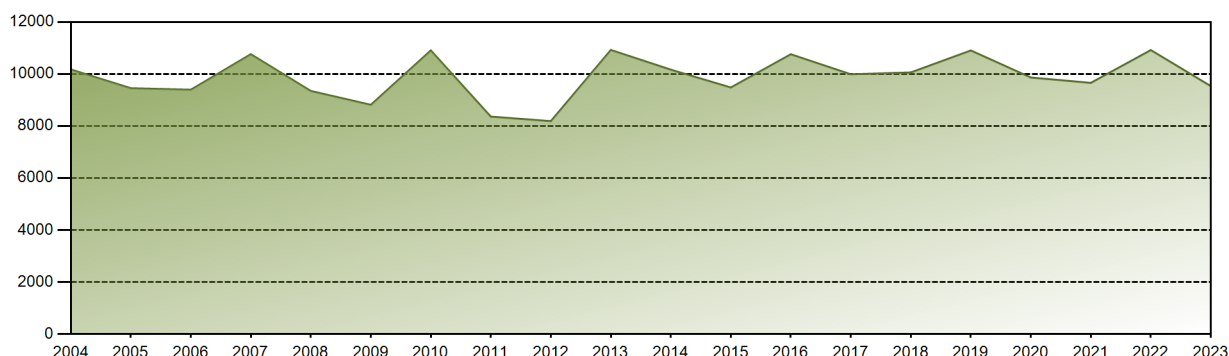


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 928.29 | 837.87 | 924.52 | 0.00 | 628.76 | 898.72 | 888.09 | 778.90 | 896.91 | 928.50 | 895.28 | 928.52 | 9534.37 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 0.00 | 74.28 | 100.00 | 96.77 | 100.00 | 100.00 | 100.00 | 99.67 | 100.00 | 89.30 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 0.00 | 74.28 | 100.00 | 96.77 | 100.00 | 100.00 | 100.00 | 99.67 | 100.00 | 89.30 |
| LF [%] | 100.14 | 100.07 | 99.86 | 0.00 | 67.83 | 100.18 | 95.80 | 84.02 | 99.98 | 100.16 | 99.66 | 100.16 | 87.35 |
| OF [%] | 100.00 | 100.00 | 100.00 | 0.00 | 74.33 | 100.00 | 95.56 | 87.90 | 100.00 | 100.00 | 100.00 | 100.00 | 88.20 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.31 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.23 | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 | 0.30 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 100.00 | 25.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.40 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

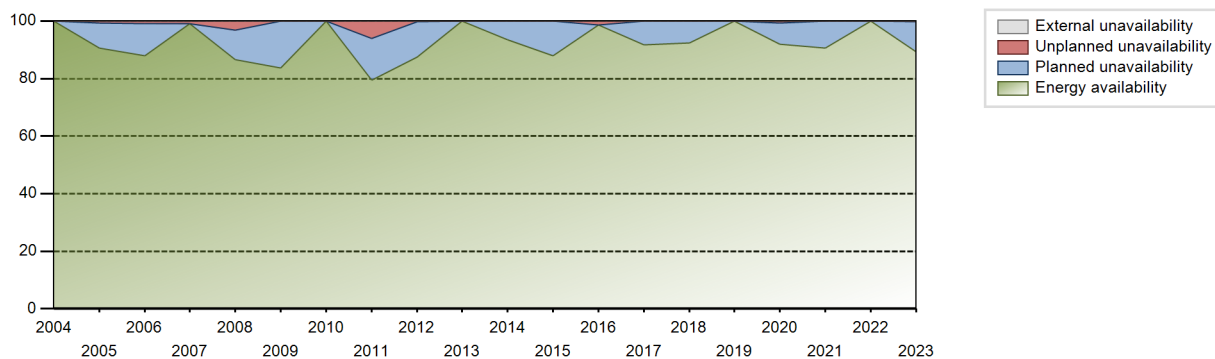
| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 310149.7 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.32 % |
| Cumulative Energy Availability Factor (EAF) | : 89.27 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.12 % |
| Cumulative Unit Capability Factor (UCF) | : 89.35 % | Cumulative Planned Unavailability Factor (PUF) | : 8.52 % |
| Cumulative Load Factor (LF) | : 87.85 % | Cumulative Externally cause unavailability (XUF) | : 0.08 % |
| Cumulative Operating Factor (OF) | : 89.07 % | | |

Electricity Production (net) [GWh]

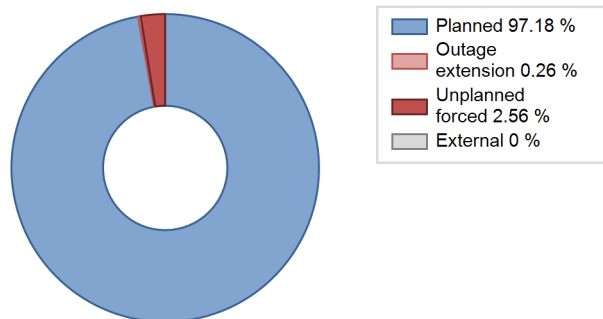


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1990 | 4094.00 | 4125 | 1151 | 84.94 | 84.94 | 82.11 | 84.94 | 15.06 | 15.06 | 0.00 | 0.00 |
| 1991 | 6814.38 | 6394 | 1150 | 73.00 | 73.00 | 67.64 | 72.99 | 6.00 | 4.66 | 22.34 | 0.00 |
| 1992 | 7868.44 | 7056 | 1150 | 80.26 | 80.26 | 77.89 | 80.33 | 1.29 | 1.05 | 18.69 | 0.00 |
| 1993 | 9046.81 | 8094 | 1150 | 92.39 | 92.39 | 89.80 | 92.40 | 7.61 | 7.61 | 0.00 | 0.00 |
| 1994 | 6203.50 | 5466 | 1150 | 62.28 | 62.28 | 61.58 | 62.40 | 9.22 | 6.33 | 31.39 | 0.00 |
| 1995 | 8380.64 | 7465 | 1150 | 85.18 | 85.18 | 83.14 | 85.22 | 5.01 | 4.49 | 10.32 | 0.00 |
| 1996 | 9844.19 | 8690 | 1158 | 98.96 | 98.96 | 96.78 | 98.93 | 1.04 | 1.04 | 0.00 | 0.00 |
| 1997 | 7945.70 | 6929 | 1158 | 79.18 | 79.18 | 78.33 | 79.10 | 8.32 | 7.18 | 13.64 | 0.00 |
| 1998 | 8388.43 | 7294 | 1158 | 83.33 | 83.33 | 82.69 | 83.26 | 16.67 | 16.67 | 0.00 | 0.00 |
| 1999 | 8685.71 | 7564 | 1156 | 86.33 | 86.33 | 85.77 | 86.35 | 0.62 | 0.54 | 13.13 | 0.00 |
| 2000 | 7921.49 | 6910 | 1155 | 78.66 | 78.66 | 78.08 | 78.67 | 2.05 | 1.64 | 19.69 | 0.00 |
| 2001 | 8692.24 | 7703 | 1155 | 87.89 | 90.59 | 85.91 | 87.93 | 1.82 | 1.68 | 7.73 | 2.70 |
| 2002 | 9293.37 | 8083 | 1155 | 92.24 | 92.24 | 91.85 | 92.27 | 0.00 | 0.00 | 7.76 | 0.00 |
| 2003 | 9275.43 | 8121 | 1155 | 92.68 | 92.68 | 91.67 | 92.71 | 0.48 | 0.45 | 6.88 | 0.00 |
| 2004 | 10176.97 | 8784 | 1155 | 100.00 | 100.00 | 100.31 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 9455.21 | 7928 | 1159 | 90.52 | 90.52 | 93.12 | 90.49 | 0.72 | 0.65 | 8.83 | 0.00 |
| 2006 | 9397.40 | 7718 | 1244 | 87.94 | 87.94 | 87.58 | 88.11 | 1.02 | 0.90 | 11.16 | 0.00 |
| 2007 | 10763.88 | 8669 | 1245 | 99.00 | 99.00 | 98.70 | 98.96 | 1.00 | 1.00 | 0.00 | 0.00 |
| 2008 | 9349.64 | 7596 | 1245 | 86.49 | 86.49 | 85.49 | 86.48 | 3.62 | 3.25 | 10.26 | 0.00 |
| 2009 | 8816.67 | 7326 | 1245 | 83.65 | 83.65 | 80.84 | 83.63 | 0.00 | 0.00 | 16.35 | 0.00 |
| 2010 | 10910.05 | 8760 | 1247 | 100.00 | 100.00 | 99.87 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 8361.74 | 6959 | 1247 | 79.46 | 79.46 | 76.55 | 79.44 | 7.19 | 6.15 | 14.38 | 0.00 |
| 2012 | 8188.86 | 7689 | 1246 | 87.55 | 87.55 | 74.82 | 87.53 | 0.18 | 0.15 | 12.30 | 0.00 |
| 2013 | 10926.11 | 8760 | 1246 | 100.00 | 100.00 | 100.09 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 10167.58 | 8190 | 1246 | 93.49 | 93.49 | 93.15 | 93.49 | 0.00 | 0.00 | 6.51 | 0.00 |
| 2015 | 9483.63 | 7705 | 1246 | 87.96 | 87.96 | 86.89 | 87.96 | 0.00 | 0.00 | 12.04 | 0.00 |
| 2016 | 10760.55 | 8667 | 1246 | 98.67 | 98.67 | 98.32 | 98.67 | 1.33 | 1.33 | 0.00 | 0.00 |
| 2017 | 9990.27 | 8033 | 1246 | 91.70 | 91.70 | 91.53 | 91.70 | 0.00 | 0.00 | 8.30 | 0.00 |
| 2018 | 10061.27 | 8093 | 1246 | 92.38 | 92.38 | 92.18 | 92.39 | 0.00 | 0.00 | 7.62 | 0.00 |
| 2019 | 10906.28 | 8760 | 1246 | 100.00 | 100.00 | 99.92 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 9865.20 | 7961 | 1246 | 91.96 | 91.96 | 90.14 | 90.63 | 0.72 | 0.67 | 7.36 | 0.00 |
| 2021 | 9660.02 | 7932 | 1246 | 90.55 | 90.55 | 88.50 | 90.55 | 0.00 | 0.00 | 9.45 | 0.00 |
| 2022 | 10921.11 | 8760 | 1246 | 100.00 | 100.00 | 100.06 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 9534.37 | 7726 | 1246 | 89.30 | 89.30 | 87.35 | 88.20 | 0.31 | 0.30 | 10.40 | 0.00 |

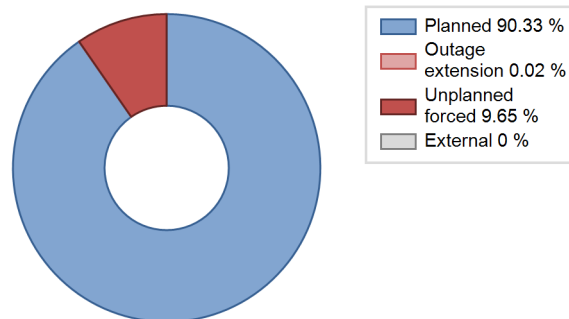
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1990 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 196 | |
| B. Refuelling without maintenance | | | | 44 | | |
| C. Inspection, maintenance or repair combined with refuelling | 911 | | | 693 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 20 | | |
| E. Testing of plant systems or components | | | | 1 | 3 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 7 |
| Z. Other | | | | 0 | 7 | |
| Subtotal | 911 | 24 | | 758 | 206 | 7 |
| Total | | 935 | | | 971 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1990 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 24 | 2 |
| 12. Reactor I&C Systems | | 3 |
| 13. Reactor Auxiliary Systems | | 52 |
| 15. Reactor Cooling Systems | | 25 |
| 16. Steam generation systems | | 0 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 24 |
| 32. Feedwater and Main Steam System | | 27 |
| 35. All other I&C Systems | | 12 |
| 41. Main Generator Systems | | 27 |
| 42. Electrical Power Supply Systems | | 23 |
| Total | 24 | 197 |

2023 Operating Experience

US-327

SEQUOYAH-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : TVA (Tennessee Valley Authority)
 Owner : TVA (Tennessee Valley Authority)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (ICECND)
 Thermal power : 3455 MWth
 Gross electrical power : 1221 MWe
 Reference unit power (net) : 1152 MWe

Key Dates

Construction Date : 1970-05-27
 Grid Date : 1980-07-22
 Commercial Date : 1981-07-01
 Age at end of year : 43 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 37
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.65
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.85
 Number of control rod assemblies : 29
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.82
 Reactor outlet temperature [°C] : 322.4
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 0.84

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.85
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

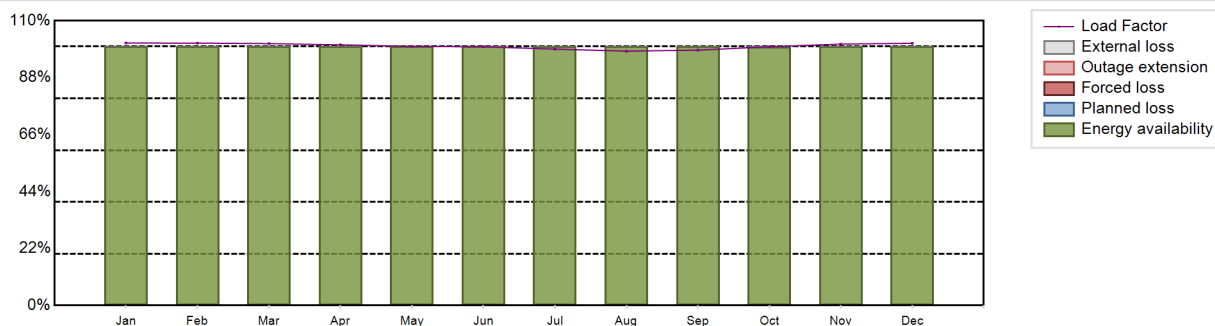
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 10112.9 GW(e).h
 Energy Availability Factor (EAF) : 99.99 %
 Unit Capability Factor (UCF) : 99.99 %
 Load Factor (LF) : 100.21 %
 Operating Factor (OF) : 100 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.01 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

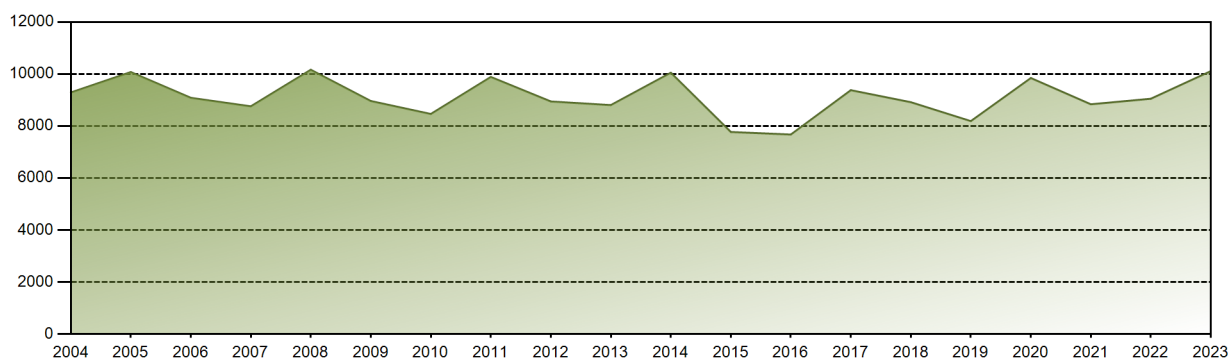


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 868.92 | 784.52 | 865.84 | 835.06 | 857.76 | 828.83 | 848.69 | 841.96 | 818.02 | 856.57 | 838.61 | 868.11 | 10112.90 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.87 | 100.00 | 100.00 | 99.99 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.87 | 100.00 | 100.00 | 99.99 |
| LF [%] | 101.38 | 101.34 | 101.16 | 100.68 | 100.08 | 99.93 | 99.02 | 98.24 | 98.62 | 99.94 | 100.97 | 101.29 | 100.21 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 323900.05 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 13.64 % |
| Cumulative Energy Availability Factor (EAF) | : 78.22 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 12.36 % |
| Cumulative Unit Capability Factor (UCF) | : 78.25 % | Cumulative Planned Unavailability Factor (PUF) | : 9.38 % |
| Cumulative Load Factor (LF) | : 76.35 % | Cumulative Externally cause unavailability (XUF) | : 0.04 % |
| Cumulative Operating Factor (OF) | : 77.96 % | | |

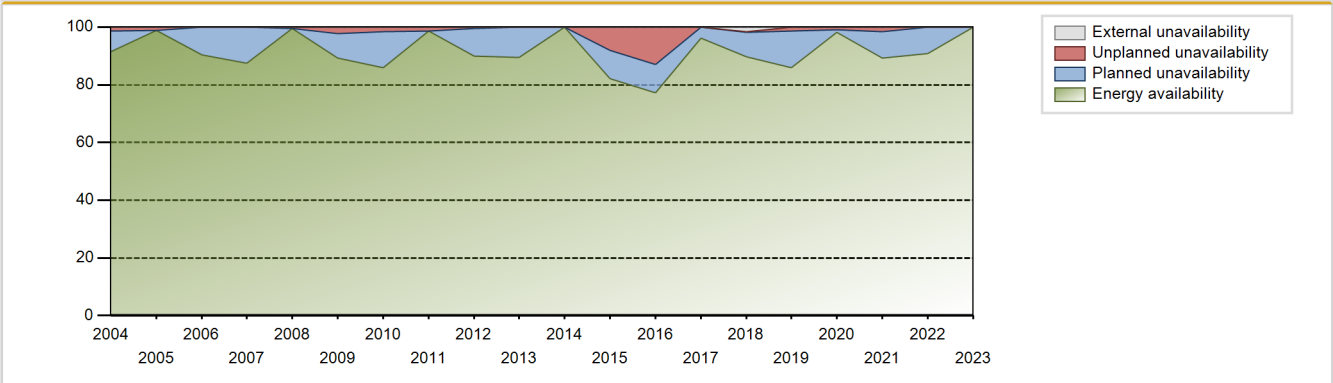
Electricity Production (net) [GWh]



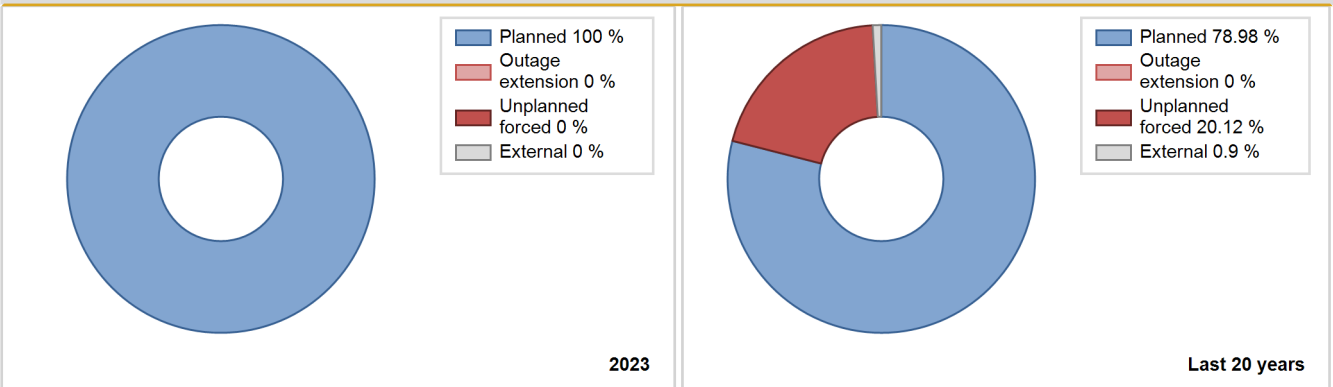
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|--------|--------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1981 | 4806.21 | 4984 | 1128 | 62.10 | 62.10 | 50.72 | 60.86 | 17.60 | 13.26 | 24.64 | 0.00 |
| 1982 | 4909.70 | 4626 | 1128 | 53.36 | 53.36 | 49.69 | 52.81 | 23.05 | 15.99 | 30.65 | 0.00 |
| 1983 | 7340.90 | 6791 | 1139 | 78.25 | 78.25 | 73.57 | 77.52 | 17.49 | 16.58 | 5.17 | 0.00 |
| 1984 | 6104.70 | 5992 | 1148 | 69.06 | 69.06 | 60.54 | 68.21 | 18.75 | 15.94 | 15.00 | 0.00 |
| 1985 | 4076.07 | 3760 | 1148 | 44.68 | 44.68 | 40.53 | 42.92 | 17.01 | 9.16 | 46.16 | 0.00 |
| 1986 | 0.00 | 0 | 1148 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1987 | 0.00 | 0 | 1148 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1988 | 127.69 | 282 | 1148 | 6.35 | 6.35 | 1.27 | 3.21 | 93.58 | 92.57 | 1.09 | 0.00 |
| 1989 | 9550.60 | 8624 | 1148 | 98.52 | 98.52 | 94.97 | 98.45 | 1.48 | 1.48 | 0.00 | 0.00 |
| 1990 | 6840.68 | 6406 | 1148 | 73.99 | 73.99 | 68.02 | 73.13 | 7.02 | 5.59 | 20.42 | 0.00 |
| 1991 | 7270.13 | 6774 | 1122 | 77.56 | 77.56 | 73.97 | 77.33 | 2.14 | 1.70 | 20.74 | 0.00 |
| 1992 | 8402.49 | 7734 | 1122 | 88.20 | 88.20 | 85.26 | 88.05 | 11.80 | 11.80 | 0.00 | 0.00 |
| 1993 | 1290.51 | 1219 | 1122 | 14.77 | 14.77 | 13.13 | 13.92 | 85.23 | 85.23 | 0.00 | 0.00 |
| 1994 | 6111.64 | 5774 | 1111 | 65.97 | 65.97 | 62.80 | 65.91 | 5.91 | 4.14 | 29.89 | 0.00 |
| 1995 | 6829.49 | 6620 | 1111 | 75.64 | 75.64 | 70.17 | 75.57 | 8.20 | 6.76 | 17.60 | 0.00 |
| 1996 | 9293.49 | 8344 | 1112 | 95.07 | 95.07 | 95.10 | 94.99 | 1.05 | 1.01 | 3.92 | 0.00 |
| 1997 | 8324.30 | 7486 | 1117 | 85.54 | 85.54 | 85.07 | 85.46 | 0.44 | 0.37 | 14.09 | 0.00 |
| 1998 | 8905.68 | 7966 | 1118 | 91.02 | 91.02 | 90.91 | 90.94 | 1.08 | 0.99 | 7.99 | 0.00 |
| 1999 | 9986.98 | 8760 | 1122 | 100.00 | 100.00 | 101.61 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2000 | 7720.48 | 6988 | 1122 | 79.53 | 79.53 | 78.34 | 79.55 | 14.83 | 13.85 | 6.63 | 0.00 |
| 2001 | 9018.99 | 7988 | 1122 | 91.21 | 91.21 | 91.76 | 91.19 | 0.00 | 0.00 | 8.79 | 0.00 |
| 2002 | 9953.53 | 8760 | 1125 | 100.00 | 100.00 | 101.07 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 7351.13 | 6443 | 1125 | 73.61 | 73.61 | 74.59 | 73.55 | 1.46 | 1.09 | 25.30 | 0.00 |
| 2004 | 9290.48 | 8027 | 1148 | 91.39 | 91.39 | 92.13 | 91.38 | 1.42 | 1.32 | 7.30 | 0.00 |
| 2005 | 10076.53 | 8658 | 1150 | 98.84 | 98.84 | 100.01 | 98.82 | 1.16 | 1.16 | 0.00 | 0.00 |
| 2006 | 9086.03 | 7915 | 1150 | 90.37 | 90.37 | 90.19 | 90.35 | 0.00 | 0.00 | 9.63 | 0.00 |
| 2007 | 8758.29 | 7668 | 1148 | 87.52 | 87.52 | 87.09 | 87.53 | 0.00 | 0.00 | 12.48 | 0.00 |
| 2008 | 10164.80 | 8738 | 1148 | 99.49 | 99.49 | 100.80 | 99.48 | 0.51 | 0.51 | 0.00 | 0.00 |
| 2009 | 8962.17 | 7820 | 1148 | 89.29 | 89.29 | 89.12 | 89.27 | 2.49 | 2.28 | 8.42 | 0.00 |
| 2010 | 8464.09 | 7524 | 1152 | 85.95 | 85.95 | 83.87 | 85.89 | 1.83 | 1.60 | 12.45 | 0.00 |
| 2011 | 9888.54 | 8636 | 1152 | 98.61 | 98.61 | 97.99 | 98.58 | 1.39 | 1.39 | 0.00 | 0.00 |
| 2012 | 8945.17 | 7907 | 1152 | 90.04 | 90.04 | 88.40 | 90.02 | 0.49 | 0.45 | 9.52 | 0.00 |
| 2013 | 8805.63 | 7834 | 1152 | 89.43 | 89.43 | 87.25 | 89.42 | 0.00 | 0.00 | 10.57 | 0.00 |
| 2014 | 10051.76 | 8760 | 1152 | 100.00 | 100.00 | 99.61 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 7771.73 | 7196 | 1152 | 82.15 | 82.15 | 77.01 | 82.15 | 9.05 | 8.17 | 9.68 | 0.00 |
| 2016 | 7673.62 | 6783 | 1152 | 77.22 | 77.22 | 75.83 | 77.22 | 14.35 | 12.94 | 9.84 | 0.00 |
| 2017 | 9378.86 | 8420 | 1152 | 96.11 | 96.11 | 92.94 | 96.12 | 0.00 | 0.00 | 3.89 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|-------|-------|--------|--------|------|------|-------|------|
| 2018 | 8916.87 | 7858 | 1152 | 89.70 | 91.23 | 88.36 | 89.70 | 0.33 | 0.30 | 8.46 | 1.53 |
| 2019 | 8189.64 | 7523 | 1152 | 85.90 | 85.90 | 81.15 | 85.88 | 1.58 | 1.38 | 12.72 | 0.00 |
| 2020 | 9846.77 | 8627 | 1152 | 98.22 | 98.22 | 97.31 | 98.21 | 0.99 | 0.98 | 0.79 | 0.00 |
| 2021 | 8836.62 | 7810 | 1152 | 89.16 | 89.16 | 87.56 | 89.16 | 1.80 | 1.64 | 9.21 | 0.00 |
| 2022 | 9049.98 | 7956 | 1152 | 90.82 | 90.82 | 89.68 | 90.82 | 0.00 | 0.00 | 9.18 | 0.00 |
| 2023 | 10112.90 | 8760 | 1152 | 99.99 | 99.99 | 100.21 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1981 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 471 | |
| B. Refuelling without maintenance | | | | 36 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 720 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 42 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 215 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 17 | |
| P. Fire | | | | | 3 | |
| Z. Other | | | | 33 | 389 | |
| Subtotal | | | | 832 | 1095 | 3 |
| Total | | 0 | | | 1930 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1981 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 17 |
| 13. Reactor Auxiliary Systems | | 11 |
| 14. Safety Systems | | 26 |
| 15. Reactor Cooling Systems | | 39 |
| 16. Steam generation systems | | 5 |
| 31. Turbine and auxiliaries | | 33 |
| 32. Feedwater and Main Steam System | | 206 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 4 |
| 41. Main Generator Systems | | 104 |
| 42. Electrical Power Supply Systems | | 28 |
| Total | | 474 |

2023 Operating Experience

US-328

SEQUOYAH-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : TVA (Tennessee Valley Authority)
 Owner : TVA (Tennessee Valley Authority)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (ICECND)
 Thermal power : 3455 MWth
 Gross electrical power : 1200 MWe
 Reference unit power (net) : 1139 MWe

Key Dates

Construction Date : 1970-05-27
 Grid Date : 1981-12-23
 Commercial Date : 1982-06-01
 Age at end of year : 42 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 37
 Average discharge burnup [MWd/t] : 45000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.65
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.85
 Number of control rod assemblies : 29
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.82
 Reactor outlet temperature [°C] : 322.4
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 0.84

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.85
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

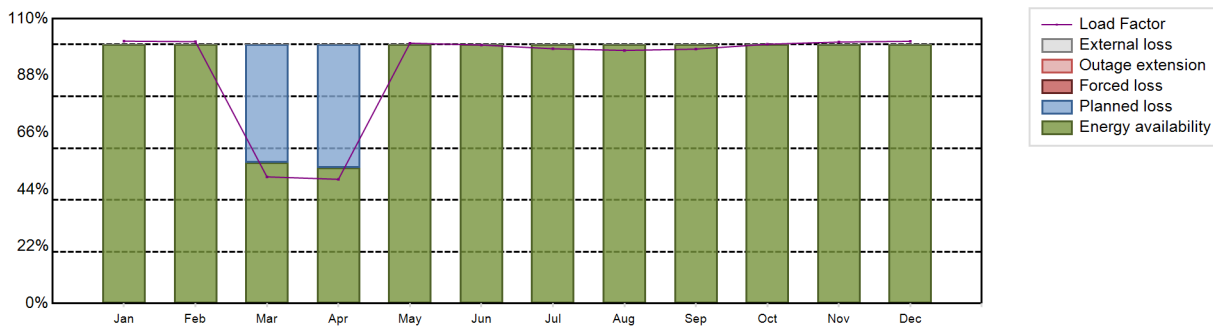
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9114.69 GW(e).h
 Energy Availability Factor (EAF) : 92.23 %
 Unit Capability Factor (UCF) : 92.23 %
 Load Factor (LF) : 91.35 %
 Operating Factor (OF) : 92.23 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 7.77 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 681 hours

Annual Summary

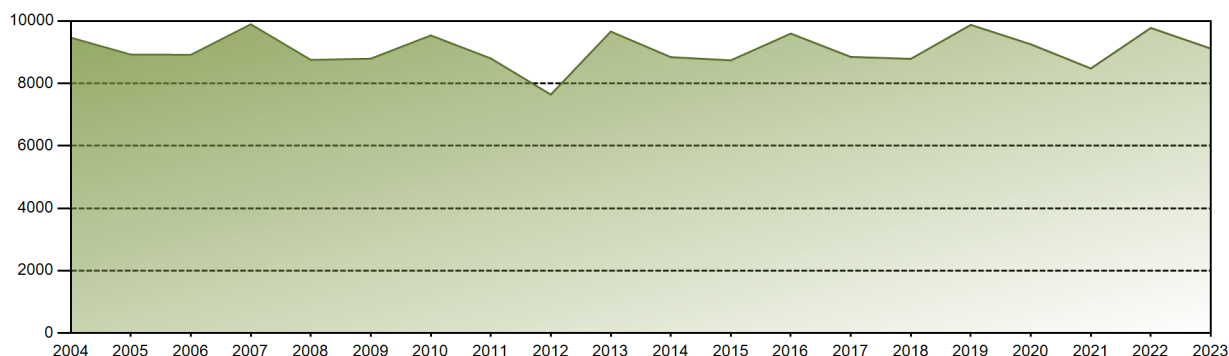


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 858.71 | 774.07 | 413.97 | 393.38 | 851.98 | 818.74 | 833.66 | 828.32 | 805.80 | 848.53 | 829.35 | 858.18 | 9114.69 |
| EAF [%] | 100.00 | 100.00 | 54.37 | 52.53 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.23 |
| UCF [%] | 100.00 | 100.00 | 54.37 | 52.53 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.23 |
| LF [%] | 101.33 | 101.13 | 48.92 | 47.97 | 100.54 | 99.84 | 98.38 | 97.75 | 98.26 | 100.13 | 100.99 | 101.27 | 91.35 |
| OF [%] | 100.00 | 100.00 | 54.37 | 52.50 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.23 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 45.63 | 47.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.77 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 325668.24 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 11.45 % |
| Cumulative Energy Availability Factor (EAF) | : 81.33 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 10.52 % |
| Cumulative Unit Capability Factor (UCF) | : 81.33 % | Cumulative Planned Unavailability Factor (PUF) | : 8.15 % |
| Cumulative Load Factor (LF) | : 79.19 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 81.27 % | | |

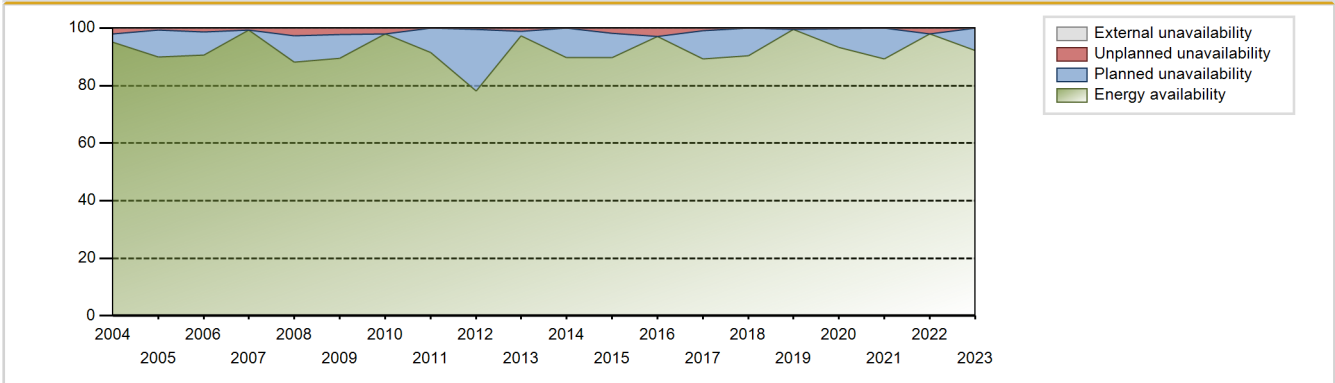
Electricity Production (net) [GWh]



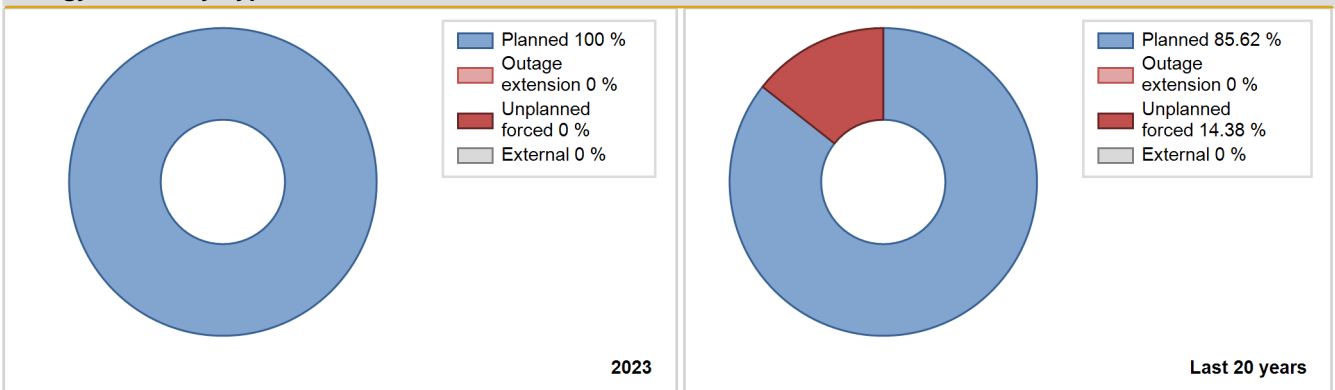
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|--------|--------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1982 | 5207.56 | 5881 | 1145 | 75.00 | 75.00 | 66.75 | 74.05 | 17.32 | 15.71 | 9.29 | 0.00 |
| 1983 | 6691.40 | 6346 | 1133 | 72.76 | 72.76 | 67.42 | 72.44 | 3.72 | 2.81 | 24.42 | 0.00 |
| 1984 | 6403.27 | 6112 | 1148 | 69.82 | 69.82 | 63.50 | 69.58 | 7.23 | 5.44 | 24.74 | 0.00 |
| 1985 | 5624.97 | 5223 | 1148 | 59.80 | 59.80 | 55.93 | 59.62 | 40.16 | 40.13 | 0.07 | 0.00 |
| 1986 | 0.00 | 0 | 1148 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1987 | 0.00 | 0 | 1148 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 | 100.00 | 0.00 | 0.00 |
| 1988 | 3934.70 | 5097 | 1148 | 59.44 | 59.44 | 39.02 | 58.03 | 40.55 | 40.55 | 0.02 | 0.00 |
| 1989 | 6067.70 | 6103 | 1148 | 70.71 | 70.71 | 60.34 | 69.67 | 5.97 | 4.49 | 24.80 | 0.00 |
| 1990 | 7185.46 | 6864 | 1148 | 79.14 | 79.14 | 71.45 | 78.36 | 1.29 | 1.03 | 19.83 | 0.00 |
| 1991 | 9318.89 | 8482 | 1122 | 96.88 | 96.88 | 94.81 | 96.83 | 3.12 | 3.12 | 0.00 | 0.00 |
| 1992 | 7276.08 | 7031 | 1122 | 80.35 | 80.35 | 73.83 | 80.04 | 2.69 | 2.22 | 17.43 | 0.00 |
| 1993 | 2094.36 | 2213 | 1122 | 26.32 | 26.32 | 21.31 | 25.26 | 73.68 | 73.68 | 0.00 | 0.00 |
| 1994 | 5849.36 | 5415 | 1106 | 61.85 | 61.85 | 60.37 | 61.82 | 2.18 | 1.38 | 36.77 | 0.00 |
| 1995 | 8887.69 | 8064 | 1106 | 92.15 | 92.15 | 91.73 | 92.05 | 7.85 | 7.85 | 0.00 | 0.00 |
| 1996 | 7682.50 | 6894 | 1108 | 78.59 | 78.59 | 78.88 | 78.48 | 8.62 | 7.42 | 13.99 | 0.00 |
| 1997 | 8725.64 | 8001 | 1117 | 91.45 | 91.45 | 89.17 | 91.34 | 0.30 | 0.27 | 8.27 | 0.00 |
| 1998 | 9799.59 | 8656 | 1117 | 98.84 | 98.84 | 100.15 | 98.81 | 1.16 | 1.16 | 0.00 | 0.00 |
| 1999 | 8978.97 | 8203 | 1117 | 93.65 | 93.65 | 91.76 | 93.64 | 0.00 | 0.00 | 6.35 | 0.00 |
| 2000 | 9058.27 | 8158 | 1117 | 92.88 | 92.88 | 92.32 | 92.87 | 0.88 | 0.82 | 6.30 | 0.00 |
| 2001 | 9939.87 | 8760 | 1117 | 100.00 | 100.00 | 101.58 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2002 | 8542.04 | 7640 | 1126 | 87.28 | 87.28 | 87.14 | 87.21 | 3.20 | 2.88 | 9.83 | 0.00 |
| 2003 | 8258.27 | 7401 | 1126 | 84.64 | 84.64 | 83.72 | 84.49 | 7.37 | 6.74 | 8.63 | 0.00 |
| 2004 | 9464.89 | 8353 | 1124 | 95.08 | 95.08 | 95.86 | 95.09 | 2.19 | 2.13 | 2.78 | 0.00 |
| 2005 | 8922.57 | 7867 | 1127 | 89.83 | 89.83 | 90.37 | 89.80 | 0.77 | 0.70 | 9.47 | 0.00 |
| 2006 | 8914.65 | 7931 | 1127 | 90.56 | 90.56 | 90.30 | 90.54 | 1.42 | 1.31 | 8.13 | 0.00 |
| 2007 | 9892.40 | 8692 | 1126 | 99.23 | 99.23 | 100.29 | 99.22 | 0.77 | 0.77 | 0.00 | 0.00 |
| 2008 | 8752.56 | 7749 | 1126 | 88.23 | 88.23 | 88.49 | 88.22 | 2.89 | 2.62 | 9.14 | 0.00 |
| 2009 | 8792.36 | 7837 | 1126 | 89.49 | 89.49 | 89.14 | 89.46 | 2.46 | 2.26 | 8.25 | 0.00 |
| 2010 | 9536.67 | 8573 | 1126 | 97.89 | 97.89 | 96.68 | 97.87 | 2.11 | 2.11 | 0.00 | 0.00 |
| 2011 | 8799.53 | 8016 | 1126 | 91.52 | 91.52 | 89.21 | 91.51 | 0.00 | 0.00 | 8.48 | 0.00 |
| 2012 | 7640.46 | 6866 | 1125 | 78.18 | 78.18 | 77.32 | 78.16 | 0.64 | 0.51 | 21.31 | 0.00 |
| 2013 | 9661.10 | 8519 | 1126 | 97.25 | 97.25 | 97.93 | 97.24 | 1.18 | 1.16 | 1.59 | 0.00 |
| 2014 | 8840.63 | 7867 | 1125 | 89.81 | 89.81 | 89.71 | 89.81 | 0.00 | 0.00 | 10.19 | 0.00 |
| 2015 | 8739.59 | 7849 | 1125 | 89.60 | 89.60 | 88.68 | 89.60 | 2.11 | 1.93 | 8.47 | 0.00 |
| 2016 | 9595.60 | 8526 | 1125 | 97.06 | 97.06 | 97.10 | 97.06 | 2.94 | 2.94 | 0.00 | 0.00 |
| 2017 | 8848.02 | 7824 | 1125 | 89.32 | 89.32 | 89.78 | 89.32 | 1.08 | 0.98 | 9.71 | 0.00 |
| 2018 | 8786.87 | 7909 | 1139 | 90.28 | 90.28 | 88.07 | 90.29 | 0.00 | 0.00 | 9.72 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2019 | 9874.98 | 8711 | 1139 | 99.45 | 99.45 | 98.97 | 99.44 | 0.55 | 0.55 | 0.00 | 0.00 |
| 2020 | 9252.42 | 8190 | 1139 | 93.24 | 93.24 | 92.48 | 93.24 | 0.33 | 0.31 | 6.45 | 0.00 |
| 2021 | 8478.57 | 7828 | 1139 | 89.36 | 89.36 | 84.98 | 89.36 | 0.00 | 0.00 | 10.64 | 0.00 |
| 2022 | 9777.31 | 8590 | 1139 | 98.06 | 98.06 | 97.99 | 98.06 | 1.94 | 1.94 | 0.00 | 0.00 |
| 2023 | 9114.69 | 8079 | 1139 | 92.23 | 92.23 | 91.35 | 92.23 | 0.00 | 0.00 | 7.77 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1982 to 2023 | | |
|---|------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 340 | |
| B. Refuelling without maintenance | | | | 36 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1200 | | | 669 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 26 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 291 | |
| L. Human factor related | | | | | 19 | |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 0 | |
| Z. Other | | | | | 270 | |
| Subtotal | 1200 | | | 732 | 920 | |
| Total | | 1200 | | | 1652 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1982 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 1 |
| 12. Reactor I&C Systems | | 5 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | | 1 |
| 15. Reactor Cooling Systems | | 34 |
| 16. Steam generation systems | | 18 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 26 |
| 32. Feedwater and Main Steam System | | 43 |
| 34. Miscellaneous Systems | | 2 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 188 |
| 42. Electrical Power Supply Systems | | 18 |
| Total | | 344 |

2023 Operating Experience

US-498

SOUTH TEXAS-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : STP (STP Nuclear Operating Co.)
 Owner : NRGENERG (NRG Energy, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3853 MWth
 Gross electrical power : 1354 MWe
 Reference unit power (net) : 1280 MWe

Key Dates

Construction Date : 1975-12-22
 Grid Date : 1988-03-30
 Commercial Date : 1988-08-25
 Age at end of year : 35 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 16.7
 Average discharge burnup [MWd/t] : 43000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.27
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.03
 Number of control rod assemblies : 29
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 330
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.397

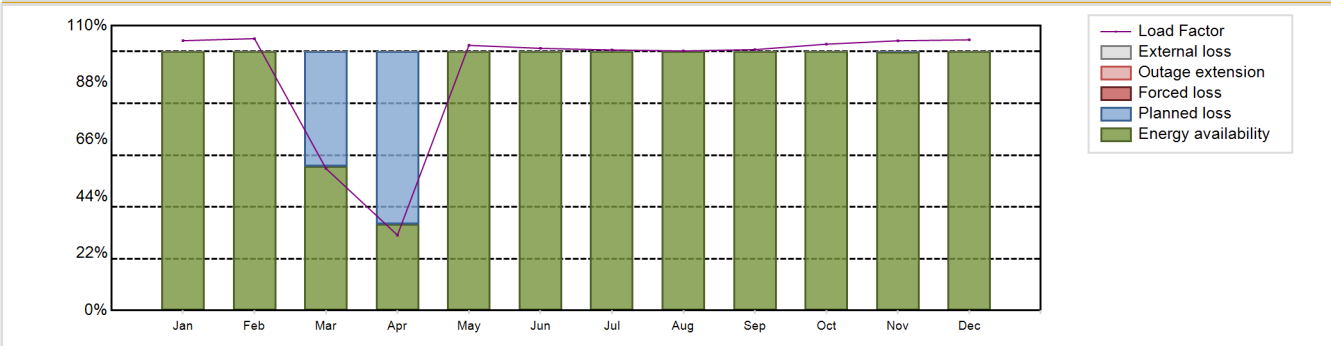
Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 7.55
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Pond (closed-cycle)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 10372.14 GW(e).h
 Energy Availability Factor (EAF) : 90.74 %
 Unit Capability Factor (UCF) : 90.74 %
 Load Factor (LF) : 92.5 %
 Operating Factor (OF) : 90.55 %
 Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 9.26 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 828 hours

Annual Summary

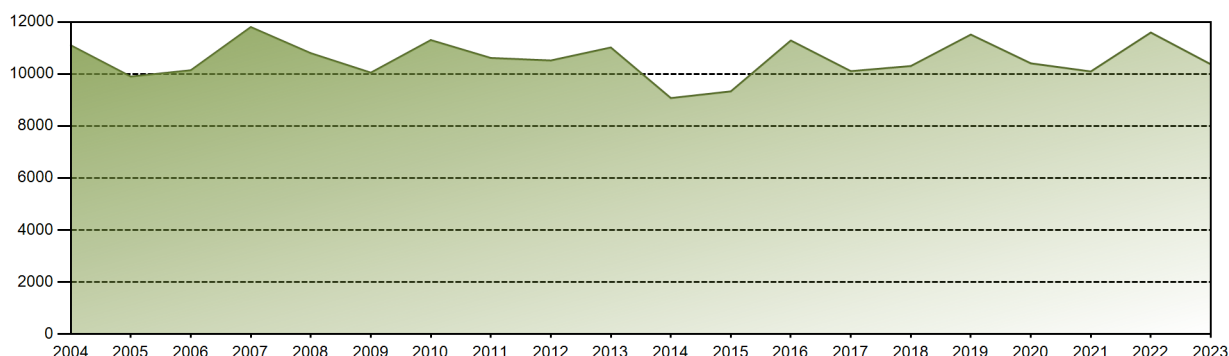


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 992.43 | 903.19 | 521.57 | 268.34 | 975.26 | 933.13 | 958.31 | 954.61 | 928.70 | 979.58 | 961.42 | 995.60 | 10372.14 |
| EAF [%] | 100.00 | 100.00 | 55.64 | 33.34 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.80 | 100.00 | 90.74 |
| UCF [%] | 100.00 | 100.00 | 55.64 | 33.34 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.80 | 100.00 | 90.74 |
| LF [%] | 104.21 | 105.00 | 54.84 | 29.12 | 102.41 | 101.25 | 100.63 | 100.24 | 100.77 | 102.86 | 104.18 | 104.54 | 92.50 |
| OF [%] | 100.00 | 100.00 | 54.64 | 31.81 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 90.55 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 44.36 | 66.66 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 9.26 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

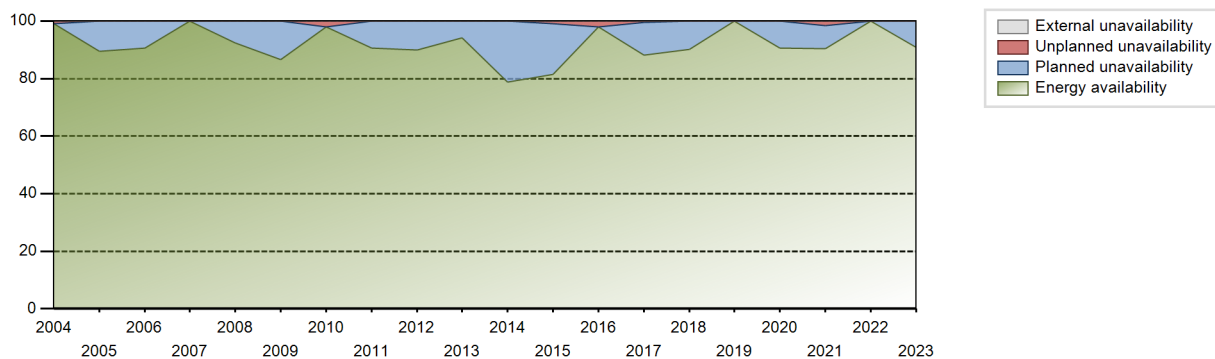
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 336516.89 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.37 % |
| Cumulative Energy Availability Factor (EAF) | : 85.16 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.82 % |
| Cumulative Unit Capability Factor (UCF) | : 85.16 % | Cumulative Planned Unavailability Factor (PUF) | : 9.03 % |
| Cumulative Load Factor (LF) | : 85.78 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 85.03 % | | |

Electricity Production (net) [GWh]

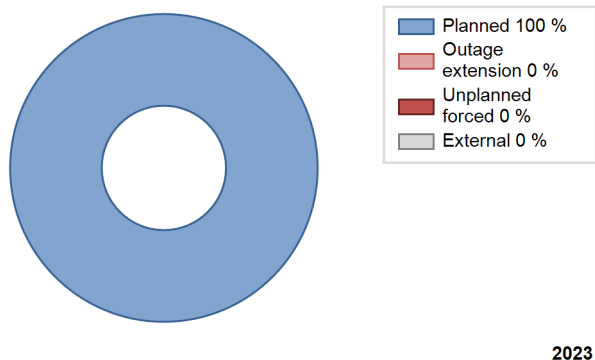


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1988 | 2791.49 | 2404 | 1250 | 80.04 | 80.04 | 74.87 | 79.55 | 7.84 | 6.81 | 13.15 | 0.00 |
| 1989 | 6307.67 | 5524 | 1250 | 63.09 | 63.09 | 57.60 | 63.06 | 8.17 | 5.62 | 31.29 | 0.00 |
| 1990 | 6072.87 | 5198 | 1251 | 59.38 | 59.38 | 55.42 | 59.34 | 23.62 | 18.37 | 22.25 | 0.00 |
| 1991 | 7239.78 | 6069 | 1251 | 69.29 | 69.29 | 66.06 | 69.28 | 11.39 | 8.90 | 21.80 | 0.00 |
| 1992 | 7265.14 | 6033 | 1251 | 68.69 | 68.69 | 66.11 | 68.68 | 14.83 | 11.96 | 19.34 | 0.00 |
| 1993 | 666.03 | 676 | 1251 | 7.73 | 7.73 | 6.08 | 7.72 | 92.27 | 92.27 | 0.00 | 0.00 |
| 1994 | 8251.41 | 6842 | 1251 | 78.15 | 78.15 | 75.30 | 78.11 | 21.80 | 21.79 | 0.06 | 0.00 |
| 1995 | 9301.77 | 7570 | 1251 | 86.46 | 86.46 | 84.88 | 86.42 | 2.38 | 2.11 | 11.43 | 0.00 |
| 1996 | 10226.80 | 8213 | 1251 | 93.53 | 93.53 | 93.07 | 93.50 | 0.00 | 0.00 | 6.47 | 0.00 |
| 1997 | 9873.23 | 8019 | 1251 | 91.61 | 91.61 | 90.09 | 91.54 | 1.57 | 1.46 | 6.93 | 0.00 |
| 1998 | 10859.94 | 8739 | 1250 | 99.77 | 99.77 | 99.11 | 99.76 | 0.00 | 0.00 | 0.23 | 0.00 |
| 1999 | 9645.37 | 7857 | 1250 | 89.72 | 89.72 | 88.09 | 89.69 | 1.38 | 1.26 | 9.02 | 0.00 |
| 2000 | 8591.90 | 6905 | 1250 | 78.64 | 78.64 | 78.25 | 78.61 | 1.22 | 0.97 | 20.39 | 0.00 |
| 2001 | 10338.16 | 8240 | 1250 | 94.07 | 94.07 | 94.41 | 94.06 | 0.00 | 0.00 | 5.93 | 0.00 |
| 2002 | 10867.94 | 8573 | 1250 | 97.85 | 97.85 | 99.01 | 97.87 | 2.15 | 2.15 | 0.00 | 0.00 |
| 2003 | 6858.78 | 5433 | 1250 | 62.26 | 62.26 | 62.64 | 62.02 | 33.18 | 30.92 | 6.82 | 0.00 |
| 2004 | 11103.58 | 8712 | 1250 | 99.17 | 99.17 | 101.13 | 99.18 | 0.83 | 0.83 | 0.00 | 0.00 |
| 2005 | 9901.85 | 7845 | 1280 | 89.57 | 89.57 | 88.30 | 89.54 | 0.00 | 0.00 | 10.43 | 0.00 |
| 2006 | 10144.55 | 7942 | 1280 | 90.67 | 90.67 | 90.47 | 90.66 | 0.00 | 0.00 | 9.33 | 0.00 |
| 2007 | 11804.80 | 8760 | 1280 | 100.00 | 100.00 | 105.28 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 10800.56 | 8108 | 1280 | 92.31 | 92.31 | 96.06 | 92.30 | 0.00 | 0.00 | 7.69 | 0.00 |
| 2009 | 10052.23 | 7582 | 1280 | 86.56 | 86.56 | 89.65 | 86.55 | 0.00 | 0.00 | 13.44 | 0.00 |
| 2010 | 11304.11 | 8588 | 1280 | 98.05 | 98.05 | 100.81 | 98.04 | 1.95 | 1.95 | 0.00 | 0.00 |
| 2011 | 10616.20 | 7909 | 1280 | 90.52 | 90.52 | 94.68 | 90.29 | 0.00 | 0.00 | 9.48 | 0.00 |
| 2012 | 10520.66 | 7891 | 1280 | 89.85 | 89.85 | 93.57 | 89.83 | 0.00 | 0.00 | 10.15 | 0.00 |
| 2013 | 11019.47 | 8247 | 1280 | 94.14 | 94.14 | 98.26 | 94.13 | 0.00 | 0.00 | 5.86 | 0.00 |
| 2014 | 9075.07 | 6894 | 1280 | 78.70 | 78.70 | 80.93 | 78.70 | 0.00 | 0.00 | 21.30 | 0.00 |
| 2015 | 9331.90 | 7140 | 1280 | 81.51 | 81.51 | 83.23 | 81.51 | 1.22 | 1.01 | 17.49 | 0.00 |
| 2016 | 11288.14 | 8599 | 1280 | 97.89 | 97.89 | 100.40 | 97.89 | 2.11 | 2.11 | 0.00 | 0.00 |
| 2017 | 10109.92 | 7715 | 1280 | 88.08 | 88.08 | 90.16 | 88.07 | 0.51 | 0.45 | 11.47 | 0.00 |
| 2018 | 10306.36 | 7881 | 1280 | 90.20 | 90.20 | 91.92 | 89.97 | 0.00 | 0.00 | 9.80 | 0.00 |
| 2019 | 11515.33 | 8760 | 1280 | 100.00 | 100.00 | 102.70 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 10409.82 | 7965 | 1280 | 90.69 | 90.69 | 92.59 | 90.68 | 0.00 | 0.00 | 9.31 | 0.00 |
| 2021 | 10097.71 | 7915 | 1280 | 90.36 | 90.36 | 90.06 | 90.35 | 0.99 | 1.63 | 8.01 | 0.00 |
| 2022 | 11593.44 | 8760 | 1280 | 100.00 | 100.00 | 103.39 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 10372.14 | 7932 | 1280 | 90.74 | 90.74 | 92.50 | 90.55 | 0.00 | 0.00 | 9.26 | 0.00 |

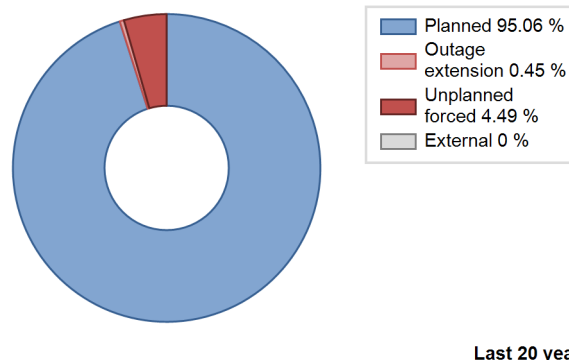
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1988 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 465 | |
| B. Refuelling without maintenance | | | | 43 | | |
| C. Inspection, maintenance or repair combined with refuelling | 414 | | | 676 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 59 | 27 | |
| E. Testing of plant systems or components | | | | 4 | | |
| H. Nuclear regulatory requirements | | | | | 11 | |
| L. Human factor related | | | | | 11 | |
| Z. Other | | | | 0 | 4 | |
| Subtotal | 414 | | | 782 | 518 | |
| Total | | 414 | | | 1300 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1988 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 2 |
| 12. Reactor I&C Systems | | 5 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | | 267 |
| 15. Reactor Cooling Systems | | 7 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 91 |
| 31. Turbine and auxiliaries | | 14 |
| 32. Feedwater and Main Steam System | | 15 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 49 |
| 42. Electrical Power Supply Systems | | 4 |
| Total | | 466 |

2023 Operating Experience

US-499

SOUTH TEXAS-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : STP (STP Nuclear Operating Co.)
 Owner : NRGENERG (NRG Energy, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3853 MWth
 Gross electrical power : 1354 MWe
 Reference unit power (net) : 1280 MWe

Key Dates

Construction Date : 1975-12-22
 Grid Date : 1989-04-11
 Commercial Date : 1989-06-19
 Age at end of year : 34 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 16.7
 Average discharge burnup [MWd/t] : 43000
 Active core diameter [m] : 3.37
 Active core height/length [m] : 4.27
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.03
 Number of control rod assemblies : 29
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 330
 Number of SG : 4
 Containment type : -
 Containment design pressure [MPa] : 0.397

Secondary systems

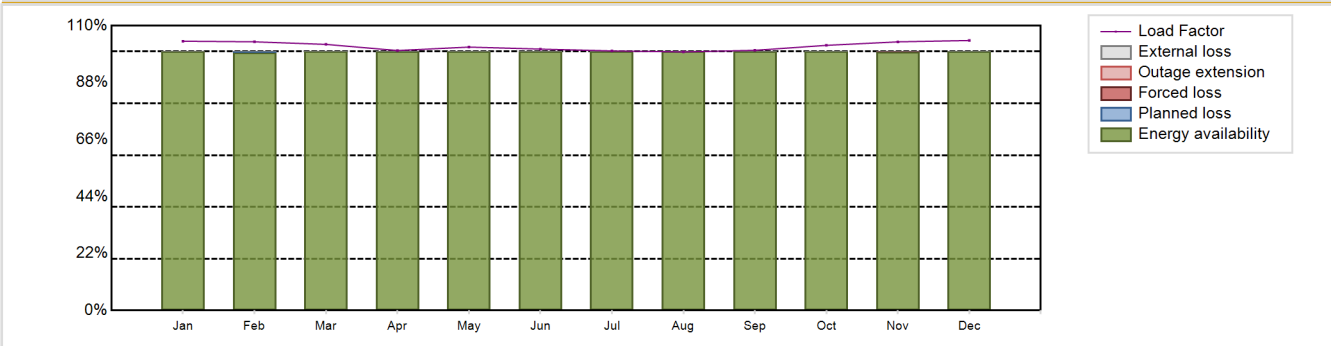
Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 7.55
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Pond (closed-cycle)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 11443.58 GW(e).h
 Energy Availability Factor (EAF) : 99.96 %
 Unit Capability Factor (UCF) : 99.96 %
 Load Factor (LF) : 102.06 %
 Operating Factor (OF) : 100 %

Forced Loss Rate (FLR) : 0.01 %
 Unplanned Capability Loss Factor (UCL) : 0.01 %
 Planned Unavailability Factor (PUF) : 0.03 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

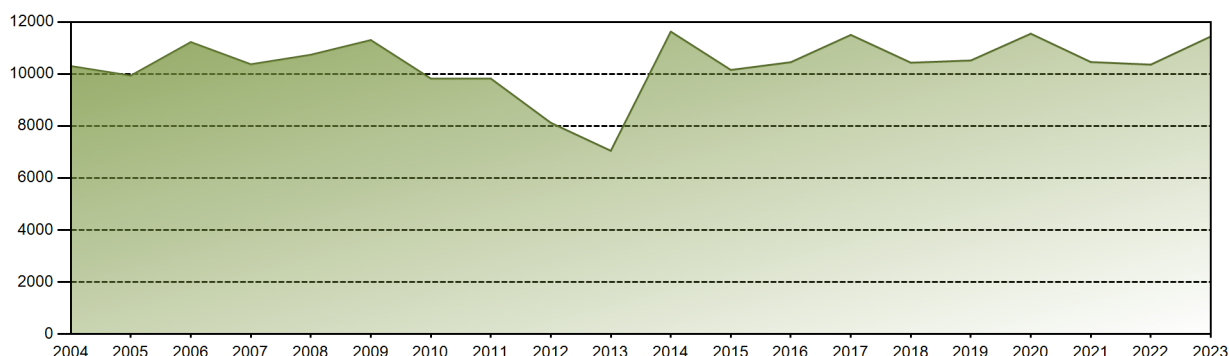


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 990.45 | 892.63 | 977.49 | 925.39 | 969.00 | 930.57 | 954.71 | 951.19 | 926.11 | 975.27 | 957.63 | 993.13 | 11443.58 |
| EAF [%] | 100.00 | 99.62 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.90 | 100.00 | 99.96 |
| UCF [%] | 100.00 | 99.62 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.90 | 100.00 | 99.96 |
| LF [%] | 104.00 | 103.77 | 102.78 | 100.41 | 101.75 | 100.97 | 100.25 | 99.88 | 100.49 | 102.41 | 103.77 | 104.29 | 102.06 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.01 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.01 |
| PUF [%] | 0.00 | 0.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

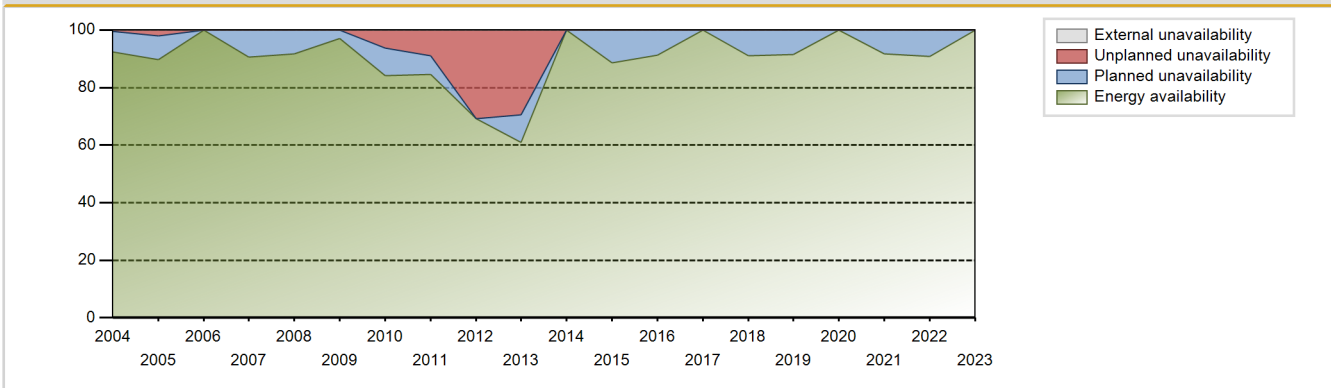
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 328305.96 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 6.42 % |
| Cumulative Energy Availability Factor (EAF) | : 85.15 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 5.84 % |
| Cumulative Unit Capability Factor (UCF) | : 85.15 % | Cumulative Planned Unavailability Factor (PUF) | : 9.01 % |
| Cumulative Load Factor (LF) | : 85.61 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 85.08 % | | |

Electricity Production (net) [GWh]

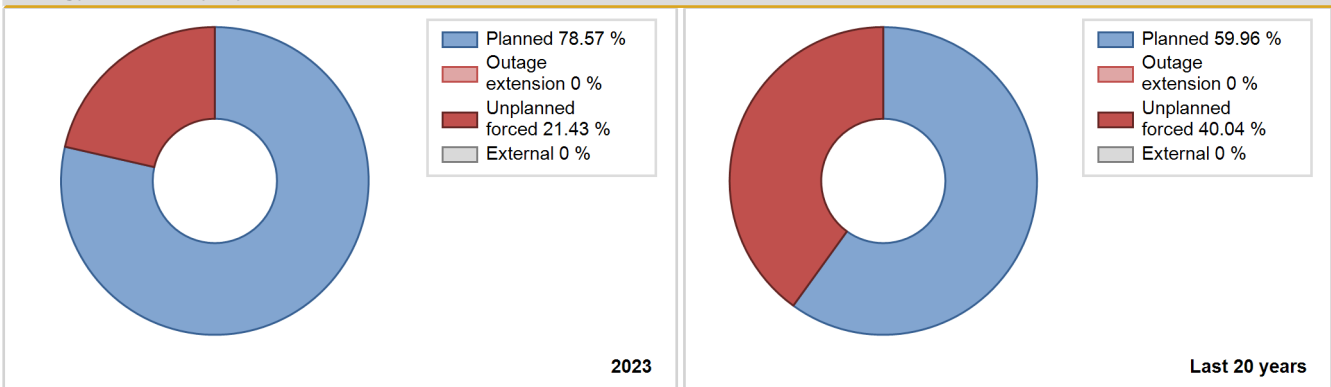


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 3026.67 | 2845 | 1250 | 57.92 | 57.92 | 48.32 | 57.89 | 22.68 | 16.99 | 25.09 | 0.00 |
| 1990 | 6452.17 | 5494 | 1251 | 62.76 | 62.76 | 58.88 | 62.72 | 21.61 | 17.31 | 19.93 | 0.00 |
| 1991 | 7267.99 | 6134 | 1251 | 70.03 | 70.03 | 66.32 | 70.02 | 9.37 | 7.24 | 22.73 | 0.00 |
| 1992 | 10340.97 | 8548 | 1251 | 97.32 | 97.32 | 94.10 | 97.31 | 2.68 | 2.68 | 0.00 | 0.00 |
| 1993 | 690.30 | 702 | 1251 | 8.00 | 8.00 | 6.30 | 8.01 | 51.35 | 8.45 | 83.55 | 0.00 |
| 1994 | 5990.98 | 5098 | 1251 | 58.23 | 58.23 | 54.67 | 58.20 | 41.72 | 41.68 | 0.09 | 0.00 |
| 1995 | 9923.09 | 7985 | 1251 | 91.19 | 91.19 | 90.55 | 91.15 | 1.69 | 1.56 | 7.25 | 0.00 |
| 1996 | 10457.93 | 8373 | 1251 | 95.34 | 95.34 | 95.17 | 95.32 | 0.68 | 0.65 | 4.01 | 0.00 |
| 1997 | 9972.90 | 8093 | 1251 | 92.44 | 92.44 | 91.00 | 92.39 | 2.88 | 2.74 | 4.82 | 0.00 |
| 1998 | 9983.91 | 8096 | 1250 | 92.46 | 92.46 | 91.11 | 92.42 | 1.33 | 1.25 | 6.29 | 0.00 |
| 1999 | 9799.26 | 8034 | 1250 | 91.73 | 91.73 | 89.49 | 91.71 | 0.99 | 0.91 | 7.36 | 0.00 |
| 2000 | 10557.22 | 8449 | 1250 | 96.20 | 96.20 | 96.15 | 96.19 | 2.08 | 2.04 | 1.75 | 0.00 |
| 2001 | 9537.56 | 7751 | 1250 | 88.52 | 88.52 | 87.10 | 88.48 | 4.44 | 4.12 | 7.36 | 0.00 |
| 2002 | 8219.85 | 6663 | 1250 | 75.89 | 75.89 | 75.07 | 76.06 | 7.57 | 6.22 | 17.89 | 0.00 |
| 2003 | 8920.21 | 7112 | 1250 | 81.07 | 81.07 | 81.46 | 81.19 | 18.93 | 18.93 | 0.00 | 0.00 |
| 2004 | 10304.10 | 8121 | 1250 | 92.28 | 92.28 | 93.84 | 92.45 | 0.50 | 0.46 | 7.26 | 0.00 |
| 2005 | 9937.18 | 7866 | 1280 | 89.81 | 89.81 | 88.62 | 89.79 | 2.18 | 2.00 | 8.19 | 0.00 |
| 2006 | 11225.96 | 8760 | 1280 | 100.00 | 100.00 | 100.12 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 10373.70 | 7943 | 1280 | 90.68 | 90.68 | 92.52 | 90.67 | 0.00 | 0.00 | 9.32 | 0.00 |
| 2008 | 10739.07 | 8047 | 1280 | 91.61 | 91.61 | 95.51 | 91.61 | 0.00 | 0.00 | 8.39 | 0.00 |
| 2009 | 11303.91 | 8498 | 1280 | 97.01 | 97.01 | 100.81 | 97.01 | 0.00 | 0.00 | 2.99 | 0.00 |
| 2010 | 9822.67 | 7371 | 1280 | 84.16 | 84.16 | 87.60 | 84.14 | 6.86 | 6.20 | 9.63 | 0.00 |
| 2011 | 9823.15 | 7408 | 1280 | 84.59 | 84.59 | 87.61 | 84.57 | 9.61 | 9.00 | 6.42 | 0.00 |
| 2012 | 8122.51 | 6073 | 1280 | 69.15 | 69.15 | 72.24 | 69.14 | 30.85 | 30.85 | 0.00 | 0.00 |
| 2013 | 7046.84 | 5338 | 1280 | 60.95 | 60.95 | 62.84 | 60.93 | 32.55 | 29.42 | 9.64 | 0.00 |
| 2014 | 11628.69 | 8760 | 1280 | 100.00 | 100.00 | 103.71 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 10154.98 | 7767 | 1280 | 88.67 | 88.67 | 90.57 | 88.66 | 0.00 | 0.00 | 11.33 | 0.00 |
| 2016 | 10452.92 | 8024 | 1280 | 91.35 | 91.35 | 92.97 | 91.35 | 0.00 | 0.00 | 8.65 | 0.00 |
| 2017 | 11502.22 | 8760 | 1280 | 100.00 | 100.00 | 102.58 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 10434.48 | 7964 | 1280 | 91.12 | 91.12 | 93.06 | 90.91 | 0.00 | 0.00 | 8.88 | 0.00 |
| 2019 | 10518.90 | 8007 | 1280 | 91.42 | 91.42 | 93.81 | 91.40 | 0.00 | 0.00 | 8.58 | 0.00 |
| 2020 | 11548.94 | 8783 | 1280 | 100.00 | 100.00 | 102.72 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 10458.96 | 8028 | 1280 | 91.64 | 91.64 | 93.28 | 91.64 | 0.00 | 0.00 | 8.36 | 0.00 |
| 2022 | 10360.23 | 7951 | 1280 | 90.75 | 90.75 | 92.40 | 90.76 | 0.00 | 0.00 | 9.25 | 0.00 |
| 2023 | 11443.58 | 8760 | 1280 | 99.96 | 99.96 | 102.06 | 100.00 | 0.01 | 0.01 | 0.03 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 502 | |
| B. Refuelling without maintenance | | | | 45 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 693 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 54 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| L. Human factor related | | | | | 5 | |
| Z. Other | | | | | 5 | |
| Subtotal | | | | 793 | 513 | |
| Total | | 0 | | | 1306 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 4 |
| 13. Reactor Auxiliary Systems | | 6 |
| 14. Safety Systems | | 119 |
| 15. Reactor Cooling Systems | | 6 |
| 16. Steam generation systems | | 9 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 4 |
| 31. Turbine and auxiliaries | | 67 |
| 32. Feedwater and Main Steam System | | 31 |
| 33. Circulating Water System | | 1 |
| 34. Miscellaneous Systems | | 9 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 126 |
| 42. Electrical Power Supply Systems | | 114 |
| Total | | 501 |

2023 Operating Experience

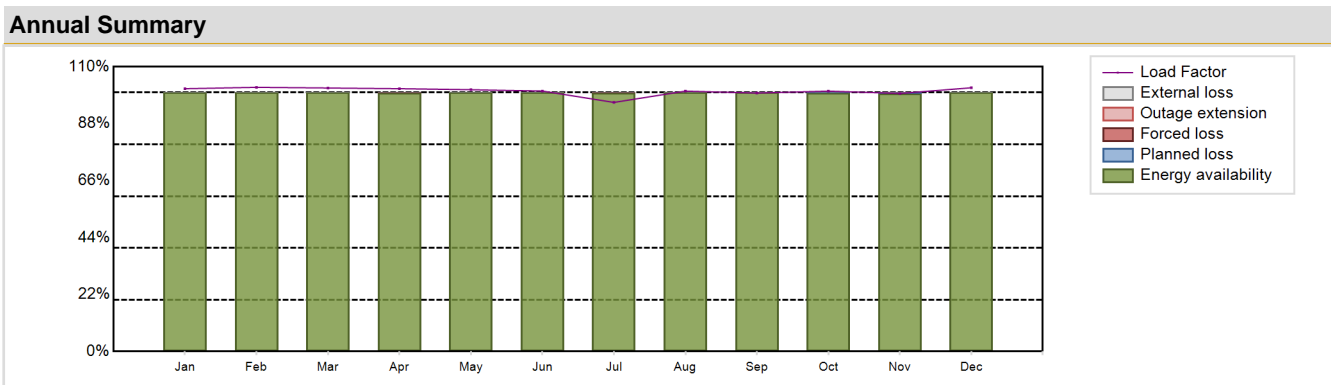
US-335 **ST. LUCIE-1** **UNITED STATES OF AMERICA**

Status at end of year : **Operational**
 Operator : FPL (Florida Power & Light Co.)
 Owner : FPL (Florida Power & Light Co.)
 Reactor Supplier : CE (COMBUSTION ENGINEERING CO.)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / CE 2LP (DRYAMB) | Construction Date | : 1970-07-01 |
| Thermal power | : 3020 MWth | Grid Date | : 1976-05-07 |
| Gross electrical power | : 1045 MWe | Commercial Date | : 1976-12-21 |
| Reference unit power (net) | : 981 MWe | Age at end of year | : 47 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.5 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 314 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.31 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.45 | HP cylinder inlet steam pressure [MPa] | : 5.38 |
| Active core height/length [m] | : 3.47 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 217 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 19.4 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 73 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 8644.64 GW(e).h | Forced Loss Rate (FLR) | : 0.01 % |
| Energy Availability Factor (EAF) | : 99.97 % | Unplanned Capability Loss Factor (UCL) | : 0.01 % |
| Unit Capability Factor (UCF) | : 99.97 % | Planned Unavailability Factor (PUF) | : 0.02 % |
| Load Factor (LF) | : 100.59 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

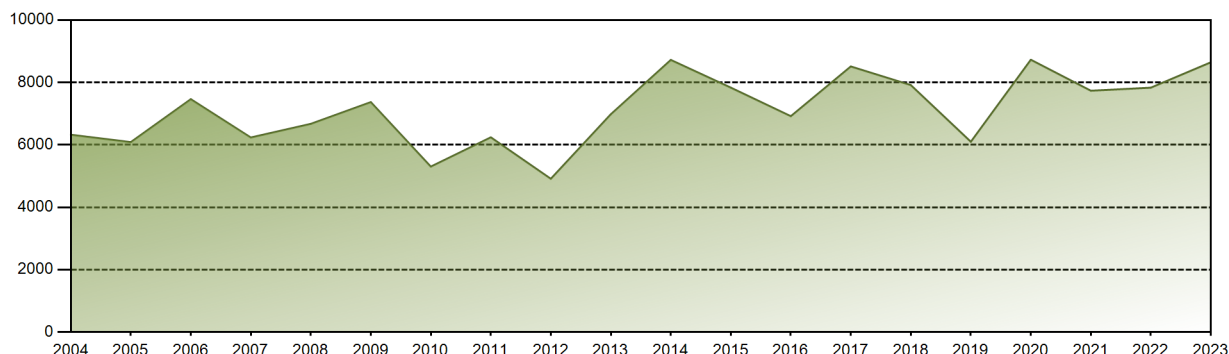


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 740.95 | 672.58 | 741.85 | 716.98 | 738.01 | 710.58 | 702.20 | 734.00 | 705.10 | 733.98 | 704.91 | 743.51 | 8644.64 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 99.97 | 100.00 | 100.00 | 99.97 | 100.00 | 100.00 | 99.97 | 99.73 | 100.00 | 99.97 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 99.97 | 100.00 | 100.00 | 99.97 | 100.00 | 100.00 | 99.97 | 99.73 | 100.00 | 99.97 |
| LF [%] | 101.52 | 102.02 | 101.78 | 101.51 | 101.12 | 100.60 | 96.21 | 100.57 | 99.83 | 100.56 | 99.66 | 101.87 | 100.59 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.27 | 0.00 | 0.02 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 299951.08 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.72 % |
| Cumulative Energy Availability Factor (EAF) | : 84.17 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.26 % |
| Cumulative Unit Capability Factor (UCF) | : 84.36 % | Cumulative Planned Unavailability Factor (PUF) | : 12.38 % |
| Cumulative Load Factor (LF) | : 83.98 % | Cumulative Externally cause unavailability (XUF) | : 0.19 % |
| Cumulative Operating Factor (OF) | : 84.04 % | | |

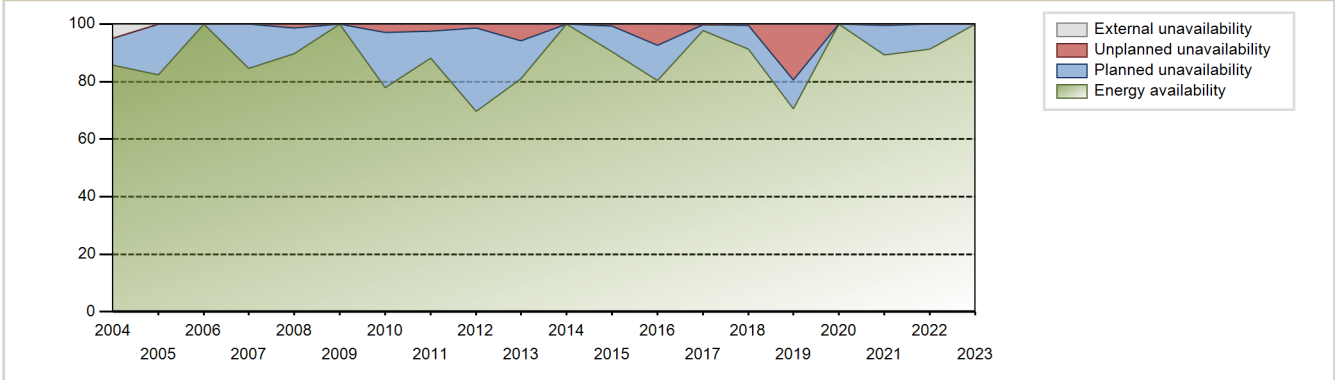
Electricity Production (net) [GWh]



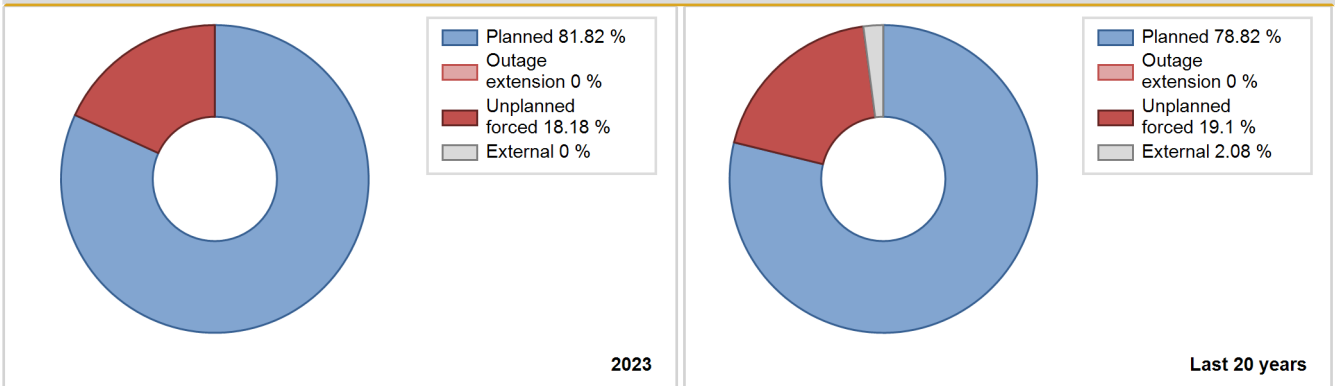
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1976 | 317.20 | 919 | 814 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1977 | 5343.70 | 7414 | 779 | 78.39 | 78.39 | 78.31 | 84.63 | 16.10 | 15.04 | 6.57 | 0.00 |
| 1978 | 5009.70 | 6674 | 777 | 73.65 | 73.65 | 73.60 | 76.19 | 3.45 | 2.64 | 23.71 | 0.00 |
| 1979 | 4889.60 | 6469 | 777 | 71.70 | 71.70 | 71.84 | 73.85 | 3.60 | 2.67 | 25.63 | 0.00 |
| 1980 | 5201.90 | 6797 | 777 | 75.98 | 75.98 | 76.22 | 77.38 | 7.26 | 5.95 | 18.07 | 0.00 |
| 1981 | 4954.70 | 6364 | 777 | 70.48 | 70.48 | 72.79 | 72.65 | 5.05 | 3.75 | 25.77 | 0.00 |
| 1982 | 6784.60 | 8227 | 803 | 94.15 | 94.15 | 96.45 | 93.92 | 0.55 | 0.52 | 5.33 | 0.00 |
| 1983 | 1099.50 | 1350 | 820 | 15.40 | 15.40 | 15.31 | 15.41 | 1.15 | 0.18 | 84.43 | 0.00 |
| 1984 | 4243.28 | 5154 | 822 | 58.64 | 60.77 | 58.77 | 58.67 | 3.05 | 1.91 | 37.31 | 2.13 |
| 1985 | 5868.61 | 7067 | 825 | 80.39 | 80.39 | 81.13 | 80.67 | 1.45 | 1.18 | 18.43 | 0.00 |
| 1986 | 7052.03 | 8351 | 829 | 95.70 | 95.70 | 97.10 | 95.33 | 0.50 | 0.48 | 3.82 | 0.00 |
| 1987 | 5719.18 | 6812 | 839 | 77.80 | 77.80 | 77.82 | 77.76 | 4.35 | 3.54 | 18.66 | 0.00 |
| 1988 | 6256.01 | 7407 | 839 | 84.36 | 84.36 | 84.89 | 84.32 | 1.56 | 1.34 | 14.31 | 0.00 |
| 1989 | 6947.34 | 8257 | 839 | 94.28 | 94.28 | 94.53 | 94.26 | 0.53 | 0.51 | 5.22 | 0.00 |
| 1990 | 4503.49 | 5463 | 839 | 64.29 | 64.29 | 61.27 | 62.36 | 33.77 | 32.79 | 2.92 | 0.00 |
| 1991 | 5793.30 | 7089 | 839 | 80.95 | 80.95 | 78.82 | 80.92 | 1.16 | 0.95 | 18.11 | 0.00 |
| 1992 | 7142.17 | 8479 | 839 | 96.54 | 96.54 | 96.91 | 96.53 | 3.46 | 3.46 | 0.00 | 0.00 |
| 1993 | 5440.51 | 6678 | 839 | 76.24 | 76.60 | 74.02 | 76.23 | 1.61 | 1.26 | 22.15 | 0.35 |
| 1994 | 6183.59 | 7600 | 839 | 86.84 | 86.84 | 84.13 | 86.76 | 5.03 | 4.60 | 8.56 | 0.00 |
| 1995 | 5519.42 | 6662 | 839 | 76.16 | 76.16 | 75.10 | 76.05 | 21.82 | 21.26 | 2.58 | 0.00 |
| 1996 | 5222.04 | 6472 | 839 | 73.76 | 73.76 | 70.86 | 73.68 | 2.99 | 2.28 | 23.96 | 0.00 |
| 1997 | 5717.75 | 6842 | 839 | 78.14 | 78.14 | 77.80 | 78.11 | 2.33 | 1.86 | 20.00 | 0.00 |
| 1998 | 7035.48 | 8393 | 839 | 95.82 | 95.82 | 95.73 | 95.81 | 0.48 | 0.46 | 3.72 | 0.00 |
| 1999 | 6532.73 | 7752 | 839 | 88.50 | 89.87 | 88.89 | 88.49 | 1.99 | 1.83 | 8.30 | 1.37 |
| 2000 | 7513.70 | 8784 | 839 | 100.00 | 100.00 | 101.95 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 6709.77 | 7915 | 839 | 90.37 | 90.37 | 91.29 | 90.35 | 1.92 | 1.77 | 7.86 | 0.00 |
| 2002 | 6919.40 | 8163 | 839 | 93.20 | 93.20 | 94.15 | 93.18 | 0.00 | 0.00 | 6.80 | 0.00 |
| 2003 | 7504.81 | 8760 | 839 | 100.00 | 100.00 | 102.11 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2004 | 6324.30 | 7518 | 839 | 85.62 | 90.45 | 85.81 | 85.59 | 0.00 | 0.00 | 9.55 | 4.83 |
| 2005 | 6088.09 | 7217 | 839 | 82.40 | 82.40 | 82.84 | 82.39 | 0.00 | 0.00 | 17.60 | 0.00 |
| 2006 | 7463.29 | 8760 | 839 | 100.00 | 100.00 | 101.55 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2007 | 6235.76 | 7417 | 839 | 84.68 | 84.68 | 84.84 | 84.67 | 0.00 | 0.00 | 15.32 | 0.00 |
| 2008 | 6673.04 | 7872 | 839 | 89.63 | 89.63 | 90.55 | 89.62 | 1.62 | 1.47 | 8.90 | 0.00 |
| 2009 | 7369.21 | 8760 | 839 | 100.00 | 100.00 | 100.27 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 5302.68 | 6813 | 839 | 77.79 | 77.79 | 72.15 | 77.77 | 3.63 | 2.93 | 19.28 | 0.00 |
| 2011 | 6240.99 | 7719 | 839 | 88.13 | 88.13 | 84.92 | 88.12 | 2.67 | 2.42 | 9.45 | 0.00 |
| 2012 | 4912.62 | 5821 | 982 | 69.71 | 69.71 | 59.09 | 66.27 | 1.83 | 1.30 | 29.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|-------|-------|-------|------|
| 2013 | 6980.44 | 7104 | 982 | 81.09 | 81.09 | 81.14 | 81.09 | 6.68 | 5.80 | 13.11 | 0.00 |
| 2014 | 8721.17 | 8760 | 982 | 100.00 | 100.00 | 101.38 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 7833.25 | 7927 | 982 | 90.48 | 90.48 | 91.06 | 90.49 | 0.65 | 0.59 | 8.92 | 0.00 |
| 2016 | 6918.93 | 7059 | 982 | 80.36 | 80.36 | 80.21 | 80.36 | 8.42 | 7.39 | 12.25 | 0.00 |
| 2017 | 8512.14 | 8554 | 981 | 97.64 | 98.00 | 99.05 | 97.65 | 0.00 | 0.00 | 2.00 | 0.35 |
| 2018 | 7914.55 | 7986 | 981 | 91.17 | 91.17 | 92.10 | 91.16 | 0.42 | 0.38 | 8.45 | 0.00 |
| 2019 | 6098.13 | 6182 | 981 | 70.59 | 70.59 | 70.96 | 70.57 | 21.67 | 19.53 | 9.89 | 0.00 |
| 2020 | 8726.84 | 8783 | 981 | 100.00 | 100.00 | 101.27 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 7734.30 | 7811 | 981 | 89.17 | 89.17 | 90.00 | 89.17 | 0.49 | 0.44 | 10.38 | 0.00 |
| 2022 | 7831.28 | 8001 | 981 | 91.33 | 91.33 | 91.13 | 91.34 | 0.01 | 0.01 | 8.65 | 0.00 |
| 2023 | 8644.64 | 8760 | 981 | 99.97 | 99.97 | 100.59 | 100.00 | 0.01 | 0.01 | 0.02 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1976 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 333 | |
| B. Refuelling without maintenance | | | | 35 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 985 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 72 | | |
| E. Testing of plant systems or components | | | | 3 | | |
| L. Human factor related | | | | | 17 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 22 |
| Z. Other | | | | 0 | 3 | |
| Subtotal | | | | 1095 | 353 | 22 |
| Total | | 0 | | | 1470 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1976 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 103 |
| 12. Reactor I&C Systems | | 12 |
| 13. Reactor Auxiliary Systems | | 10 |
| 14. Safety Systems | | 11 |
| 15. Reactor Cooling Systems | | 100 |
| 16. Steam generation systems | | 1 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 1 |
| 31. Turbine and auxiliaries | | 13 |
| 32. Feedwater and Main Steam System | | 20 |
| 33. Circulating Water System | | 6 |
| 34. Miscellaneous Systems | | 12 |
| 41. Main Generator Systems | | 44 |
| 42. Electrical Power Supply Systems | | 19 |
| Total | | 352 |

2023 Operating Experience

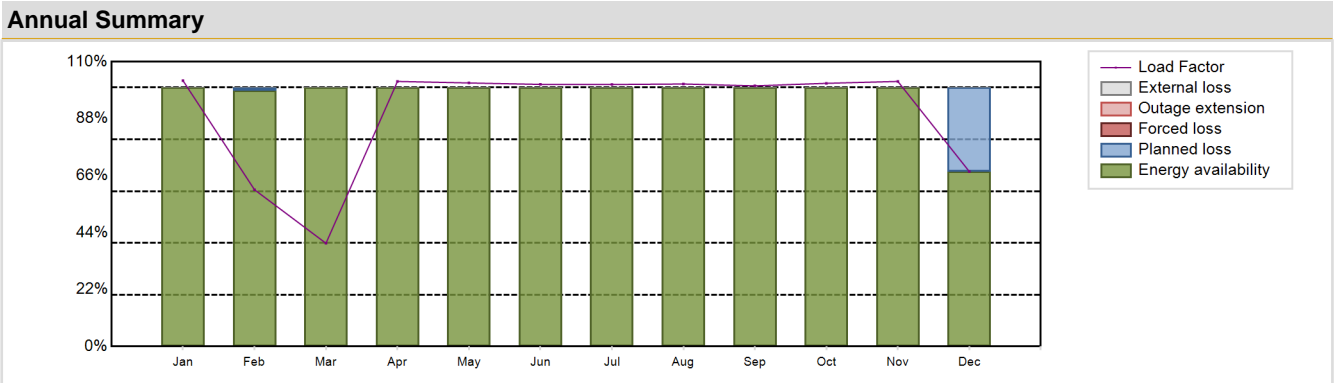
US-389 **ST. LUCIE-2** **UNITED STATES OF AMERICA**

Status at end of year : **Operational**
 Operator : FPL (Florida Power & Light Co.)
 Owner : FPL (Florida Power & Light Co.)
 Reactor Supplier : CE (COMBUSTION ENGINEERING CO.)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)

| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / CE 2LP (DRYAMB) | Construction Date | : 1977-06-02 |
| Thermal power | : 3020 MWth | Grid Date | : 1983-06-13 |
| Gross electrical power | : 1050 MWe | Commercial Date | : 1983-08-08 |
| Reference unit power (net) | : 987 MWe | Age at end of year | : 40 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.8 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 314 |
| Fuel material | : UO2 | Number of SG | : 2 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.31 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 35 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 36000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.45 | HP cylinder inlet steam pressure [MPa] | : 5.38 |
| Active core height/length [m] | : 3.47 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 217 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 14.5 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 91 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 7816.91 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 97.16 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 97.16 % | Planned Unavailability Factor (PUF) | : 2.84 % |
| Load Factor (LF) | : 90.41 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 89.35 % | Total off-line time | : 933 hours |

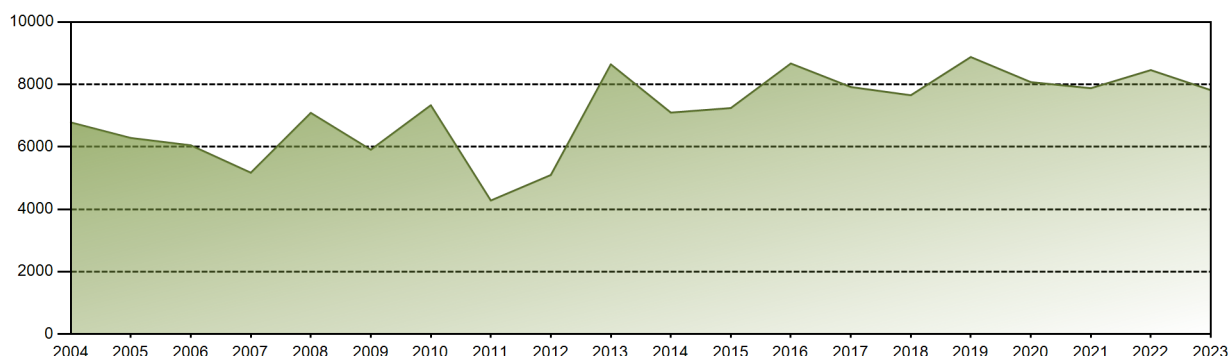


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 754.12 | 401.69 | 292.43 | 727.53 | 747.55 | 719.41 | 743.09 | 744.48 | 715.40 | 746.50 | 728.61 | 496.11 | 7816.91 |
| EAF [%] | 100.00 | 98.82 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 67.63 | 97.16 |
| UCF [%] | 100.00 | 98.82 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 67.63 | 97.16 |
| LF [%] | 102.69 | 60.56 | 39.88 | 102.38 | 101.80 | 101.23 | 101.19 | 101.38 | 100.67 | 101.66 | 102.39 | 67.56 | 90.41 |
| OF [%] | 100.00 | 60.71 | 42.40 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 67.61 | 89.35 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 1.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 32.37 | 2.84 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 269032.71 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.3 % |
| Cumulative Energy Availability Factor (EAF) | : 87.13 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.13 % |
| Cumulative Unit Capability Factor (UCF) | : 87.46 % | Cumulative Planned Unavailability Factor (PUF) | : 9.42 % |
| Cumulative Load Factor (LF) | : 86.74 % | Cumulative Externally cause unavailability (XUF) | : 0.33 % |
| Cumulative Operating Factor (OF) | : 86.69 % | | |

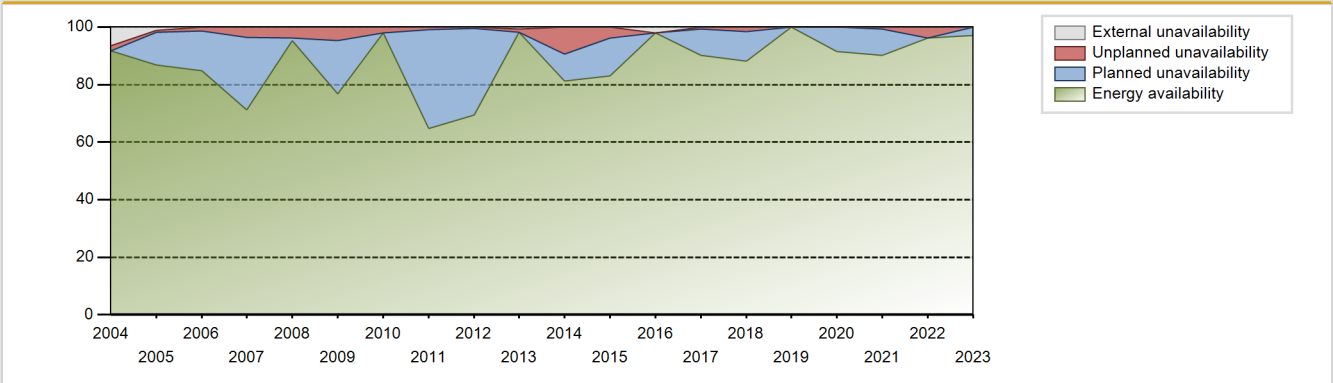
Electricity Production (net) [GWh]



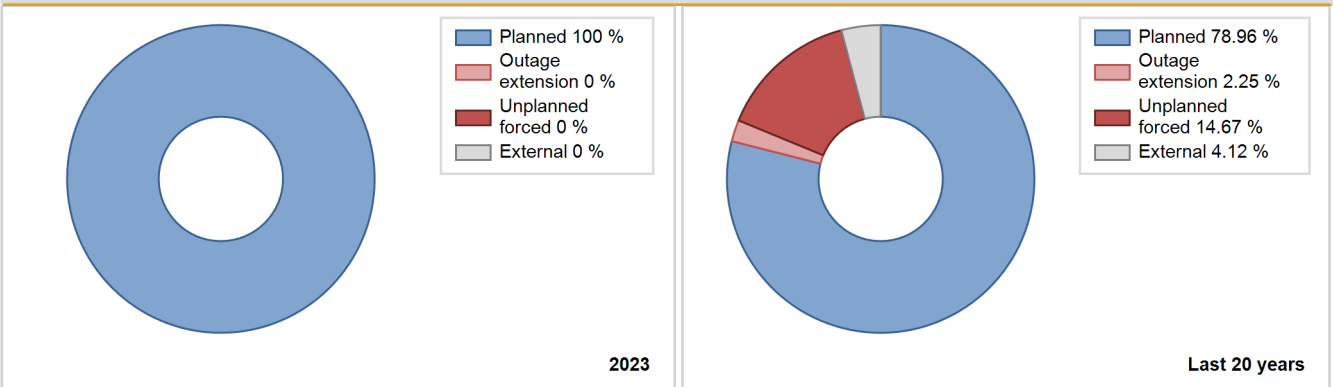
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 2575.80 | 3598 | 808 | 89.40 | 89.40 | 87.03 | 89.27 | 10.60 | 10.60 | 0.00 | 0.00 |
| 1984 | 5564.83 | 7067 | 786 | 79.49 | 82.85 | 80.60 | 80.45 | 6.88 | 6.13 | 11.02 | 3.36 |
| 1985 | 6108.63 | 7368 | 824 | 83.89 | 83.89 | 84.58 | 84.11 | 13.57 | 13.18 | 2.94 | 0.00 |
| 1986 | 6151.23 | 7253 | 837 | 82.80 | 82.80 | 83.86 | 82.80 | 1.02 | 0.86 | 16.35 | 0.00 |
| 1987 | 5950.18 | 7206 | 839 | 82.30 | 82.30 | 80.96 | 82.26 | 4.13 | 3.54 | 14.16 | 0.00 |
| 1988 | 7407.10 | 8784 | 839 | 100.00 | 100.00 | 100.51 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1989 | 5443.45 | 6531 | 839 | 74.59 | 74.59 | 74.06 | 74.55 | 2.05 | 1.56 | 23.85 | 0.00 |
| 1990 | 5341.48 | 6487 | 839 | 74.08 | 74.08 | 72.68 | 74.05 | 10.25 | 8.46 | 17.47 | 0.00 |
| 1991 | 7428.74 | 8760 | 839 | 100.00 | 100.00 | 101.08 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1992 | 5431.15 | 6598 | 839 | 75.15 | 75.15 | 73.69 | 75.11 | 8.10 | 6.63 | 18.23 | 0.00 |
| 1993 | 4719.91 | 6687 | 839 | 76.36 | 76.36 | 64.22 | 76.34 | 23.64 | 23.64 | 0.00 | 0.00 |
| 1994 | 5607.44 | 6971 | 839 | 79.62 | 79.62 | 76.30 | 79.58 | 2.30 | 1.87 | 18.50 | 0.00 |
| 1995 | 5295.95 | 6570 | 839 | 75.05 | 75.05 | 72.06 | 75.00 | 2.52 | 1.94 | 23.01 | 0.00 |
| 1996 | 6984.80 | 8444 | 839 | 96.16 | 96.16 | 94.78 | 96.13 | 2.75 | 2.72 | 1.12 | 0.00 |
| 1997 | 6498.92 | 7756 | 839 | 88.55 | 88.55 | 88.43 | 88.54 | 0.00 | 0.00 | 11.45 | 0.00 |
| 1998 | 6739.45 | 8009 | 839 | 91.45 | 91.45 | 91.70 | 91.43 | 0.00 | 0.00 | 8.55 | 0.00 |
| 1999 | 7212.98 | 8583 | 839 | 97.99 | 97.99 | 98.14 | 97.98 | 2.01 | 2.01 | 0.00 | 0.00 |
| 2000 | 6804.33 | 8041 | 839 | 91.56 | 91.56 | 92.33 | 91.54 | 4.79 | 4.61 | 3.83 | 0.00 |
| 2001 | 6707.49 | 7979 | 839 | 91.11 | 91.11 | 91.26 | 91.08 | 1.97 | 1.84 | 7.05 | 0.00 |
| 2002 | 7424.99 | 8742 | 839 | 99.80 | 99.80 | 101.03 | 99.79 | 0.00 | 0.00 | 0.20 | 0.00 |
| 2003 | 5891.34 | 7120 | 839 | 81.31 | 81.31 | 80.16 | 81.28 | 6.03 | 5.22 | 13.47 | 0.00 |
| 2004 | 6781.43 | 8059 | 839 | 91.77 | 98.17 | 92.02 | 91.75 | 1.83 | 1.83 | 0.00 | 6.40 |
| 2005 | 6283.15 | 7602 | 839 | 86.81 | 87.89 | 85.49 | 86.78 | 0.97 | 0.86 | 11.26 | 1.08 |
| 2006 | 6048.25 | 7434 | 839 | 84.88 | 84.88 | 82.29 | 84.86 | 1.70 | 1.47 | 13.65 | 0.00 |
| 2007 | 5170.45 | 6232 | 839 | 71.16 | 71.16 | 70.35 | 71.14 | 4.71 | 3.52 | 25.32 | 0.00 |
| 2008 | 7087.29 | 8361 | 839 | 95.19 | 95.19 | 96.17 | 95.18 | 3.83 | 3.79 | 1.02 | 0.00 |
| 2009 | 5906.55 | 6721 | 839 | 76.75 | 76.75 | 80.37 | 76.72 | 5.72 | 4.66 | 18.59 | 0.00 |
| 2010 | 7331.25 | 8589 | 839 | 98.05 | 98.05 | 99.75 | 98.05 | 1.95 | 1.95 | 0.00 | 0.00 |
| 2011 | 4279.08 | 5674 | 839 | 64.78 | 64.78 | 58.22 | 64.77 | 1.30 | 0.86 | 34.36 | 0.00 |
| 2012 | 5096.77 | 6101 | 839 | 69.47 | 69.47 | 69.16 | 69.46 | 0.78 | 0.54 | 29.99 | 0.00 |
| 2013 | 8641.77 | 8583 | 987 | 98.28 | 99.05 | 99.94 | 97.97 | 0.95 | 0.95 | 0.00 | 0.77 |
| 2014 | 7096.40 | 7121 | 987 | 81.30 | 81.30 | 82.08 | 81.29 | 5.23 | 9.51 | 9.19 | 0.00 |
| 2015 | 7242.01 | 7272 | 987 | 83.01 | 83.01 | 83.76 | 83.01 | 4.42 | 3.84 | 13.15 | 0.00 |
| 2016 | 8669.53 | 8604 | 987 | 97.95 | 100.00 | 100.00 | 97.95 | 0.00 | 0.00 | 0.00 | 2.05 |
| 2017 | 7915.78 | 7904 | 987 | 90.23 | 90.23 | 91.55 | 90.23 | 0.89 | 0.81 | 8.96 | 0.00 |
| 2018 | 7652.59 | 7723 | 987 | 88.16 | 88.16 | 88.51 | 88.16 | 1.68 | 1.51 | 10.33 | 0.00 |
| 2019 | 8876.97 | 8760 | 987 | 100.00 | 100.00 | 102.67 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|-------|-------|------|------|------|------|
| 2020 | 8073.53 | 8035 | 987 | 91.48 | 91.48 | 93.12 | 91.47 | 0.00 | 0.00 | 8.52 | 0.00 |
| 2021 | 7878.34 | 7890 | 987 | 90.07 | 90.07 | 91.12 | 90.07 | 0.86 | 0.78 | 9.16 | 0.00 |
| 2022 | 8458.50 | 8425 | 987 | 96.17 | 96.17 | 97.83 | 96.18 | 3.83 | 3.83 | 0.00 | 0.00 |
| 2023 | 7816.91 | 7827 | 987 | 97.16 | 97.16 | 90.41 | 89.35 | 0.00 | 0.00 | 2.84 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 249 | |
| B. Refuelling without maintenance | | | | 38 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 779 | | |
| D. Inspection, maintenance or repair without refuelling | 528 | | | 45 | | |
| E. Testing of plant systems or components | | | | 1 | 0 | |
| H. Nuclear regulatory requirements | | | | | 6 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 8 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 31 |
| P. Fire | | | | | 2 | |
| Z. Other | | | | 0 | 12 | |
| Subtotal | 528 | | | 863 | 277 | 31 |
| Total | | 528 | | | 1171 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 0 |
| 12. Reactor I&C Systems | | 27 |
| 14. Safety Systems | | 21 |
| 15. Reactor Cooling Systems | | 97 |
| 16. Steam generation systems | | 17 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 34 |
| 32. Feedwater and Main Steam System | | 44 |
| 33. Circulating Water System | | 7 |
| 34. Miscellaneous Systems | | 4 |
| 41. Main Generator Systems | | 19 |
| 42. Electrical Power Supply Systems | | 5 |
| Total | | 277 |

2023 Operating Experience

US-395

SUMMER-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : SCE&G (SOUTH CAROLINA ELECTRIC & GAS CO.)
 Owner : SCE&G (SOUTH CAROLINA ELECTRIC & GAS CO.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / WH 3LP (DRYAMB)
 Thermal power : 2900 MWth
 Gross electrical power : 1006 MWe
 Reference unit power (net) : 973 MWe

Key Dates

Construction Date : 1973-03-21
 Grid Date : 1982-11-16
 Commercial Date : 1984-01-01
 Age at end of year : 41 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 43.3
 Average discharge burnup [MWd/t] : 38900
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 17.83
 Number of control rod assemblies : -
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 327
 Number of SG : 3
 Containment type : -
 Containment design pressure [MPa] : 0.4

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 8.33
 Output voltage [kV] : -
 Primary means of condenser cooling : Lake (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

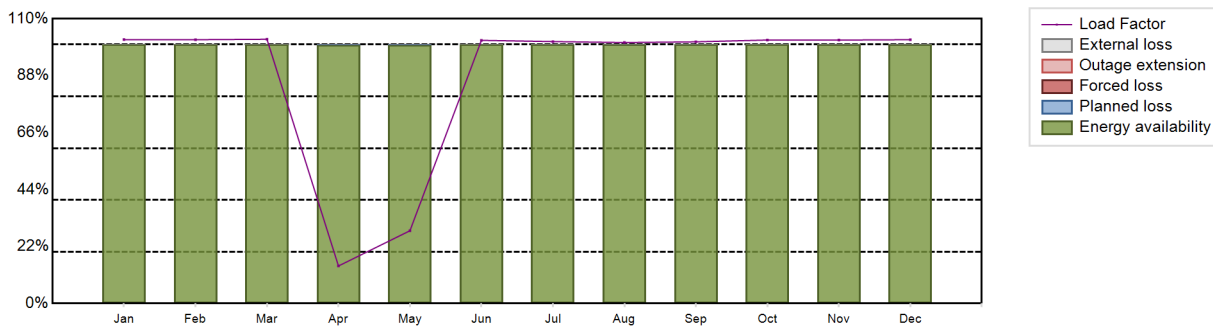
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7517.23 GW(e).h
 Energy Availability Factor (EAF) : 99.99 %
 Unit Capability Factor (UCF) : 99.99 %
 Load Factor (LF) : 88.19 %
 Operating Factor (OF) : 87.89 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.01 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1061 hours

Annual Summary

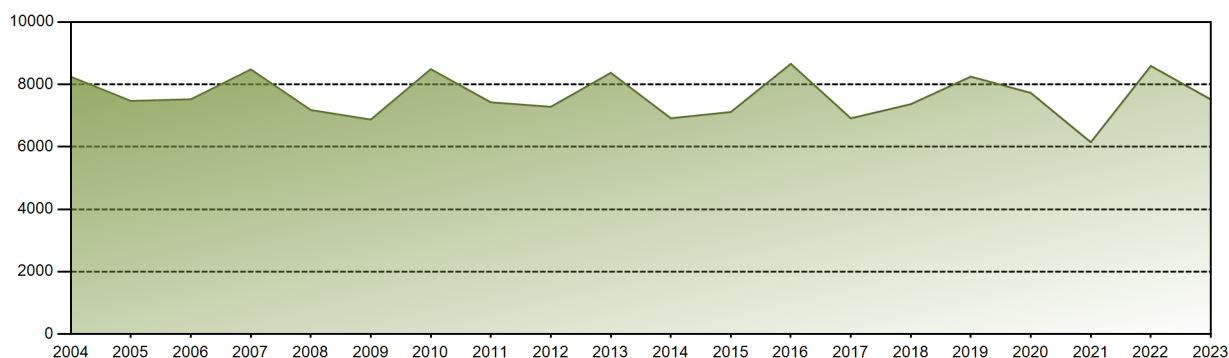


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 737.84 | 666.16 | 737.84 | 101.61 | 203.47 | 712.09 | 732.31 | 729.80 | 708.03 | 736.75 | 713.76 | 737.57 | 7517.23 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 99.97 | 99.90 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 99.97 | 99.90 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| LF [%] | 101.92 | 101.88 | 102.06 | 14.50 | 28.11 | 101.65 | 101.16 | 100.81 | 101.07 | 101.77 | 101.74 | 101.89 | 88.19 |
| OF [%] | 100.00 | 100.00 | 100.00 | 14.31 | 40.32 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 87.89 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.03 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 279529.5 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.32 % |
| Cumulative Energy Availability Factor (EAF) | : 86.68 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.06 % |
| Cumulative Unit Capability Factor (UCF) | : 86.68 % | Cumulative Planned Unavailability Factor (PUF) | : 11.26 % |
| Cumulative Load Factor (LF) | : 84.71 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 86.15 % | | |

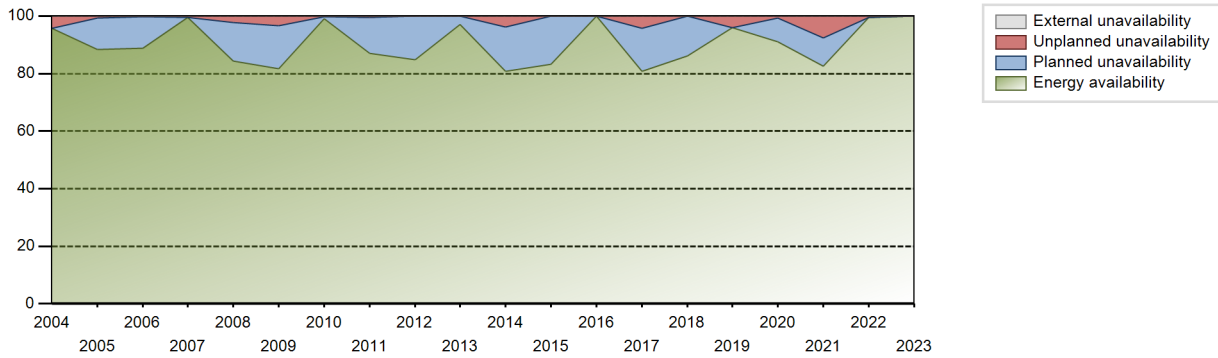
Electricity Production (net) [GWh]



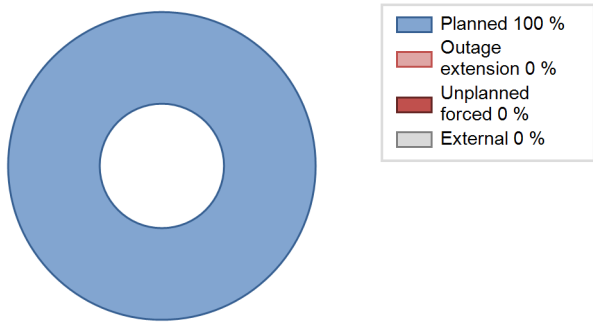
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1984 | 4208.59 | 5362 | 900 | 61.26 | 61.26 | 53.24 | 61.04 | 10.76 | 7.38 | 31.36 | 0.00 |
| 1985 | 5235.09 | 6272 | 885 | 71.64 | 71.64 | 67.53 | 71.60 | 6.13 | 4.68 | 23.68 | 0.00 |
| 1986 | 7160.64 | 8346 | 885 | 95.33 | 95.33 | 92.36 | 95.27 | 4.67 | 4.67 | 0.00 | 0.00 |
| 1987 | 5168.12 | 6135 | 885 | 70.07 | 70.07 | 66.66 | 70.03 | 5.44 | 4.03 | 25.90 | 0.00 |
| 1988 | 5068.16 | 5952 | 885 | 67.79 | 67.79 | 65.20 | 67.76 | 5.40 | 3.87 | 28.34 | 0.00 |
| 1989 | 5412.76 | 7073 | 885 | 80.79 | 80.79 | 69.82 | 80.74 | 19.04 | 18.99 | 0.21 | 0.00 |
| 1990 | 6117.27 | 7261 | 885 | 82.90 | 82.90 | 78.91 | 82.89 | 0.00 | 0.00 | 17.10 | 0.00 |
| 1991 | 5346.13 | 7065 | 885 | 80.65 | 80.65 | 68.96 | 80.65 | 0.72 | 0.58 | 18.77 | 0.00 |
| 1992 | 7515.20 | 8532 | 885 | 97.14 | 97.14 | 96.67 | 97.13 | 0.00 | 0.00 | 2.86 | 0.00 |
| 1993 | 6109.46 | 7258 | 885 | 82.87 | 82.87 | 78.81 | 82.85 | 1.44 | 1.21 | 15.92 | 0.00 |
| 1994 | 4456.04 | 6022 | 885 | 68.77 | 68.77 | 57.48 | 68.74 | 0.00 | 0.00 | 31.23 | 0.00 |
| 1995 | 7561.35 | 8478 | 885 | 96.80 | 96.80 | 97.53 | 96.78 | 0.02 | 0.02 | 3.17 | 0.00 |
| 1996 | 7155.13 | 7829 | 923 | 89.60 | 89.60 | 88.24 | 89.13 | 0.00 | 0.00 | 10.40 | 0.00 |
| 1997 | 7267.91 | 7805 | 948 | 89.87 | 89.87 | 87.49 | 89.10 | 1.52 | 1.39 | 8.75 | 0.00 |
| 1998 | 8188.92 | 8638 | 953 | 98.71 | 98.71 | 98.07 | 98.61 | 1.29 | 1.29 | 0.00 | 0.00 |
| 1999 | 7376.30 | 7779 | 954 | 88.85 | 88.85 | 88.26 | 88.80 | 0.74 | 0.66 | 10.49 | 0.00 |
| 2000 | 6358.81 | 6688 | 966 | 76.23 | 76.23 | 75.02 | 76.14 | 0.46 | 0.35 | 23.42 | 0.00 |
| 2001 | 6757.53 | 7095 | 966 | 81.02 | 81.02 | 79.86 | 80.99 | 0.87 | 0.71 | 18.27 | 0.00 |
| 2002 | 7379.52 | 7645 | 966 | 87.28 | 87.28 | 87.21 | 87.27 | 0.52 | 0.46 | 12.26 | 0.00 |
| 2003 | 7352.06 | 7564 | 966 | 86.37 | 86.37 | 86.88 | 86.35 | 1.14 | 1.00 | 12.64 | 0.00 |
| 2004 | 8243.34 | 8413 | 966 | 95.80 | 95.80 | 97.15 | 95.78 | 4.20 | 4.20 | 0.00 | 0.00 |
| 2005 | 7469.40 | 7746 | 966 | 88.44 | 88.44 | 88.26 | 88.41 | 0.69 | 0.61 | 10.95 | 0.00 |
| 2006 | 7521.40 | 7783 | 966 | 88.86 | 88.86 | 88.88 | 88.85 | 0.29 | 0.26 | 10.88 | 0.00 |
| 2007 | 8479.04 | 8719 | 966 | 99.53 | 99.53 | 100.20 | 99.53 | 0.47 | 0.47 | 0.00 | 0.00 |
| 2008 | 7178.10 | 7404 | 966 | 84.31 | 84.31 | 84.59 | 84.29 | 2.57 | 2.23 | 13.47 | 0.00 |
| 2009 | 6872.04 | 7150 | 966 | 81.64 | 81.64 | 81.21 | 81.62 | 3.94 | 3.35 | 15.01 | 0.00 |
| 2010 | 8487.08 | 8681 | 966 | 99.11 | 99.11 | 100.29 | 99.10 | 0.20 | 0.20 | 0.69 | 0.00 |
| 2011 | 7426.23 | 7622 | 966 | 87.02 | 87.02 | 87.76 | 87.01 | 0.66 | 0.58 | 12.40 | 0.00 |
| 2012 | 7281.60 | 7456 | 971 | 84.89 | 84.89 | 85.37 | 84.88 | 0.00 | 0.00 | 15.11 | 0.00 |
| 2013 | 8369.88 | 8501 | 971 | 97.05 | 97.05 | 98.39 | 97.03 | 0.00 | 0.00 | 2.95 | 0.00 |
| 2014 | 6914.78 | 7078 | 971 | 80.80 | 80.80 | 81.29 | 80.80 | 4.41 | 3.72 | 15.48 | 0.00 |
| 2015 | 7115.39 | 7301 | 971 | 83.35 | 83.35 | 83.65 | 83.34 | 0.00 | 0.00 | 16.65 | 0.00 |
| 2016 | 8658.36 | 8784 | 971 | 100.00 | 100.00 | 101.51 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 6913.29 | 7079 | 973 | 80.85 | 80.85 | 81.11 | 80.81 | 5.01 | 4.27 | 14.89 | 0.00 |
| 2018 | 7366.39 | 7540 | 973 | 86.17 | 86.17 | 86.42 | 86.07 | 0.00 | 0.00 | 13.83 | 0.00 |
| 2019 | 8248.44 | 8402 | 973 | 95.92 | 95.92 | 96.77 | 95.91 | 4.08 | 4.08 | 0.00 | 0.00 |
| 2020 | 7727.52 | 8002 | 973 | 91.11 | 91.11 | 90.41 | 91.10 | 0.73 | 0.67 | 8.22 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|-------|-------|--------|-------|------|------|-------|------|
| 2021 | 6146.32 | 7224 | 973 | 82.47 | 82.47 | 72.11 | 82.47 | 8.36 | 7.52 | 10.01 | 0.00 |
| 2022 | 8591.09 | 8710 | 973 | 99.43 | 99.43 | 100.79 | 99.43 | 0.57 | 0.57 | 0.00 | 0.00 |
| 2023 | 7517.23 | 7699 | 973 | 99.99 | 99.99 | 88.19 | 87.89 | 0.00 | 0.00 | 0.01 | 0.00 |

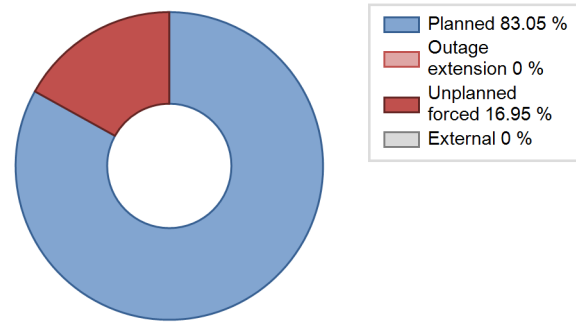
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1984 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 126 | |
| B. Refuelling without maintenance | | | | 40 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 892 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 121 | | |
| E. Testing of plant systems or components | | | | 2 | 0 | |
| H. Nuclear regulatory requirements | | | | | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 0 |
| L. Human factor related | | | | | 7 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | | 1 | |
| Z. Other | | | | | 41 | |
| Subtotal | | | | 1055 | 176 | 1 |
| Total | | 0 | | | 1232 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1984 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 5 |
| 12. Reactor I&C Systems | | 15 |
| 13. Reactor Auxiliary Systems | | 8 |
| 14. Safety Systems | | 3 |
| 15. Reactor Cooling Systems | | 25 |
| 16. Steam generation systems | | 16 |
| 31. Turbine and auxiliaries | | 9 |
| 32. Feedwater and Main Steam System | | 13 |
| 34. Miscellaneous Systems | | 1 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 19 |
| 42. Electrical Power Supply Systems | | 15 |
| Total | | 130 |

2023 Operating Experience

US-280

SURRY-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : DOMINION (Dominion Energy)
 Owner : DOMINRES (Dominion Resources, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 3LP (DRYSUB)
 Thermal power : 2587 MWth
 Gross electrical power : 890 MWe
 Reference unit power (net) : 838 MWe

Key Dates

Construction Date : 1968-06-25
 Grid Date : 1972-07-04
 Commercial Date : 1972-12-22
 Age at end of year : 51 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 38
 Average discharge burnup [MWd/t] : 48000
 Active core diameter [m] : 3.035
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 21.6
 Number of control rod assemblies : 32
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 318
 Number of SG : 3
 Containment type : -
 Containment design pressure [MPa] : 0.422

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.59
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

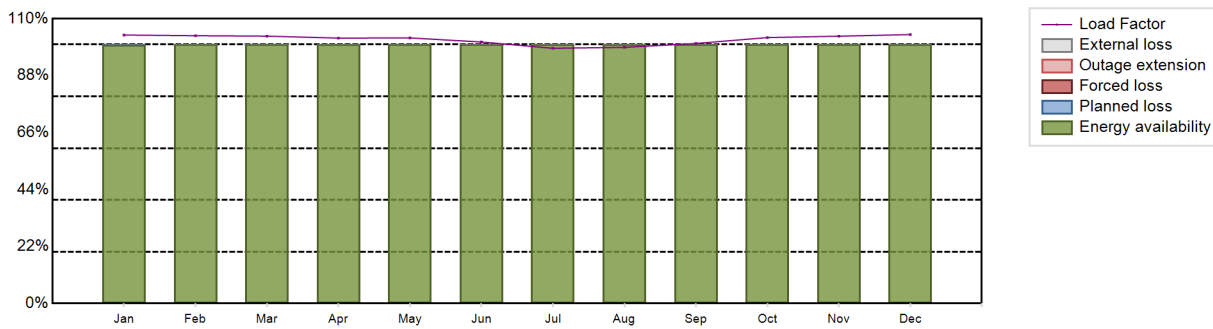
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 7488.81 GW(e).h
 Energy Availability Factor (EAF) : 99.99 %
 Unit Capability Factor (UCF) : 99.99 %
 Load Factor (LF) : 102.02 %
 Operating Factor (OF) : 100 %

Forced Loss Rate (FLR) : 0 %
 Unplanned Capability Loss Factor (UCL) : 0 %
 Planned Unavailability Factor (PUF) : 0.01 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 0 hours

Annual Summary

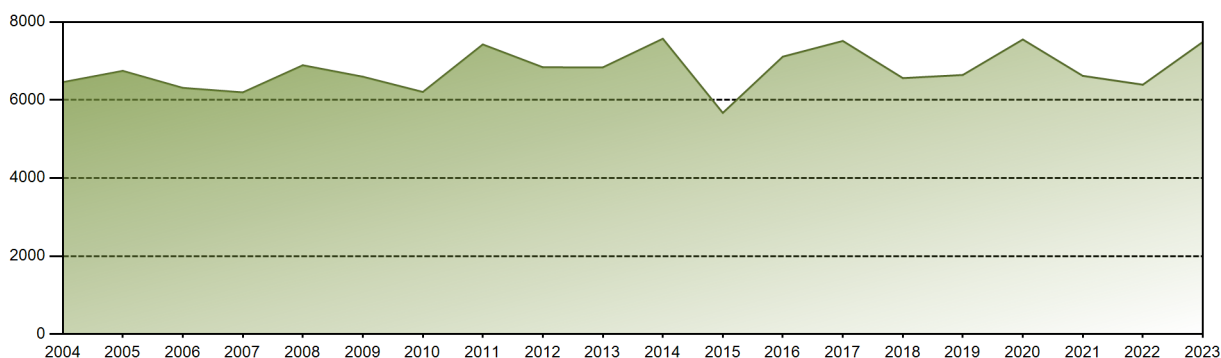


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 646.59 | 582.49 | 642.98 | 618.51 | 639.59 | 609.41 | 614.62 | 616.87 | 605.98 | 640.38 | 623.80 | 647.59 | 7488.81 |
| EAF [%] | 99.87 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| UCF [%] | 99.87 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.99 |
| LF [%] | 103.71 | 103.44 | 103.27 | 102.51 | 102.59 | 101.00 | 98.58 | 98.94 | 100.43 | 102.71 | 103.24 | 103.87 | 102.02 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 284785.98 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 8.14 % |
| Cumulative Energy Availability Factor (EAF) | : 80.06 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.1 % |
| Cumulative Unit Capability Factor (UCF) | : 80.1 % | Cumulative Planned Unavailability Factor (PUF) | : 12.8 % |
| Cumulative Load Factor (LF) | : 79.4 % | Cumulative Externally cause unavailability (XUF) | : 0.04 % |
| Cumulative Operating Factor (OF) | : 80.57 % | | |

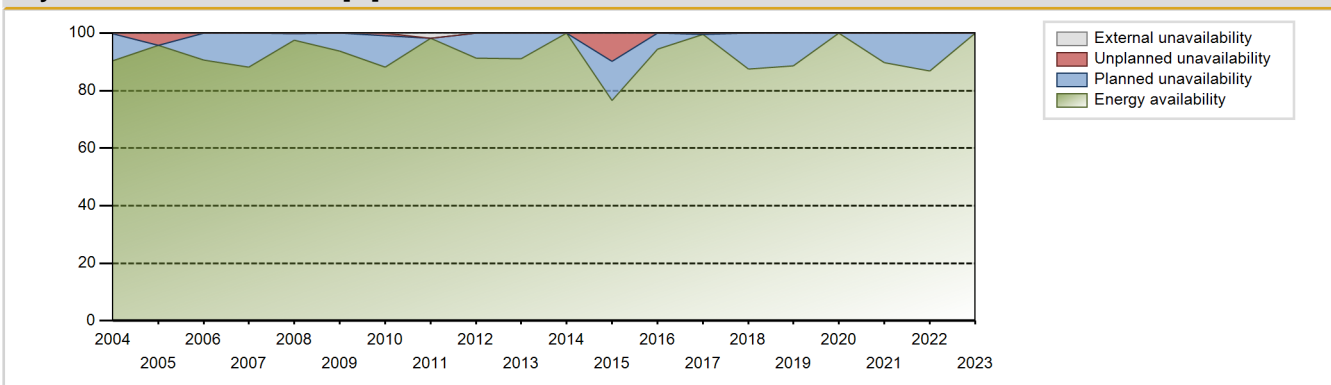
Electricity Production (net) [GWh]



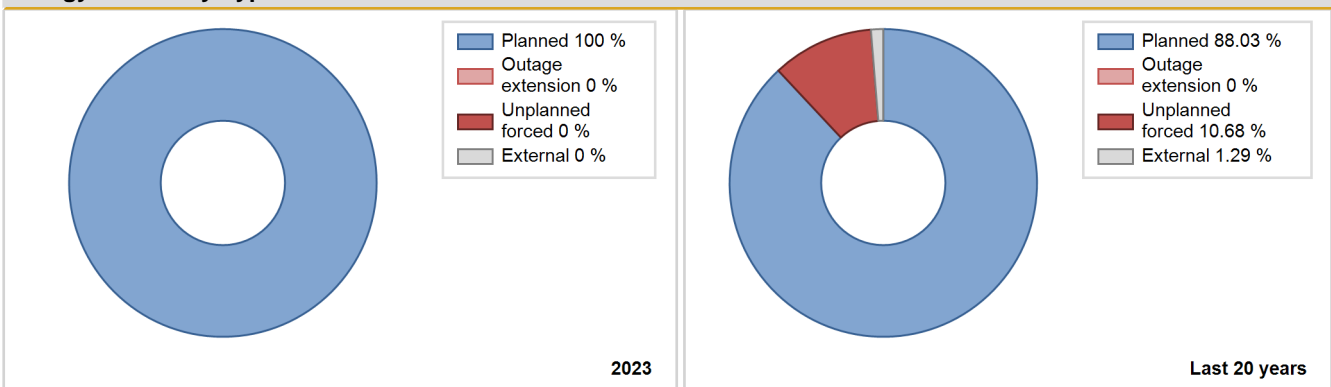
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1972 | 407.60 | 1048 | 794 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | 3479.70 | 5377 | 788 | 61.88 | 61.88 | 50.41 | 61.38 | 27.15 | 23.06 | 15.06 | 0.00 |
| 1974 | 3318.10 | 4800 | 788 | 54.81 | 54.81 | 48.07 | 54.79 | 32.59 | 26.50 | 18.69 | 0.00 |
| 1975 | 3858.40 | 5343 | 788 | 56.10 | 56.10 | 56.05 | 61.16 | 18.03 | 12.34 | 31.56 | 0.00 |
| 1976 | 4396.80 | 6010 | 788 | 63.58 | 63.58 | 63.52 | 68.42 | 18.17 | 14.12 | 22.31 | 0.00 |
| 1977 | 5023.90 | 6661 | 776 | 74.03 | 74.03 | 73.91 | 76.04 | 3.67 | 2.82 | 23.15 | 0.00 |
| 1978 | 4704.20 | 6291 | 775 | 69.27 | 69.27 | 69.29 | 71.82 | 8.43 | 6.38 | 24.35 | 0.00 |
| 1979 | 2255.10 | 3045 | 775 | 33.22 | 33.22 | 33.22 | 34.76 | 66.59 | 66.20 | 0.59 | 0.00 |
| 1980 | 2472.60 | 3762 | 775 | 42.17 | 42.17 | 36.32 | 42.83 | 40.05 | 28.17 | 29.66 | 0.00 |
| 1981 | 2377.40 | 3403 | 775 | 39.05 | 39.05 | 35.02 | 38.85 | 11.43 | 5.04 | 55.91 | 0.00 |
| 1982 | 5483.10 | 7776 | 775 | 89.22 | 89.22 | 80.76 | 88.77 | 7.28 | 7.01 | 3.77 | 0.00 |
| 1983 | 3517.10 | 5010 | 775 | 56.29 | 56.41 | 51.81 | 57.19 | 3.64 | 2.13 | 41.45 | 0.13 |
| 1984 | 3334.11 | 5138 | 775 | 58.15 | 58.15 | 48.98 | 58.49 | 4.21 | 2.56 | 39.30 | 0.00 |
| 1985 | 5618.28 | 7827 | 779 | 89.33 | 89.33 | 82.28 | 89.35 | 10.30 | 10.26 | 0.41 | 0.00 |
| 1986 | 4488.63 | 6013 | 781 | 68.08 | 68.08 | 65.61 | 68.64 | 3.77 | 2.67 | 29.25 | 0.00 |
| 1987 | 4633.40 | 6113 | 781 | 70.14 | 70.14 | 67.72 | 69.78 | 16.11 | 13.47 | 16.39 | 0.00 |
| 1988 | 2685.03 | 3632 | 781 | 18.73 | 18.73 | 39.14 | 41.35 | 73.97 | 53.22 | 28.06 | 0.00 |
| 1989 | 3170.53 | 4217 | 781 | 46.83 | 46.83 | 46.34 | 48.14 | 53.17 | 53.17 | 0.00 | 0.00 |
| 1990 | 4772.20 | 6655 | 781 | 74.91 | 74.91 | 69.75 | 75.97 | 4.53 | 3.55 | 21.54 | 0.00 |
| 1991 | 6590.94 | 8760 | 781 | 100.00 | 100.00 | 96.34 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1992 | 5223.79 | 7033 | 781 | 79.61 | 79.61 | 76.15 | 80.07 | 3.23 | 2.66 | 17.74 | 0.00 |
| 1993 | 6229.24 | 8402 | 781 | 95.89 | 95.89 | 91.05 | 95.91 | 1.52 | 1.48 | 2.64 | 0.00 |
| 1994 | 4881.92 | 6560 | 781 | 74.30 | 74.30 | 71.36 | 74.89 | 0.41 | 0.30 | 25.39 | 0.00 |
| 1995 | 5746.95 | 7505 | 784 | 85.42 | 85.42 | 83.64 | 85.67 | 2.81 | 2.47 | 12.11 | 0.00 |
| 1996 | 7137.78 | 8784 | 801 | 100.00 | 100.00 | 101.45 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1997 | 5640.47 | 7067 | 801 | 80.74 | 80.74 | 80.39 | 80.67 | 3.86 | 3.24 | 16.02 | 0.00 |
| 1998 | 5752.38 | 7170 | 801 | 81.87 | 81.87 | 81.98 | 81.85 | 6.87 | 6.04 | 12.09 | 0.00 |
| 1999 | 7116.20 | 8760 | 801 | 100.00 | 100.00 | 101.42 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2000 | 6548.43 | 8188 | 801 | 93.23 | 93.23 | 93.07 | 93.21 | 0.34 | 0.32 | 6.45 | 0.00 |
| 2001 | 5941.63 | 7380 | 810 | 84.27 | 84.27 | 83.74 | 84.25 | 0.00 | 0.00 | 15.73 | 0.00 |
| 2002 | 7149.46 | 8760 | 810 | 100.00 | 100.00 | 100.76 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 5419.78 | 6741 | 810 | 76.97 | 76.97 | 76.38 | 76.95 | 6.27 | 5.15 | 17.88 | 0.00 |
| 2004 | 6457.13 | 7943 | 810 | 90.45 | 90.45 | 90.75 | 90.43 | 0.36 | 0.33 | 9.22 | 0.00 |
| 2005 | 6746.56 | 8376 | 810 | 95.63 | 95.63 | 95.08 | 95.62 | 4.37 | 4.37 | 0.00 | 0.00 |
| 2006 | 6311.00 | 7931 | 799 | 90.56 | 90.56 | 90.17 | 90.54 | 0.00 | 0.00 | 9.44 | 0.00 |
| 2007 | 6195.20 | 7720 | 799 | 88.15 | 88.15 | 88.51 | 88.13 | 0.00 | 0.00 | 11.85 | 0.00 |
| 2008 | 6890.50 | 8560 | 799 | 97.46 | 97.46 | 98.18 | 97.45 | 0.31 | 0.31 | 2.23 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|-------|------|-------|------|
| 2009 | 6597.35 | 8214 | 799 | 93.78 | 93.78 | 94.26 | 93.77 | 0.00 | 0.00 | 6.22 | 0.00 |
| 2010 | 6206.40 | 7724 | 839 | 88.25 | 88.25 | 88.30 | 88.17 | 1.06 | 0.95 | 10.80 | 0.00 |
| 2011 | 7423.81 | 8590 | 839 | 98.07 | 100.00 | 101.01 | 98.06 | 0.00 | 0.00 | 0.00 | 1.93 |
| 2012 | 6839.54 | 8019 | 838 | 91.30 | 91.30 | 92.92 | 91.29 | 0.00 | 0.00 | 8.70 | 0.00 |
| 2013 | 6836.37 | 7980 | 838 | 91.09 | 91.09 | 93.12 | 91.09 | 0.00 | 0.00 | 8.91 | 0.00 |
| 2014 | 7570.57 | 8760 | 838 | 100.00 | 100.00 | 103.13 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 5669.30 | 6701 | 838 | 76.50 | 76.50 | 77.23 | 76.50 | 11.35 | 9.80 | 13.70 | 0.00 |
| 2016 | 7111.17 | 8294 | 838 | 94.42 | 94.42 | 96.61 | 94.42 | 0.00 | 0.00 | 5.58 | 0.00 |
| 2017 | 7513.73 | 8720 | 838 | 99.54 | 99.54 | 102.35 | 99.54 | 0.46 | 0.46 | 0.00 | 0.00 |
| 2018 | 6561.75 | 7671 | 838 | 87.56 | 87.56 | 89.39 | 87.57 | 0.00 | 0.00 | 12.44 | 0.00 |
| 2019 | 6642.08 | 7754 | 838 | 88.53 | 88.53 | 90.48 | 88.52 | 0.00 | 0.00 | 11.47 | 0.00 |
| 2020 | 7551.07 | 8783 | 838 | 100.00 | 100.00 | 102.58 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 6618.86 | 7868 | 838 | 89.82 | 89.82 | 90.16 | 89.82 | 0.00 | 0.00 | 10.18 | 0.00 |
| 2022 | 6392.66 | 7607 | 838 | 86.84 | 86.84 | 87.08 | 86.84 | 0.00 | 0.00 | 13.16 | 0.00 |
| 2023 | 7488.81 | 8760 | 838 | 99.99 | 99.99 | 102.02 | 100.00 | 0.00 | 0.00 | 0.01 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1972 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 435 | |
| B. Refuelling without maintenance | | | | 40 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 747 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 315 | | |
| E. Testing of plant systems or components | | | | 1 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 145 | |
| L. Human factor related | | | | | 14 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 5 |
| Z. Other | | | | | 89 | |
| Subtotal | | | | 1104 | 684 | 5 |
| Total | | 0 | | | 1793 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1972 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 0 |
| 12. Reactor I&C Systems | | 25 |
| 13. Reactor Auxiliary Systems | | 5 |
| 14. Safety Systems | | 4 |
| 15. Reactor Cooling Systems | | 154 |
| 16. Steam generation systems | | 42 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 2 |
| 31. Turbine and auxiliaries | | 17 |
| 32. Feedwater and Main Steam System | | 67 |
| 34. Miscellaneous Systems | | 37 |
| 41. Main Generator Systems | | 22 |
| 42. Electrical Power Supply Systems | | 66 |
| Total | | 441 |

2023 Operating Experience

US-281

SURRY-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : DOMINION (Dominion Energy)
 Owner : DOMINRES (Dominion Resources, Inc.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 3LP (DRYSUB)
 Thermal power : 2587 MWth
 Gross electrical power : 890 MWe
 Reference unit power (net) : 838 MWe

Key Dates

Construction Date : 1968-06-25
 Grid Date : 1973-03-10
 Commercial Date : 1973-05-01
 Age at end of year : 50 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 38
 Average discharge burnup [MWd/t] : 48000
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 Number of control rod assemblies : 32
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.8
 Reactor outlet temperature [°C] : 318
 Number of SG : 3
 Containment type : -
 Containment design pressure [MPa] : 0.422

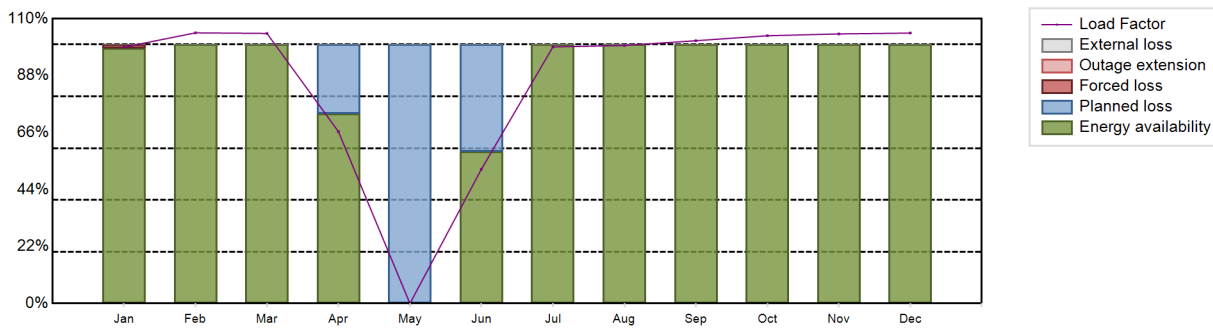
Secondary systems

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 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.59
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6345.86 GW(e).h
 Energy Availability Factor (EAF) : 85.81 %
 Unit Capability Factor (UCF) : 85.81 %
 Load Factor (LF) : 86.45 %
 Operating Factor (OF) : 85.91 %
 Forced Loss Rate (FLR) : 0.13 %
 Unplanned Capability Loss Factor (UCL) : 0.11 %
 Planned Unavailability Factor (PUF) : 14.09 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1234 hours

Annual Summary

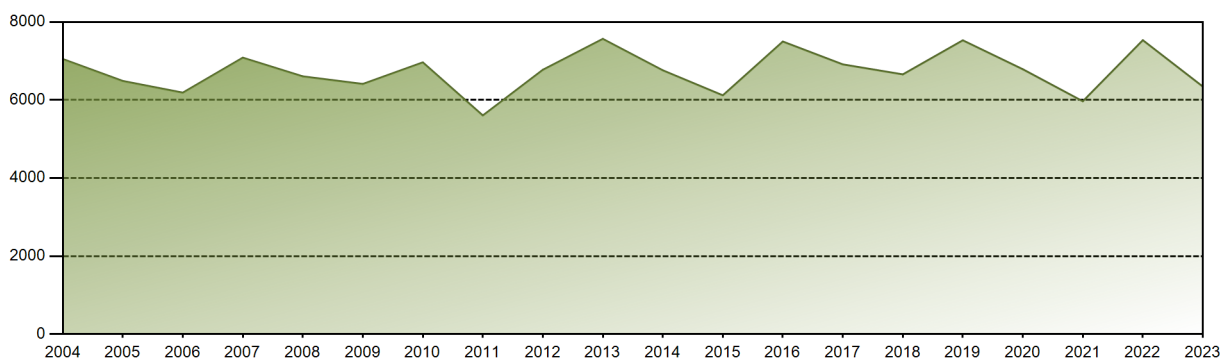


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 617.24 | 588.72 | 649.52 | 400.47 | 0.00 | 313.14 | 617.84 | 621.37 | 612.38 | 644.83 | 629.08 | 651.27 | 6345.86 |
| EAF [%] | 98.71 | 100.00 | 100.00 | 73.37 | 0.00 | 58.60 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.81 |
| UCF [%] | 98.71 | 100.00 | 100.00 | 73.37 | 0.00 | 58.60 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.81 |
| LF [%] | 99.00 | 104.54 | 104.32 | 66.37 | 0.00 | 51.90 | 99.10 | 99.66 | 101.50 | 103.42 | 104.12 | 104.46 | 86.45 |
| OF [%] | 100.00 | 100.00 | 100.00 | 73.33 | 0.00 | 58.61 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 85.91 |
| FLR [%] | 1.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |
| UCL [%] | 1.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 26.63 | 100.00 | 41.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.09 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 282963.55 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 5.78 % |
| Cumulative Energy Availability Factor (EAF) | : 80.48 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 4.94 % |
| Cumulative Unit Capability Factor (UCF) | : 80.54 % | Cumulative Planned Unavailability Factor (PUF) | : 14.52 % |
| Cumulative Load Factor (LF) | : 79.45 % | Cumulative Externally cause unavailability (XUF) | : 0.05 % |
| Cumulative Operating Factor (OF) | : 80.54 % | | |

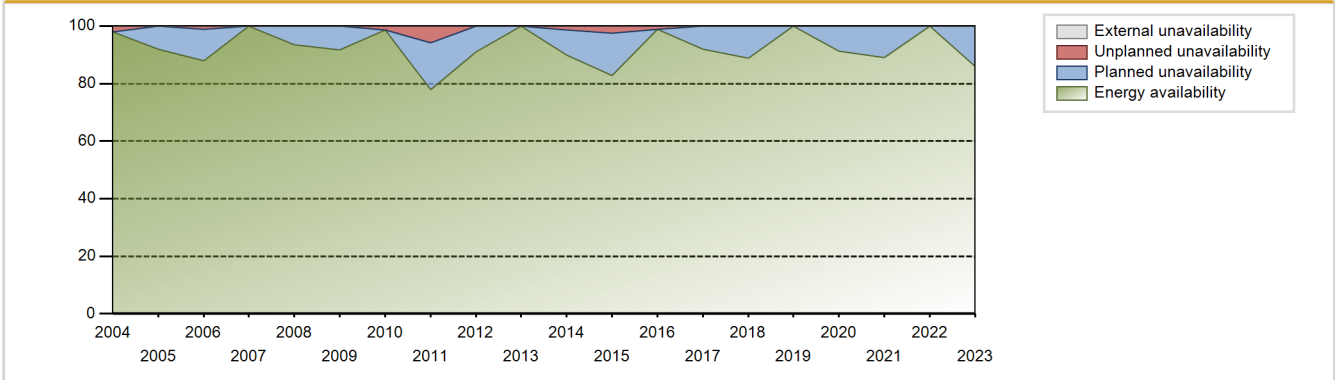
Electricity Production (net) [GWh]



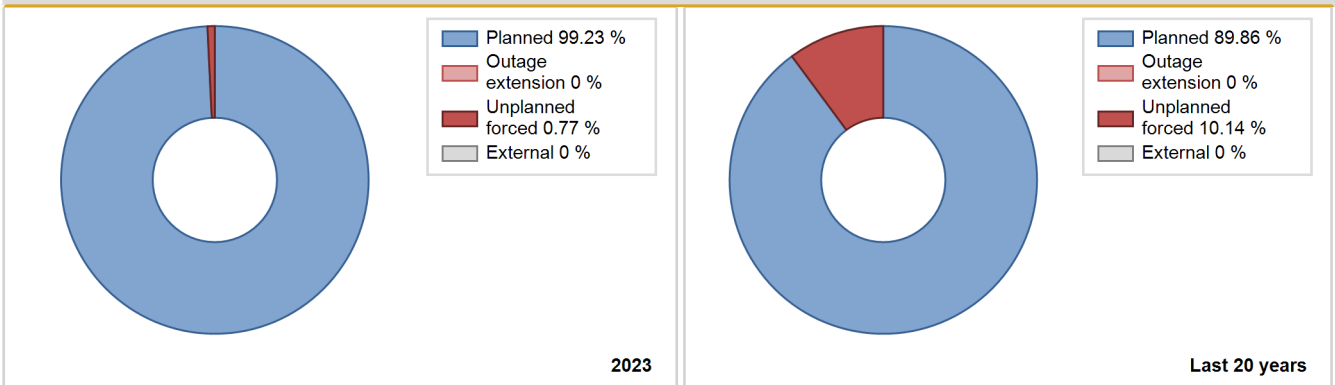
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1973 | 3377.50 | 5392 | 790 | 77.93 | 77.93 | 66.14 | 77.09 | 5.82 | 4.82 | 17.25 | 0.00 |
| 1974 | 2660.50 | 3854 | 788 | 44.00 | 44.00 | 38.54 | 44.00 | 36.59 | 25.39 | 30.61 | 0.00 |
| 1975 | 5053.10 | 6967 | 788 | 73.25 | 73.25 | 73.20 | 79.53 | 11.31 | 9.35 | 17.40 | 0.00 |
| 1976 | 3343.40 | 4585 | 788 | 48.34 | 48.34 | 48.30 | 52.20 | 43.48 | 37.19 | 14.47 | 0.00 |
| 1977 | 4457.30 | 5980 | 776 | 65.56 | 65.56 | 65.57 | 68.26 | 27.45 | 24.81 | 9.63 | 0.00 |
| 1978 | 5372.00 | 7244 | 775 | 79.12 | 79.12 | 79.13 | 82.69 | 4.04 | 3.33 | 17.54 | 0.00 |
| 1979 | 611.50 | 818 | 775 | 9.01 | 9.01 | 9.01 | 9.34 | 0.00 | 0.00 | 90.99 | 0.00 |
| 1980 | 2241.60 | 3139 | 775 | 35.97 | 35.97 | 32.93 | 35.74 | 2.54 | 0.94 | 63.09 | 0.00 |
| 1981 | 5150.30 | 6972 | 775 | 79.57 | 82.36 | 75.86 | 79.59 | 3.12 | 2.65 | 14.99 | 2.78 |
| 1982 | 5492.20 | 7729 | 775 | 88.72 | 88.72 | 80.90 | 88.23 | 1.95 | 1.76 | 9.52 | 0.00 |
| 1983 | 4086.10 | 5729 | 775 | 64.98 | 64.98 | 60.19 | 65.40 | 5.41 | 3.71 | 31.31 | 0.00 |
| 1984 | 5209.38 | 7327 | 775 | 83.31 | 83.31 | 76.52 | 83.41 | 16.69 | 16.69 | 0.00 | 0.00 |
| 1985 | 4072.44 | 5857 | 775 | 65.77 | 65.77 | 59.99 | 66.86 | 0.32 | 0.21 | 34.02 | 0.00 |
| 1986 | 4498.94 | 6072 | 780 | 68.71 | 68.71 | 65.80 | 69.32 | 14.94 | 12.07 | 19.23 | 0.00 |
| 1987 | 4790.95 | 6456 | 781 | 73.60 | 73.60 | 70.03 | 73.70 | 22.97 | 21.94 | 4.45 | 0.00 |
| 1988 | 3570.90 | 4993 | 781 | 56.55 | 56.55 | 52.05 | 56.84 | 18.21 | 12.59 | 30.86 | 0.00 |
| 1989 | 893.58 | 1355 | 781 | 13.32 | 13.32 | 13.06 | 15.47 | 48.28 | 12.44 | 74.24 | 0.00 |
| 1990 | 5837.77 | 7919 | 781 | 84.82 | 84.82 | 85.33 | 90.40 | 15.18 | 15.18 | 0.00 | 0.00 |
| 1991 | 3985.21 | 5886 | 781 | 66.55 | 66.55 | 58.25 | 67.19 | 17.38 | 14.00 | 19.45 | 0.00 |
| 1992 | 6426.48 | 8470 | 781 | 96.33 | 96.33 | 93.68 | 96.43 | 0.00 | 0.00 | 3.67 | 0.00 |
| 1993 | 4541.66 | 6283 | 781 | 71.02 | 71.02 | 66.38 | 71.72 | 9.76 | 7.68 | 21.30 | 0.00 |
| 1994 | 6260.97 | 8251 | 781 | 94.05 | 94.05 | 91.51 | 94.19 | 0.00 | 0.00 | 5.95 | 0.00 |
| 1995 | 5517.38 | 7087 | 787 | 80.65 | 80.65 | 79.96 | 80.90 | 7.47 | 6.51 | 12.84 | 0.00 |
| 1996 | 6081.46 | 7539 | 801 | 85.88 | 85.88 | 86.43 | 85.83 | 1.69 | 1.48 | 12.64 | 0.00 |
| 1997 | 6451.27 | 8034 | 801 | 91.75 | 91.75 | 91.94 | 91.71 | 1.33 | 1.23 | 7.02 | 0.00 |
| 1998 | 7178.88 | 8760 | 801 | 100.00 | 100.00 | 102.31 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1999 | 5874.83 | 7493 | 801 | 85.56 | 85.56 | 83.73 | 85.54 | 3.20 | 2.83 | 11.61 | 0.00 |
| 2000 | 6539.43 | 8022 | 801 | 91.33 | 91.33 | 92.94 | 91.33 | 0.00 | 0.00 | 8.67 | 0.00 |
| 2001 | 6720.74 | 8203 | 815 | 93.68 | 93.68 | 94.14 | 93.64 | 0.54 | 0.50 | 5.82 | 0.00 |
| 2002 | 6523.67 | 7966 | 815 | 90.97 | 90.97 | 91.38 | 90.94 | 1.18 | 1.09 | 7.95 | 0.00 |
| 2003 | 5612.12 | 6861 | 815 | 78.33 | 78.33 | 78.61 | 78.32 | 2.04 | 1.63 | 20.03 | 0.00 |
| 2004 | 7051.74 | 8606 | 815 | 97.98 | 97.98 | 98.50 | 97.97 | 2.02 | 2.02 | 0.00 | 0.00 |
| 2005 | 6488.55 | 8046 | 815 | 91.86 | 91.86 | 90.87 | 91.84 | 0.00 | 0.00 | 8.14 | 0.00 |
| 2006 | 6189.36 | 7705 | 799 | 87.97 | 87.97 | 88.43 | 87.96 | 1.32 | 1.17 | 10.86 | 0.00 |
| 2007 | 7086.34 | 8760 | 799 | 100.00 | 100.00 | 101.24 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 6606.84 | 8205 | 799 | 93.42 | 93.42 | 94.14 | 93.41 | 0.00 | 0.00 | 6.58 | 0.00 |
| 2009 | 6412.30 | 8026 | 799 | 91.63 | 91.63 | 91.61 | 91.62 | 0.00 | 0.00 | 8.37 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2010 | 6966.03 | 8646 | 799 | 98.70 | 98.70 | 99.53 | 98.70 | 1.30 | 1.30 | 0.00 | 0.00 |
| 2011 | 5605.67 | 6771 | 839 | 77.88 | 77.88 | 78.12 | 77.29 | 6.89 | 5.76 | 16.36 | 0.00 |
| 2012 | 6775.06 | 8001 | 838 | 91.10 | 91.10 | 92.04 | 91.09 | 0.00 | 0.00 | 8.90 | 0.00 |
| 2013 | 7568.22 | 8760 | 838 | 100.00 | 100.00 | 103.09 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 6761.76 | 7882 | 838 | 89.96 | 89.96 | 92.11 | 89.98 | 1.51 | 1.38 | 8.66 | 0.00 |
| 2015 | 6120.41 | 7250 | 838 | 82.77 | 82.77 | 83.37 | 82.76 | 3.01 | 2.57 | 14.66 | 0.00 |
| 2016 | 7499.35 | 8691 | 838 | 98.94 | 98.94 | 101.88 | 98.94 | 1.06 | 1.06 | 0.00 | 0.00 |
| 2017 | 6913.92 | 8057 | 838 | 91.98 | 91.98 | 94.18 | 91.97 | 0.00 | 0.00 | 8.02 | 0.00 |
| 2018 | 6657.38 | 7788 | 838 | 88.90 | 88.90 | 90.69 | 88.90 | 0.00 | 0.00 | 11.10 | 0.00 |
| 2019 | 7530.89 | 8760 | 838 | 100.00 | 100.00 | 102.59 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 6789.08 | 8014 | 838 | 91.25 | 91.25 | 92.23 | 91.23 | 0.00 | 0.00 | 8.75 | 0.00 |
| 2021 | 5968.00 | 7103 | 838 | 89.04 | 89.04 | 81.30 | 81.08 | 0.00 | 0.00 | 10.96 | 0.00 |
| 2022 | 7533.78 | 8760 | 838 | 100.00 | 100.00 | 102.63 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 6345.86 | 7526 | 838 | 85.81 | 85.81 | 86.45 | 85.91 | 0.13 | 0.11 | 14.09 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1973 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 412 | |
| B. Refuelling without maintenance | | | | 34 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1123 | | | 1046 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 168 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 1 | | |
| H. Nuclear regulatory requirements | | | | | 18 | |
| L. Human factor related | | | | | 14 | |
| Z. Other | | | | 4 | 0 | |
| Subtotal | 1123 | | | 1254 | 444 | |
| Total | | 1123 | | | 1698 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1973 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 30 |
| 13. Reactor Auxiliary Systems | | 3 |
| 14. Safety Systems | | 49 |
| 15. Reactor Cooling Systems | | 23 |
| 16. Steam generation systems | | 98 |
| 31. Turbine and auxiliaries | | 84 |
| 32. Feedwater and Main Steam System | | 88 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 15 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 6 |
| 42. Electrical Power Supply Systems | | 21 |
| Total | | 420 |

2023 Operating Experience

US-387 SUSQUEHANNA-1 UNITED STATES OF AMERICA

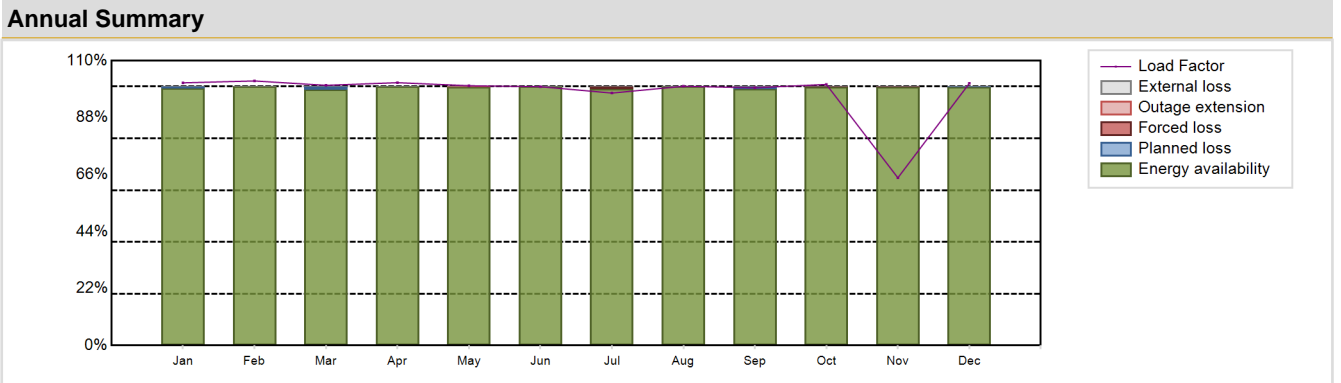
Status at end of year : **Operational**
 Operator : PPL_SUSQ (PPL Susquehanna, LLC)
 Owner : PPL_CORP (PPL Corporation (former PENNSYLVANIA POWER & LIGHT CO. (PP&L)))
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 2) | Construction Date | : 1973-11-02 |
| Thermal power | : 3952 MWth | Grid Date | : 1982-11-16 |
| Gross electrical power | : 1330 MWe | Commercial Date | : 1983-06-08 |
| Reference unit power (net) | : 1257 MWe | Age at end of year | : 41 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.19 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 304 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.372 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 30 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 36000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.57 | HP cylinder inlet steam pressure [MPa] | : 6.69 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 764 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 19.32 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|--------------------|--|-------------|
| Net Energy Production | : 10738.36 GW(e).h | Forced Loss Rate (FLR) | : 0.09 % |
| Energy Availability Factor (EAF) | : 99.68 % | Unplanned Capability Loss Factor (UCL) | : 0.1 % |
| Unit Capability Factor (UCF) | : 99.68 % | Planned Unavailability Factor (PUF) | : 0.22 % |
| Load Factor (LF) | : 97.52 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 97.42 % | Total off-line time | : 226 hours |

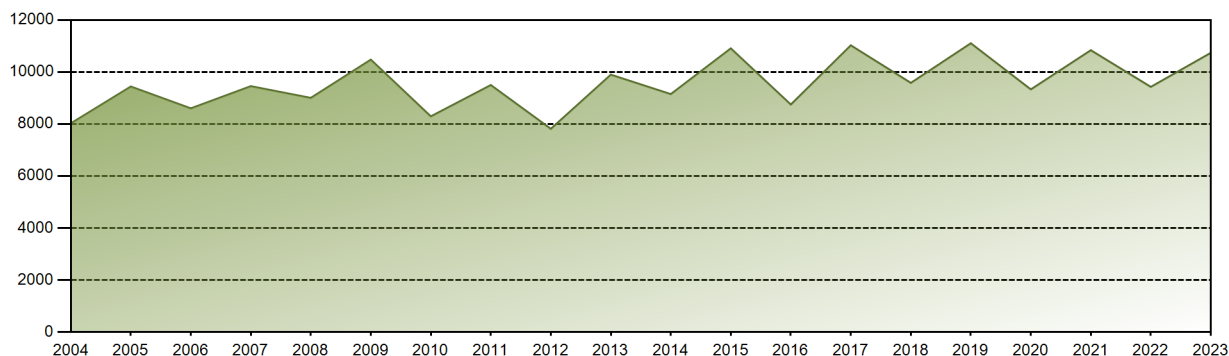


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 948.74 | 863.09 | 938.50 | 918.73 | 938.34 | 904.76 | 911.88 | 936.29 | 901.06 | 942.92 | 587.03 | 947.01 | 10738.36 |
| EAF [%] | 99.35 | 100.00 | 98.84 | 100.00 | 99.87 | 100.00 | 99.16 | 100.00 | 99.23 | 99.87 | 99.97 | 99.94 | 99.68 |
| UCF [%] | 99.35 | 100.00 | 98.84 | 100.00 | 99.87 | 100.00 | 99.16 | 100.00 | 99.23 | 99.87 | 99.97 | 99.94 | 99.68 |
| LF [%] | 101.45 | 102.18 | 100.49 | 101.51 | 100.33 | 99.97 | 97.51 | 100.12 | 99.56 | 100.83 | 64.77 | 101.26 | 97.52 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 68.65 | 100.00 | 97.42 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.84 | 0.00 | 0.00 | 0.13 | 0.03 | 0.00 | 0.09 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.84 | 0.00 | 0.00 | 0.13 | 0.03 | 0.00 | 0.10 |
| PUF [%] | 0.65 | 0.00 | 1.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.77 | 0.00 | 0.00 | 0.06 | 0.22 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|-----------|
| Lifetime energy generation | : 344141.6 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.42 % |
| Cumulative Energy Availability Factor (EAF) | : 86.49 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.19 % |
| Cumulative Unit Capability Factor (UCF) | : 86.55 % | Cumulative Planned Unavailability Factor (PUF) | : 10.26 % |
| Cumulative Load Factor (LF) | : 84.97 % | Cumulative Externally cause unavailability (XUF) | : 0.05 % |
| Cumulative Operating Factor (OF) | : 86.02 % | | |

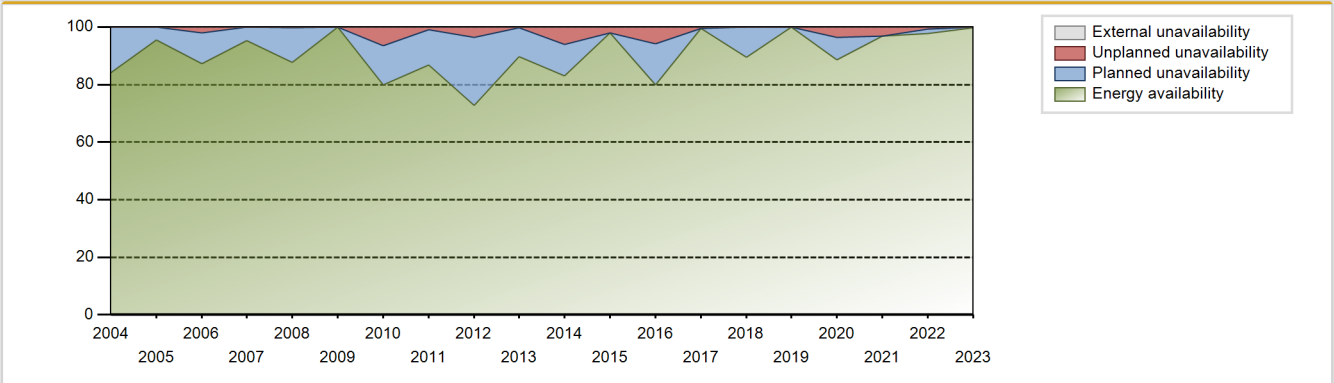
Electricity Production (net) [GWh]



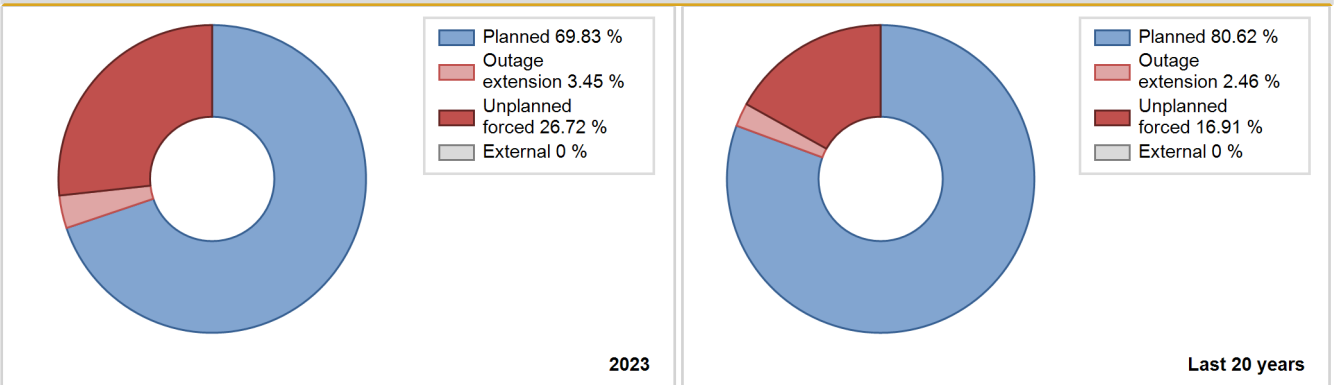
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1983 | 4472.80 | 4891 | 1034 | 76.29 | 76.29 | 66.58 | 73.31 | 11.82 | 10.23 | 13.49 | 0.00 |
| 1984 | 6088.14 | 6377 | 1032 | 72.02 | 74.45 | 67.16 | 72.60 | 13.03 | 11.15 | 14.40 | 2.43 |
| 1985 | 5286.43 | 5469 | 1032 | 60.37 | 60.37 | 58.48 | 62.43 | 6.06 | 3.89 | 35.74 | 0.00 |
| 1986 | 5839.25 | 5992 | 1032 | 66.81 | 66.81 | 64.59 | 68.40 | 12.07 | 9.17 | 24.02 | 0.00 |
| 1987 | 6132.87 | 6331 | 1032 | 70.74 | 70.74 | 67.84 | 72.27 | 10.27 | 8.10 | 21.16 | 0.00 |
| 1988 | 8410.06 | 8206 | 1032 | 93.06 | 93.06 | 92.77 | 93.42 | 5.00 | 4.90 | 2.04 | 0.00 |
| 1989 | 6483.95 | 6447 | 1032 | 72.15 | 72.15 | 71.72 | 73.60 | 8.90 | 7.04 | 20.81 | 0.00 |
| 1990 | 6446.70 | 6528 | 1033 | 73.14 | 73.14 | 71.24 | 74.52 | 4.60 | 3.53 | 23.33 | 0.00 |
| 1991 | 8821.60 | 8596 | 1035 | 98.04 | 98.04 | 97.21 | 98.13 | 1.96 | 1.96 | 0.00 | 0.00 |
| 1992 | 6400.29 | 6568 | 1040 | 73.60 | 73.60 | 70.06 | 74.77 | 7.61 | 6.06 | 20.34 | 0.00 |
| 1993 | 5232.40 | 5205 | 1040 | 57.49 | 57.49 | 57.43 | 59.42 | 19.76 | 14.15 | 28.36 | 0.00 |
| 1994 | 8414.45 | 8249 | 1040 | 94.18 | 94.18 | 92.36 | 94.17 | 0.00 | 0.00 | 5.82 | 0.00 |
| 1995 | 7432.27 | 7126 | 1073 | 81.11 | 81.11 | 79.03 | 81.35 | 0.00 | 0.00 | 18.89 | 0.00 |
| 1996 | 7752.89 | 7434 | 1090 | 84.68 | 84.68 | 80.97 | 84.63 | 3.04 | 2.65 | 12.67 | 0.00 |
| 1997 | 9085.32 | 8274 | 1090 | 94.47 | 94.47 | 95.15 | 94.45 | 5.53 | 5.53 | 0.00 | 0.00 |
| 1998 | 7652.80 | 7015 | 1090 | 81.47 | 81.47 | 80.15 | 80.08 | 6.20 | 5.38 | 13.15 | 0.00 |
| 1999 | 8814.47 | 8234 | 1090 | 94.01 | 94.01 | 92.31 | 94.00 | 5.99 | 5.99 | 0.00 | 0.00 |
| 2000 | 8180.56 | 7598 | 1090 | 86.52 | 86.52 | 85.44 | 86.50 | 0.33 | 0.28 | 13.19 | 0.00 |
| 2001 | 9412.96 | 8718 | 1090 | 99.53 | 99.53 | 98.58 | 99.52 | 0.23 | 0.23 | 0.25 | 0.00 |
| 2002 | 8026.62 | 7493 | 1105 | 85.67 | 85.67 | 83.39 | 85.54 | 0.64 | 0.55 | 13.78 | 0.00 |
| 2003 | 9359.91 | 8585 | 1105 | 98.04 | 98.04 | 96.70 | 98.00 | 1.79 | 1.79 | 0.17 | 0.00 |
| 2004 | 8027.00 | 7359 | 1135 | 84.08 | 84.08 | 81.22 | 83.78 | 0.00 | 0.00 | 15.92 | 0.00 |
| 2005 | 9442.62 | 8357 | 1105 | 95.41 | 95.41 | 97.55 | 95.40 | 0.00 | 0.00 | 4.59 | 0.00 |
| 2006 | 8602.67 | 7639 | 1135 | 87.24 | 87.24 | 86.52 | 87.20 | 2.27 | 2.02 | 10.73 | 0.00 |
| 2007 | 9456.33 | 8349 | 1149 | 95.37 | 95.37 | 93.95 | 95.31 | 0.00 | 0.00 | 4.63 | 0.00 |
| 2008 | 9005.70 | 7704 | 1149 | 87.72 | 87.72 | 89.23 | 87.70 | 0.33 | 0.29 | 11.99 | 0.00 |
| 2009 | 10475.53 | 8760 | 1185 | 100.00 | 100.00 | 100.91 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 8294.36 | 6958 | 1239 | 80.00 | 80.00 | 77.82 | 79.43 | 7.48 | 6.47 | 13.53 | 0.00 |
| 2011 | 9499.00 | 7588 | 1260 | 86.83 | 86.83 | 86.42 | 86.62 | 1.09 | 0.98 | 12.19 | 0.00 |
| 2012 | 7814.86 | 6382 | 1257 | 72.69 | 72.69 | 70.78 | 72.65 | 4.77 | 3.64 | 23.67 | 0.00 |
| 2013 | 9898.58 | 7860 | 1257 | 89.73 | 89.73 | 89.88 | 89.72 | 0.27 | 0.24 | 10.02 | 0.00 |
| 2014 | 9150.78 | 7276 | 1257 | 83.06 | 83.06 | 83.10 | 83.06 | 1.94 | 6.11 | 10.83 | 0.00 |
| 2015 | 10908.97 | 8584 | 1257 | 97.99 | 97.99 | 99.07 | 97.99 | 2.01 | 2.01 | 0.00 | 0.00 |
| 2016 | 8749.66 | 7016 | 1257 | 79.86 | 79.86 | 79.24 | 79.87 | 6.81 | 5.83 | 14.31 | 0.00 |
| 2017 | 11026.09 | 8711 | 1257 | 99.44 | 99.44 | 100.13 | 99.44 | 0.56 | 0.56 | 0.00 | 0.00 |
| 2018 | 9582.31 | 7840 | 1257 | 89.49 | 89.49 | 87.02 | 89.50 | 0.00 | 0.00 | 10.51 | 0.00 |
| 2019 | 11105.06 | 8760 | 1257 | 100.00 | 100.00 | 100.85 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|-------|-------|-------|-------|------|------|------|------|
| 2020 | 9332.24 | 7790 | 1257 | 88.69 | 88.69 | 84.52 | 88.68 | 3.97 | 3.67 | 7.64 | 0.00 |
| 2021 | 10838.48 | 8491 | 1257 | 96.94 | 96.94 | 98.43 | 96.93 | 3.06 | 3.06 | 0.00 | 0.00 |
| 2022 | 9428.21 | 7862 | 1257 | 97.82 | 97.82 | 85.62 | 89.75 | 0.80 | 0.79 | 1.39 | 0.00 |
| 2023 | 10738.36 | 8534 | 1257 | 99.68 | 99.68 | 97.52 | 97.42 | 0.09 | 0.10 | 0.22 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1983 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 218 | |
| B. Refuelling without maintenance | | | | 37 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 715 | 10 | |
| D. Inspection, maintenance or repair without refuelling | | | | 114 | | |
| E. Testing of plant systems or components | | | | 39 | | |
| H. Nuclear regulatory requirements | | | | | 18 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 26 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 3 |
| S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation) | | | | 10 | | |
| Z. Other | | | | 48 | 33 | |
| Subtotal | | 24 | | 963 | 305 | 5 |
| Total | | 24 | | | 1273 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1983 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 8 |
| 12. Reactor I&C Systems | | 12 |
| 13. Reactor Auxiliary Systems | | 8 |
| 14. Safety Systems | | 12 |
| 15. Reactor Cooling Systems | | 36 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 6 |
| 31. Turbine and auxiliaries | | 57 |
| 32. Feedwater and Main Steam System | 24 | 34 |
| 33. Circulating Water System | | 11 |
| 34. Miscellaneous Systems | | 31 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 12 |
| 42. Electrical Power Supply Systems | | 19 |
| Total | 24 | 248 |

2023 Operating Experience

US-388 SUSQUEHANNA-2 UNITED STATES OF AMERICA

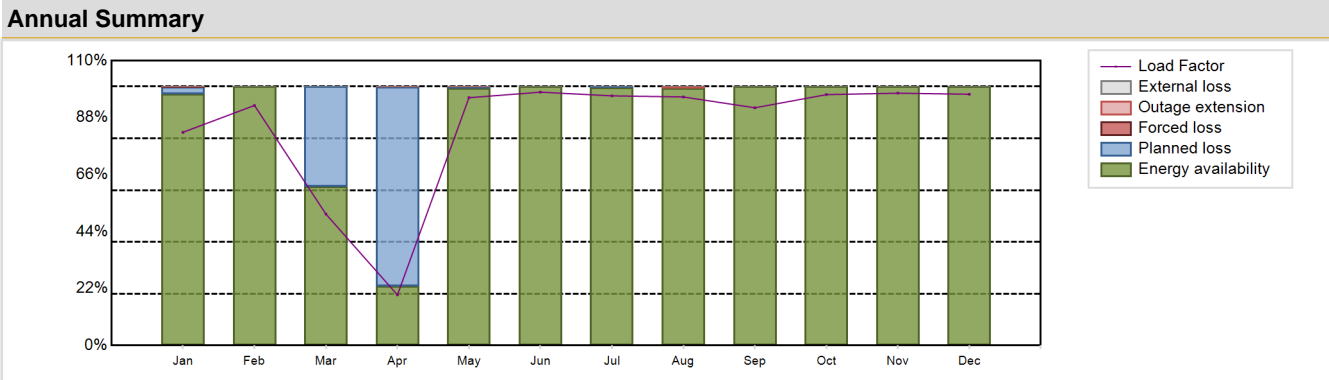
Status at end of year : **Operational**
 Operator : PPL_SUSQ (PPL Susquehanna, LLC)
 Owner : PPL_CORP (PPL Corporation (former PENNSYLVANIA POWER & LIGHT CO. (PP&L)))
 Reactor Supplier : GE (GENERAL ELECTRIC CO.)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|------------------------|--------------------|--------------|
| Reactor type and model | : BWR / BWR-4 (Mark 2) | Construction Date | : 1973-11-02 |
| Thermal power | : 3952 MWth | Grid Date | : 1984-07-03 |
| Gross electrical power | : 1330 MWe | Commercial Date | : 1985-02-12 |
| Reference unit power (net) | : 1257 MWe | Age at end of year | : 39 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 7.19 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 287 |
| Fuel material | : UO2 | Number of SG | : NA |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.372 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 24 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 30 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 36000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 4.57 | HP cylinder inlet steam pressure [MPa] | : 6.69 |
| Active core height/length [m] | : 3.81 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 764 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 14.32 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 185 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 2 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 9312.42 GW(e).h | Forced Loss Rate (FLR) | : 0.01 % |
| Energy Availability Factor (EAF) | : 90.01 % | Unplanned Capability Loss Factor (UCL) | : 0.08 % |
| Unit Capability Factor (UCF) | : 90.01 % | Planned Unavailability Factor (PUF) | : 9.9 % |
| Load Factor (LF) | : 84.57 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 89.25 % | Total off-line time | : 942 hours |

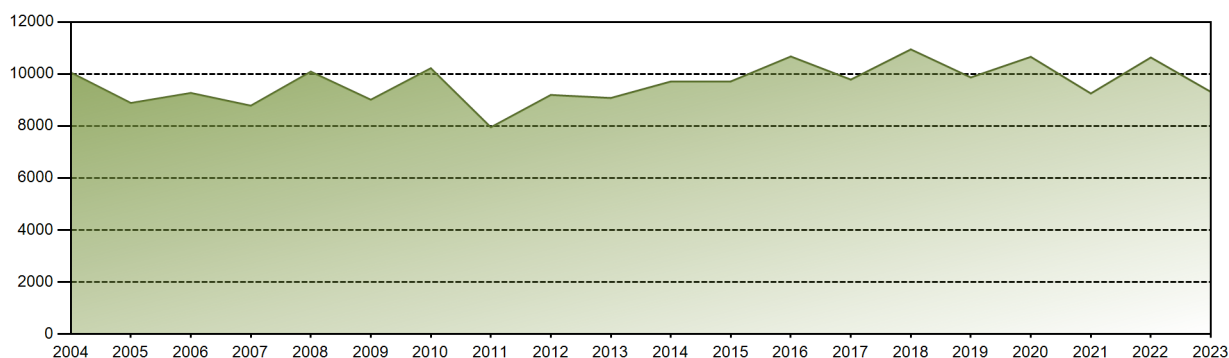


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 770.29 | 783.17 | 473.92 | 176.82 | 895.12 | 885.54 | 901.73 | 897.81 | 830.96 | 906.18 | 883.34 | 907.53 | 9312.42 |
| EAF [%] | 97.16 | 100.00 | 61.49 | 23.00 | 99.26 | 100.00 | 99.52 | 99.45 | 100.00 | 100.00 | 100.00 | 100.00 | 90.01 |
| UCF [%] | 97.16 | 100.00 | 61.49 | 23.00 | 99.26 | 100.00 | 99.52 | 99.45 | 100.00 | 100.00 | 100.00 | 100.00 | 90.01 |
| LF [%] | 82.37 | 92.71 | 50.74 | 19.54 | 95.71 | 97.85 | 96.42 | 96.00 | 91.81 | 96.90 | 97.47 | 97.04 | 84.57 |
| OF [%] | 87.90 | 100.00 | 61.51 | 23.06 | 100.00 | 100.00 | 100.00 | 100.00 | 98.33 | 100.00 | 100.00 | 100.00 | 89.25 |
| FLR [%] | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| UCL [%] | 0.13 | 0.00 | 0.00 | 0.03 | 0.26 | 0.00 | 0.00 | 0.55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 |
| PUF [%] | 2.71 | 0.00 | 38.51 | 76.97 | 0.48 | 0.00 | 0.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.90 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 341951.64 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.43 % |
| Cumulative Energy Availability Factor (EAF) | : 89.02 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.26 % |
| Cumulative Unit Capability Factor (UCF) | : 89.03 % | Cumulative Planned Unavailability Factor (PUF) | : 8.72 % |
| Cumulative Load Factor (LF) | : 87.52 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 88.78 % | | |

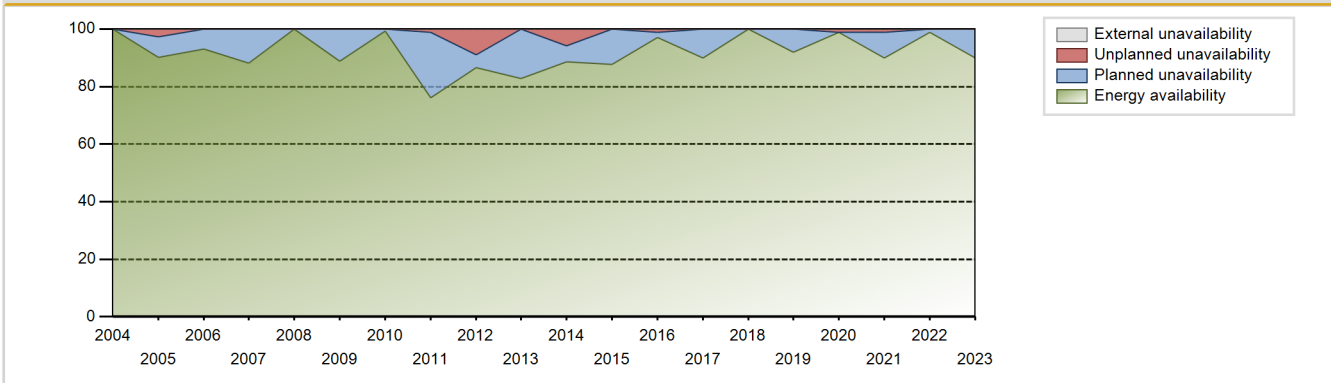
Electricity Production (net) [GWh]



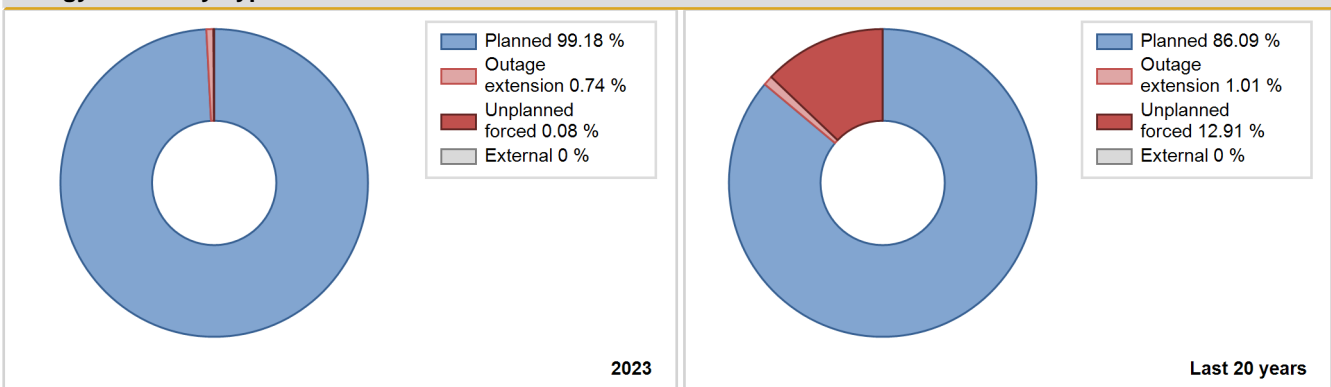
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 7323.31 | 7463 | 1032 | 90.18 | 90.61 | 84.07 | 87.24 | 9.39 | 9.39 | 0.00 | 0.43 |
| 1986 | 5458.36 | 5730 | 1032 | 63.50 | 63.50 | 60.38 | 65.41 | 16.73 | 12.76 | 23.74 | 0.00 |
| 1987 | 8598.43 | 8431 | 1032 | 96.03 | 96.03 | 95.11 | 96.24 | 3.97 | 3.97 | 0.00 | 0.00 |
| 1988 | 5915.25 | 5985 | 1034 | 66.32 | 66.32 | 65.13 | 68.14 | 0.20 | 0.13 | 33.55 | 0.00 |
| 1989 | 6777.04 | 6745 | 1038 | 76.89 | 76.89 | 74.53 | 77.00 | 2.10 | 1.65 | 21.46 | 0.00 |
| 1990 | 8290.70 | 8143 | 1038 | 94.41 | 94.41 | 91.14 | 92.96 | 5.18 | 5.16 | 0.43 | 0.00 |
| 1991 | 7041.38 | 6955 | 1041 | 78.37 | 78.37 | 77.21 | 79.39 | 3.36 | 2.72 | 18.91 | 0.00 |
| 1992 | 7186.16 | 7119 | 1044 | 80.17 | 80.17 | 78.36 | 81.05 | 2.41 | 1.98 | 17.85 | 0.00 |
| 1993 | 8337.86 | 8094 | 1044 | 92.30 | 92.30 | 91.17 | 92.40 | 7.70 | 7.70 | 0.00 | 0.00 |
| 1994 | 6909.84 | 6577 | 1073 | 74.66 | 74.66 | 73.49 | 75.08 | 0.85 | 0.64 | 24.70 | 0.00 |
| 1995 | 8192.74 | 7691 | 1094 | 87.83 | 87.83 | 85.49 | 87.80 | 1.91 | 1.71 | 10.46 | 0.00 |
| 1996 | 9127.17 | 8346 | 1094 | 95.03 | 95.03 | 94.98 | 95.01 | 4.97 | 4.97 | 0.00 | 0.00 |
| 1997 | 7732.57 | 7211 | 1094 | 82.36 | 82.36 | 80.69 | 82.32 | 2.53 | 2.13 | 15.50 | 0.00 |
| 1998 | 8820.75 | 8172 | 1094 | 93.29 | 93.29 | 92.04 | 93.29 | 5.18 | 5.09 | 1.61 | 0.00 |
| 1999 | 7794.67 | 7268 | 1094 | 83.00 | 83.00 | 81.33 | 82.97 | 4.59 | 3.99 | 13.01 | 0.00 |
| 2000 | 9347.19 | 8587 | 1094 | 97.76 | 97.76 | 97.27 | 97.76 | 2.24 | 2.24 | 0.00 | 0.00 |
| 2001 | 8397.15 | 7693 | 1111 | 87.93 | 87.93 | 86.94 | 87.82 | 0.00 | 0.00 | 12.07 | 0.00 |
| 2002 | 9306.16 | 8439 | 1111 | 96.35 | 96.35 | 95.62 | 96.34 | 3.65 | 3.65 | 0.00 | 0.00 |
| 2003 | 8654.66 | 7701 | 1140 | 88.15 | 88.15 | 87.23 | 87.91 | 0.00 | 0.00 | 11.85 | 0.00 |
| 2004 | 10057.13 | 8784 | 1140 | 100.00 | 100.00 | 100.43 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2005 | 8885.73 | 7900 | 1140 | 90.20 | 90.20 | 88.97 | 90.17 | 2.83 | 2.63 | 7.17 | 0.00 |
| 2006 | 9270.90 | 8155 | 1140 | 93.12 | 93.12 | 92.84 | 93.09 | 0.00 | 0.00 | 6.88 | 0.00 |
| 2007 | 8781.57 | 7726 | 1140 | 88.21 | 88.21 | 87.94 | 88.20 | 0.00 | 0.00 | 11.79 | 0.00 |
| 2008 | 10091.45 | 8784 | 1140 | 100.00 | 100.00 | 100.78 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2009 | 9011.13 | 7775 | 1140 | 88.78 | 88.78 | 90.23 | 88.76 | 0.00 | 0.00 | 11.22 | 0.00 |
| 2010 | 10221.22 | 8686 | 1190 | 99.19 | 99.19 | 98.05 | 99.16 | 0.00 | 0.00 | 0.81 | 0.00 |
| 2011 | 7951.26 | 6600 | 1260 | 76.06 | 76.06 | 74.08 | 75.34 | 1.51 | 1.17 | 22.77 | 0.00 |
| 2012 | 9194.97 | 7609 | 1257 | 86.65 | 86.65 | 83.28 | 86.62 | 9.37 | 8.96 | 4.39 | 0.00 |
| 2013 | 9076.94 | 7256 | 1257 | 82.83 | 82.83 | 82.42 | 82.82 | 0.16 | 0.13 | 17.04 | 0.00 |
| 2014 | 9710.29 | 7756 | 1257 | 88.54 | 88.54 | 88.18 | 88.54 | 4.77 | 5.94 | 5.52 | 0.00 |
| 2015 | 9714.51 | 7685 | 1257 | 87.73 | 87.73 | 88.22 | 87.73 | 0.03 | 0.03 | 12.25 | 0.00 |
| 2016 | 10673.32 | 8523 | 1257 | 97.03 | 97.03 | 96.67 | 97.03 | 1.09 | 1.07 | 1.90 | 0.00 |
| 2017 | 9784.47 | 7876 | 1257 | 89.89 | 89.89 | 88.86 | 89.91 | 0.00 | 0.00 | 10.11 | 0.00 |
| 2018 | 10945.59 | 8760 | 1257 | 100.00 | 100.00 | 99.40 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 9867.64 | 8059 | 1257 | 92.01 | 92.01 | 89.61 | 92.00 | 0.00 | 0.00 | 7.99 | 0.00 |
| 2020 | 10658.67 | 8683 | 1257 | 98.86 | 98.86 | 96.53 | 98.85 | 1.14 | 1.14 | 0.00 | 0.00 |
| 2021 | 9251.27 | 7879 | 1257 | 89.94 | 89.94 | 84.02 | 89.94 | 1.15 | 1.05 | 9.01 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|-------|-------|-------|-------|------|------|------|------|
| 2022 | 10634.60 | 8661 | 1257 | 98.88 | 98.88 | 96.58 | 98.87 | 0.00 | 0.00 | 1.12 | 0.00 |
| 2023 | 9312.42 | 7818 | 1257 | 90.01 | 90.01 | 84.57 | 89.25 | 0.01 | 0.08 | 9.90 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 200 | |
| B. Refuelling without maintenance | | | | 20 | | |
| C. Inspection, maintenance or repair combined with refuelling | 840 | | | 680 | | |
| D. Inspection, maintenance or repair without refuelling | 24 | | | 67 | | |
| E. Testing of plant systems or components | | | | 50 | | |
| L. Human factor related | | | | | 4 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | | 12 | |
| Subtotal | 864 | | | 817 | 216 | 1 |
| Total | | 864 | | | 1034 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 12 |
| 12. Reactor I&C Systems | | 15 |
| 13. Reactor Auxiliary Systems | | 4 |
| 14. Safety Systems | | 6 |
| 15. Reactor Cooling Systems | | 17 |
| 31. Turbine and auxiliaries | | 35 |
| 32. Feedwater and Main Steam System | | 35 |
| 34. Miscellaneous Systems | | 28 |
| 41. Main Generator Systems | | 19 |
| 42. Electrical Power Supply Systems | | 34 |
| Total | | 205 |

2023 Operating Experience

US-250 TURKEY POINT-3 UNITED STATES OF AMERICA

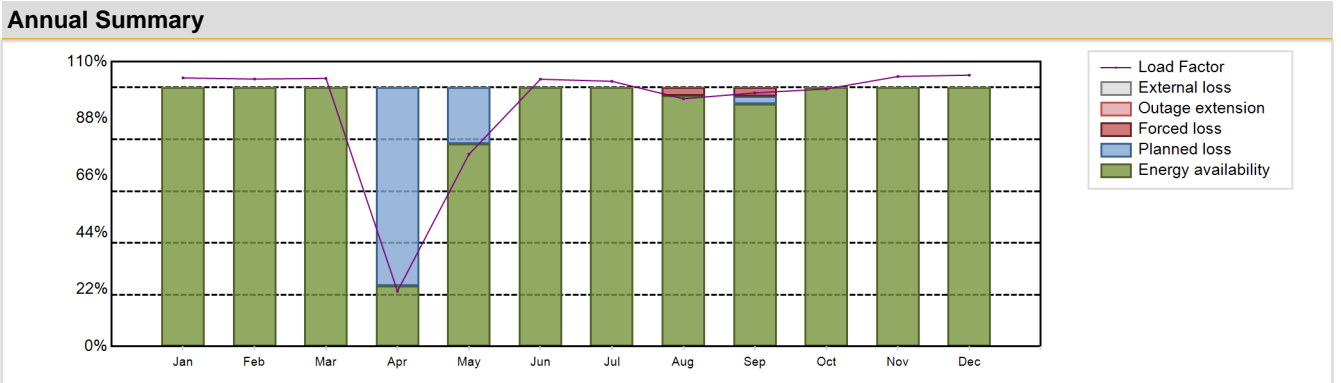
Status at end of year : **Operational**
 Operator : FPL (Florida Power & Light Co.)
 Owner : FPL (Florida Power & Light Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 3LP (DRYAMB) | Construction Date | : 1967-04-27 |
| Thermal power | : 2644 MWth | Grid Date | : 1972-11-02 |
| Gross electrical power | : 829 MWe | Commercial Date | : 1972-12-14 |
| Reference unit power (net) | : 837 MWe | Age at end of year | : 51 years |

| Design Characteristics | | | |
|---|------------|--|----------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.7 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 338 |
| Fuel material | : UO2 | Number of SG | : 3 |
| Refuelling type | : OFF-line | Containment type | : - |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.41 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33.3 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 33000 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.04 | HP cylinder inlet steam pressure [MPa] | : 5.13 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 157 | Primary means of condenser cooling | : Sea (once-through) |
| Fuel linear heat generation rate [kW/m] | : 18 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 29 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 3 | Number of on-site safety related diesel generators | : - |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 6809.83 GW(e).h | Forced Loss Rate (FLR) | : 0.6 % |
| Energy Availability Factor (EAF) | : 91.04 % | Unplanned Capability Loss Factor (UCL) | : 0.55 % |
| Unit Capability Factor (UCF) | : 91.04 % | Planned Unavailability Factor (PUF) | : 8.41 % |
| Load Factor (LF) | : 92.88 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 90.75 % | Total off-line time | : 810 hours |

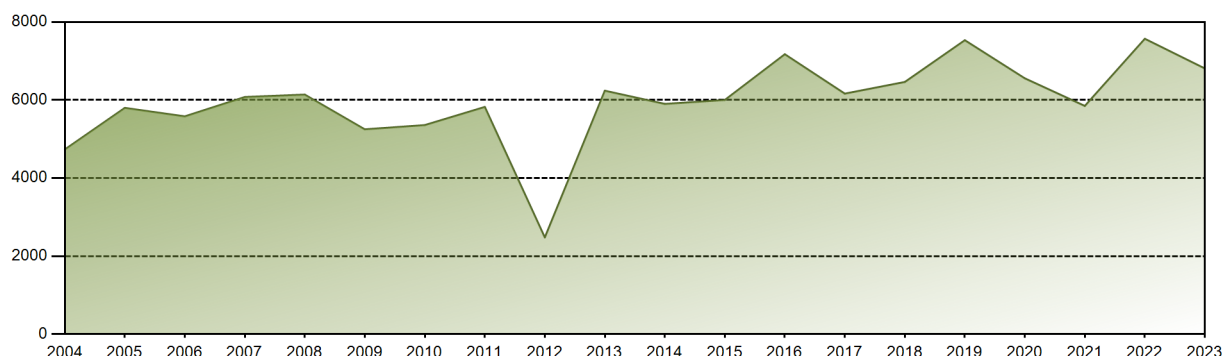


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 645.92 | 581.00 | 644.08 | 128.84 | 462.33 | 622.11 | 637.87 | 595.91 | 590.31 | 619.46 | 629.33 | 652.66 | 6809.83 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 23.34 | 78.19 | 100.00 | 100.00 | 96.77 | 93.56 | 100.00 | 100.00 | 100.00 | 91.04 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 23.34 | 78.19 | 100.00 | 100.00 | 96.77 | 93.56 | 100.00 | 100.00 | 100.00 | 91.04 |
| LF [%] | 103.72 | 103.30 | 103.57 | 21.38 | 74.24 | 103.23 | 102.43 | 95.69 | 97.95 | 99.47 | 104.28 | 104.81 | 92.88 |
| OF [%] | 100.00 | 100.00 | 100.00 | 23.33 | 78.23 | 100.00 | 100.00 | 94.35 | 95.97 | 96.64 | 100.00 | 100.00 | 90.75 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.23 | 3.44 | 0.00 | 0.00 | 0.00 | 0.60 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.23 | 3.33 | 0.00 | 0.00 | 0.00 | 0.55 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 76.66 | 21.81 | 0.00 | 0.00 | 0.00 | 3.10 | 0.00 | 0.00 | 0.00 | 8.41 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 249382.17 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.61 % |
| Cumulative Energy Availability Factor (EAF) | : 80.89 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.91 % |
| Cumulative Unit Capability Factor (UCF) | : 81.01 % | Cumulative Planned Unavailability Factor (PUF) | : 15.08 % |
| Cumulative Load Factor (LF) | : 79.48 % | Cumulative Externally cause unavailability (XUF) | : 0.12 % |
| Cumulative Operating Factor (OF) | : 79.23 % | | |

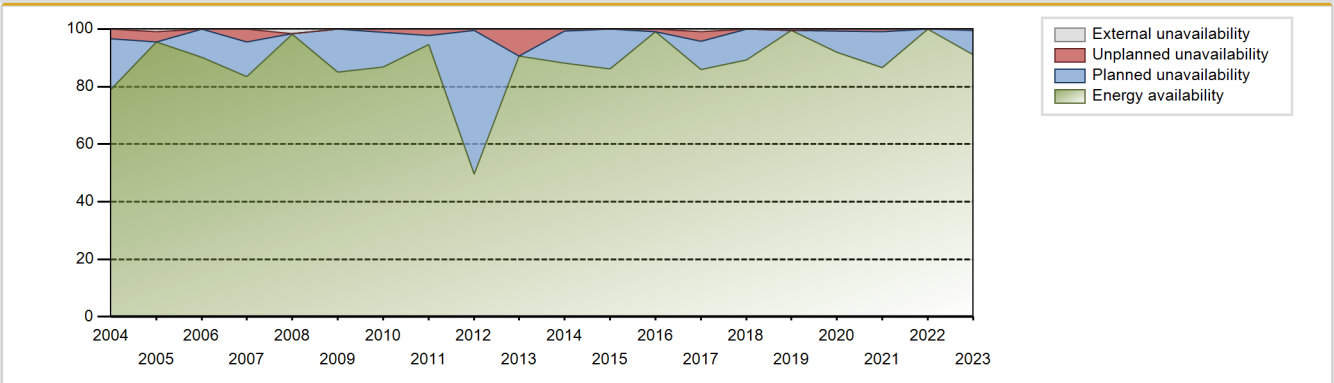
Electricity Production (net) [GWh]



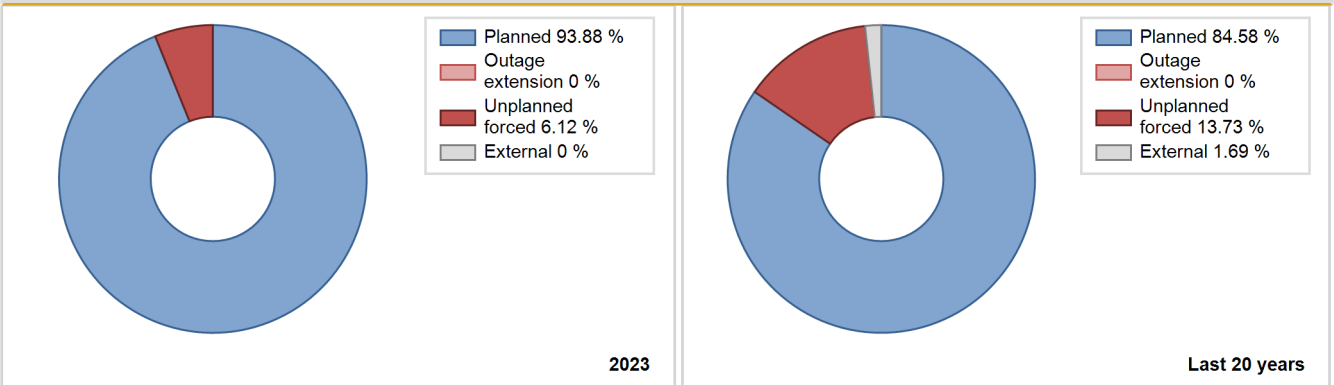
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|-------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1972 | 101.10 | 420 | 670 | 100.00 | 100.00 | 14.55 | 40.86 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1973 | Data not provided | | | | | | | | | | |
| 1974 | 3478.80 | 6090 | 666 | 100.00 | 100.00 | 59.63 | 69.52 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1975 | 4376.00 | 6948 | 666 | 74.91 | 74.91 | 75.01 | 79.32 | 5.56 | 4.41 | 20.67 | 0.00 |
| 1976 | 4322.00 | 6665 | 666 | 73.94 | 73.94 | 73.88 | 75.88 | 0.56 | 0.42 | 25.64 | 0.00 |
| 1977 | 4474.10 | 6994 | 666 | 76.56 | 76.56 | 76.69 | 79.84 | 4.46 | 3.58 | 19.86 | 0.00 |
| 1978 | 4502.70 | 7087 | 666 | 77.20 | 77.20 | 77.18 | 80.90 | 2.53 | 2.00 | 20.80 | 0.00 |
| 1979 | 2881.60 | 4509 | 666 | 49.39 | 49.39 | 49.39 | 51.47 | 3.82 | 1.96 | 48.64 | 0.00 |
| 1980 | 4389.00 | 6812 | 657 | 77.93 | 77.93 | 76.05 | 77.55 | 0.97 | 0.77 | 21.31 | 0.00 |
| 1981 | 933.20 | 1385 | 646 | 13.23 | 13.23 | 16.49 | 15.81 | 57.53 | 17.92 | 68.84 | 0.00 |
| 1982 | 3771.40 | 5612 | 646 | 64.25 | 64.25 | 66.64 | 64.06 | 11.20 | 8.11 | 27.64 | 0.00 |
| 1983 | 4331.00 | 6415 | 659 | 73.35 | 73.35 | 75.02 | 73.23 | 1.99 | 1.49 | 25.16 | 0.00 |
| 1984 | 4784.19 | 7253 | 666 | 82.62 | 82.62 | 81.78 | 82.57 | 11.67 | 10.91 | 6.47 | 0.00 |
| 1985 | 3420.99 | 5224 | 666 | 59.70 | 60.99 | 58.64 | 59.63 | 4.64 | 2.97 | 36.04 | 1.29 |
| 1986 | 4513.06 | 6816 | 666 | 77.87 | 77.87 | 77.36 | 77.81 | 17.05 | 16.00 | 6.13 | 0.00 |
| 1987 | 885.28 | 1566 | 666 | 17.91 | 17.91 | 15.17 | 17.88 | 63.55 | 31.22 | 50.87 | 0.00 |
| 1988 | 3467.96 | 5320 | 666 | 60.60 | 60.60 | 59.28 | 60.56 | 39.29 | 39.22 | 0.18 | 0.00 |
| 1989 | 3605.10 | 5696 | 666 | 65.06 | 65.06 | 61.79 | 65.02 | 14.66 | 11.18 | 23.77 | 0.00 |
| 1990 | 3388.41 | 5200 | 666 | 59.37 | 59.37 | 58.08 | 59.36 | 4.04 | 2.50 | 38.13 | 0.00 |
| 1991 | 1332.05 | 2155 | 666 | 50.01 | 50.01 | 22.83 | 24.60 | 0.59 | 0.30 | 49.69 | 0.00 |
| 1992 | 3428.22 | 5896 | 666 | 67.16 | 67.16 | 58.60 | 67.12 | 5.96 | 4.26 | 28.59 | 0.00 |
| 1993 | 5657.35 | 8421 | 666 | 96.14 | 96.14 | 96.97 | 96.13 | 1.78 | 1.75 | 2.11 | 0.00 |
| 1994 | 4924.92 | 7513 | 666 | 85.83 | 85.83 | 84.42 | 85.76 | 1.93 | 1.69 | 12.48 | 0.00 |
| 1995 | 5218.97 | 7846 | 666 | 89.61 | 89.61 | 89.46 | 89.57 | 0.82 | 0.74 | 9.65 | 0.00 |
| 1996 | 5750.84 | 8490 | 673 | 96.73 | 96.73 | 97.27 | 96.65 | 3.27 | 3.27 | 0.00 | 0.00 |
| 1997 | 5252.35 | 7570 | 693 | 87.00 | 87.00 | 86.52 | 86.42 | 1.37 | 1.21 | 11.79 | 0.00 |
| 1998 | 5408.30 | 7757 | 693 | 89.01 | 89.78 | 89.09 | 88.55 | 1.08 | 0.98 | 9.24 | 0.77 |
| 1999 | 6112.35 | 8684 | 693 | 99.14 | 99.14 | 100.69 | 99.13 | 0.86 | 0.86 | 0.00 | 0.00 |
| 2000 | 5684.42 | 8122 | 693 | 92.47 | 92.47 | 93.38 | 92.46 | 0.00 | 0.00 | 7.53 | 0.00 |
| 2001 | 5526.02 | 7923 | 693 | 90.46 | 90.46 | 91.03 | 90.45 | 1.95 | 1.80 | 7.74 | 0.00 |
| 2002 | 6215.43 | 8760 | 693 | 100.00 | 100.00 | 102.38 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2003 | 5445.57 | 7930 | 693 | 90.56 | 90.56 | 89.70 | 90.53 | 1.99 | 1.83 | 7.61 | 0.00 |
| 2004 | 4734.02 | 6934 | 693 | 78.96 | 78.96 | 77.77 | 78.94 | 3.97 | 3.27 | 17.77 | 0.00 |
| 2005 | 5798.91 | 8362 | 693 | 95.47 | 96.41 | 95.52 | 95.46 | 3.59 | 3.59 | 0.00 | 0.94 |
| 2006 | 5581.94 | 7905 | 693 | 90.25 | 90.25 | 91.95 | 90.24 | 0.00 | 0.00 | 9.75 | 0.00 |
| 2007 | 6078.10 | 7320 | 693 | 83.57 | 83.57 | 100.12 | 83.56 | 5.06 | 4.45 | 11.97 | 0.00 |
| 2008 | 6139.53 | 8617 | 693 | 98.12 | 99.78 | 100.86 | 98.10 | 0.00 | 0.00 | 0.22 | 1.66 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2009 | 5249.30 | 7451 | 693 | 85.06 | 85.06 | 86.47 | 85.06 | 0.00 | 0.00 | 14.94 | 0.00 |
| 2010 | 5358.09 | 7594 | 693 | 86.71 | 86.71 | 88.26 | 86.69 | 1.19 | 1.04 | 12.25 | 0.00 |
| 2011 | 5822.87 | 8291 | 693 | 94.66 | 94.66 | 95.92 | 94.65 | 2.25 | 2.18 | 3.16 | 0.00 |
| 2012 | 2477.38 | 4121 | 802 | 49.51 | 49.51 | 38.67 | 46.91 | 0.88 | 0.44 | 50.05 | 0.00 |
| 2013 | 6239.35 | 7945 | 802 | 90.70 | 90.70 | 88.80 | 90.69 | 9.30 | 9.30 | 0.00 | 0.00 |
| 2014 | 5900.85 | 7726 | 802 | 88.19 | 88.19 | 83.99 | 88.20 | 0.78 | 0.69 | 11.11 | 0.00 |
| 2015 | 6002.32 | 7552 | 802 | 86.22 | 86.22 | 85.44 | 86.21 | 0.00 | 0.00 | 13.78 | 0.00 |
| 2016 | 7174.17 | 8710 | 802 | 99.15 | 99.15 | 101.84 | 99.16 | 0.85 | 0.85 | 0.00 | 0.00 |
| 2017 | 6163.82 | 7531 | 802 | 85.98 | 86.95 | 87.73 | 85.97 | 3.60 | 3.25 | 9.80 | 0.97 |
| 2018 | 6462.92 | 7811 | 837 | 89.22 | 89.22 | 90.49 | 89.17 | 0.00 | 0.00 | 10.78 | 0.00 |
| 2019 | 7533.69 | 8726 | 837 | 99.62 | 100.00 | 102.75 | 99.61 | 0.00 | 0.00 | 0.00 | 0.38 |
| 2020 | 6556.42 | 7996 | 837 | 92.01 | 92.01 | 89.18 | 91.03 | 0.85 | 0.79 | 7.21 | 0.00 |
| 2021 | 5848.82 | 7584 | 837 | 86.57 | 86.57 | 79.77 | 86.58 | 1.07 | 0.94 | 12.49 | 0.00 |
| 2022 | 7570.46 | 8760 | 837 | 100.00 | 100.00 | 103.25 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 6809.83 | 7950 | 837 | 91.04 | 91.04 | 92.88 | 90.75 | 0.60 | 0.55 | 8.41 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1972 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 48 | | | 359 | |
| B. Refuelling without maintenance | | | | 34 | | |
| C. Inspection, maintenance or repair combined with refuelling | 714 | | | 855 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 235 | | |
| E. Testing of plant systems or components | | | | 7 | 1 | |
| F. Major backfitting, refurbishment or upgrading activities with refuelling | | | | 2 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | 16 | 4 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 56 |
| P. Fire | | | | | 2 | |
| Z. Other | | | | 138 | 18 | |
| Subtotal | 714 | 48 | | 1287 | 384 | 59 |
| Total | | 762 | | | 1730 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 1972 to 2023 | |
|--|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 48 | | 1 |
| 12. Reactor I&C Systems | | | | 37 |
| 13. Reactor Auxiliary Systems | | | | 40 |
| 14. Safety Systems | | | | 16 |
| 15. Reactor Cooling Systems | | | | 73 |
| 16. Steam generation systems | | | | 20 |
| 17. Safety I&C Systems (excluding reactor I&C) | | | | 1 |
| 21. Fuel Handling and Storage Facilities | | | | 1 |
| 31. Turbine and auxiliaries | | | | 37 |
| 32. Feedwater and Main Steam System | | | | 30 |
| 33. Circulating Water System | | | | 2 |
| 34. Miscellaneous Systems | | | | 40 |
| 35. All other I&C Systems | | | | 2 |
| 41. Main Generator Systems | | | | 57 |
| 42. Electrical Power Supply Systems | | | | 12 |
| Total | | 48 | | 369 |

2023 Operating Experience

US-251

TURKEY POINT-4

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : FPL (Florida Power & Light Co.)
 Owner : FPL (Florida Power & Light Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 3LP (DRYAMB)
 Thermal power : 2644 MWth
 Gross electrical power : 829 MWe
 Reference unit power (net) : 821 MWe

Key Dates

Construction Date : 1967-04-27
 Grid Date : 1973-06-21
 Commercial Date : 1973-09-07
 Age at end of year : 50 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33.3
 Average discharge burnup [MWd/t] : 33000
 Active core diameter [m] : 3.04
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 157
 Fuel linear heat generation rate [kW/m] : 18
 Number of control rod assemblies : 29
 Number of external reactor coolant loops : 3
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.7
 Reactor outlet temperature [°C] : 338
 Number of SG : 3
 Containment type : -
 Containment design pressure [MPa] : 0.41

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 5.13
 Output voltage [kV] : -
 Primary means of condenser cooling : Sea (once-through)
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

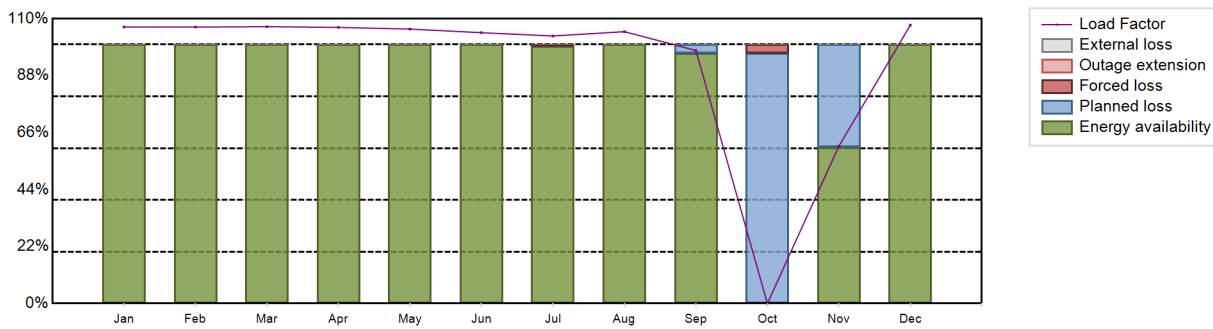
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 6656.18 GW(e).h
 Energy Availability Factor (EAF) : 87.92 %
 Unit Capability Factor (UCF) : 87.92 %
 Load Factor (LF) : 92.55 %
 Operating Factor (OF) : 88.07 %

Forced Loss Rate (FLR) : 0.38 %
 Unplanned Capability Loss Factor (UCL) : 0.33 %
 Planned Unavailability Factor (PUF) : 11.75 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 1045 hours

Annual Summary

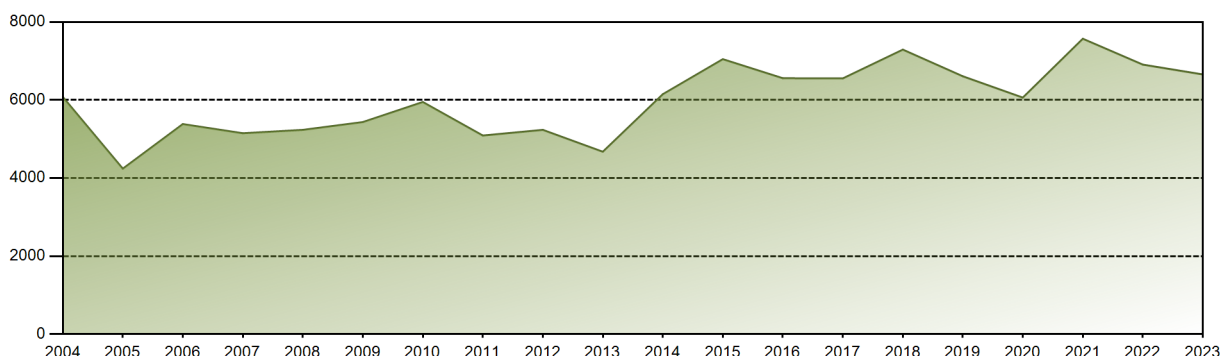


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 652.20 | 588.96 | 652.21 | 630.29 | 647.41 | 618.32 | 631.12 | 641.30 | 577.74 | 0.00 | 359.76 | 656.87 | 6656.18 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.37 | 100.00 | 96.57 | 0.00 | 60.44 | 100.00 | 87.92 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.37 | 100.00 | 96.57 | 0.00 | 60.44 | 100.00 | 87.92 |
| LF [%] | 106.77 | 106.75 | 106.92 | 106.63 | 105.99 | 104.60 | 103.32 | 104.99 | 97.74 | 0.00 | 60.78 | 107.54 | 92.55 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 96.67 | 0.00 | 61.58 | 100.00 | 88.07 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.63 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 0.38 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.63 | 0.00 | 0.00 | 3.29 | 0.00 | 0.00 | 0.33 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.43 | 96.71 | 39.56 | 0.00 | 11.75 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 249333.84 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 4.55 % |
| Cumulative Energy Availability Factor (EAF) | : 81.24 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.88 % |
| Cumulative Unit Capability Factor (UCF) | : 81.28 % | Cumulative Planned Unavailability Factor (PUF) | : 14.84 % |
| Cumulative Load Factor (LF) | : 79.94 % | Cumulative Externally cause unavailability (XUF) | : 0.04 % |
| Cumulative Operating Factor (OF) | : 79.78 % | | |

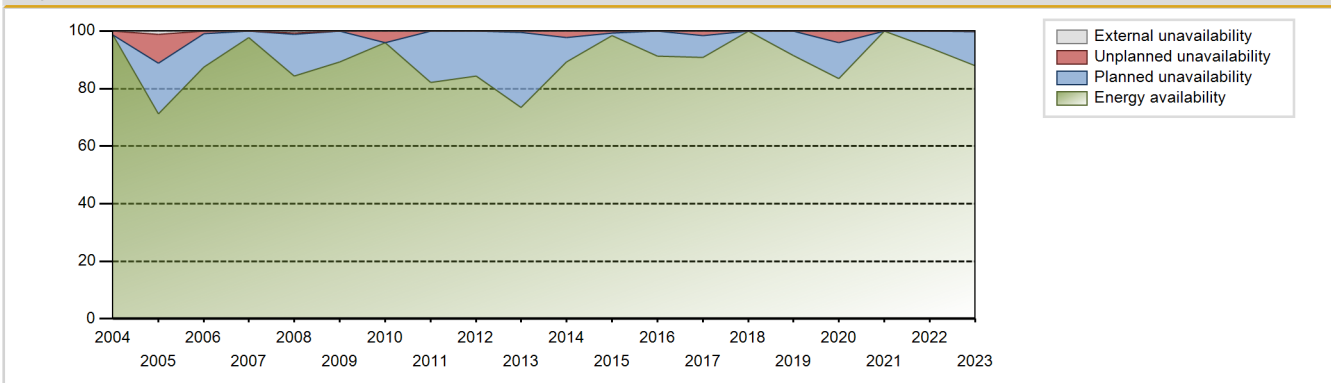
Electricity Production (net) [GWh]



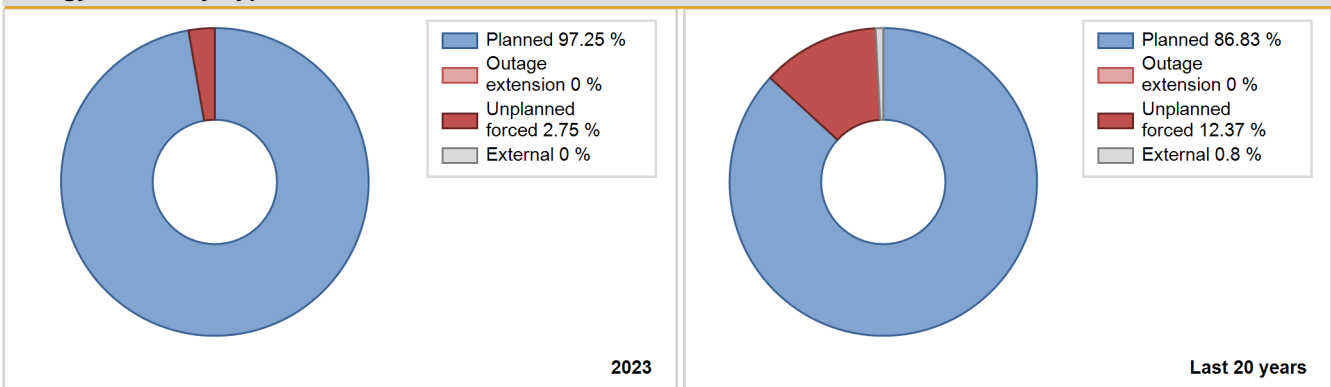
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1973 | | | | Data not provided | | | | | | | |
| 1974 | 4513.40 | 6759 | 728 | 100.00 | 100.00 | 70.77 | 77.16 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1975 | 3991.90 | 6172 | 666 | 68.33 | 68.33 | 68.42 | 70.46 | 0.88 | 0.60 | 31.07 | 0.00 |
| 1976 | 3774.80 | 5825 | 666 | 64.33 | 64.33 | 64.52 | 66.31 | 6.81 | 4.70 | 30.97 | 0.00 |
| 1977 | 3671.00 | 5578 | 666 | 62.74 | 62.74 | 62.92 | 63.68 | 3.32 | 2.15 | 35.10 | 0.00 |
| 1978 | 3791.40 | 6693 | 666 | 64.99 | 64.99 | 64.99 | 76.40 | 4.78 | 3.26 | 31.75 | 0.00 |
| 1979 | 3846.60 | 6361 | 666 | 65.94 | 65.94 | 65.93 | 72.61 | 7.34 | 5.22 | 28.84 | 0.00 |
| 1980 | 3856.50 | 6093 | 657 | 69.40 | 69.40 | 66.82 | 69.36 | 0.00 | 0.00 | 30.60 | 0.00 |
| 1981 | 4507.20 | 6801 | 646 | 77.32 | 77.32 | 79.65 | 77.64 | 3.42 | 2.74 | 19.94 | 0.00 |
| 1982 | 3847.20 | 5806 | 646 | 66.35 | 66.35 | 67.98 | 66.28 | 11.74 | 8.82 | 24.83 | 0.00 |
| 1983 | 2978.90 | 4568 | 659 | 52.44 | 52.44 | 51.60 | 52.15 | 10.71 | 6.29 | 41.26 | 0.00 |
| 1984 | 3084.14 | 4774 | 666 | 54.43 | 54.43 | 52.72 | 54.35 | 29.05 | 22.28 | 23.29 | 0.00 |
| 1985 | 5177.93 | 7852 | 666 | 89.68 | 89.81 | 88.75 | 89.63 | 6.85 | 6.60 | 3.59 | 0.13 |
| 1986 | 1744.00 | 2790 | 666 | 31.88 | 31.88 | 29.89 | 31.85 | 10.14 | 3.60 | 64.53 | 0.00 |
| 1987 | 2657.55 | 4314 | 666 | 49.31 | 49.31 | 45.55 | 49.25 | 50.69 | 50.69 | 0.00 | 0.00 |
| 1988 | 3267.74 | 4986 | 666 | 56.80 | 56.80 | 55.86 | 56.76 | 19.71 | 13.95 | 29.25 | 0.00 |
| 1989 | 2107.57 | 3676 | 666 | 42.00 | 42.00 | 36.12 | 41.96 | 22.72 | 12.35 | 45.65 | 0.00 |
| 1990 | 4384.92 | 6692 | 666 | 76.42 | 76.42 | 75.16 | 76.39 | 12.38 | 10.80 | 12.79 | 0.00 |
| 1991 | 808.05 | 1335 | 666 | 48.18 | 48.18 | 13.85 | 15.24 | 0.59 | 0.29 | 51.53 | 0.00 |
| 1992 | 4642.28 | 7139 | 666 | 81.31 | 81.31 | 79.35 | 81.27 | 13.23 | 12.40 | 6.30 | 0.00 |
| 1993 | 4746.29 | 7277 | 666 | 83.11 | 83.11 | 81.35 | 83.07 | 2.03 | 1.72 | 15.17 | 0.00 |
| 1994 | 4844.35 | 7437 | 666 | 84.95 | 84.95 | 83.03 | 84.90 | 3.83 | 3.38 | 11.67 | 0.00 |
| 1995 | 5780.13 | 8629 | 666 | 98.52 | 98.52 | 99.07 | 98.50 | 1.48 | 1.48 | 0.00 | 0.00 |
| 1996 | 5165.36 | 7771 | 673 | 88.63 | 88.63 | 87.37 | 88.47 | 0.33 | 0.29 | 11.07 | 0.00 |
| 1997 | 5442.56 | 7809 | 693 | 89.60 | 89.60 | 89.65 | 89.14 | 1.04 | 0.94 | 9.46 | 0.00 |
| 1998 | 6181.46 | 8760 | 693 | 100.00 | 100.00 | 101.82 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1999 | 5735.27 | 8185 | 693 | 93.45 | 93.45 | 94.47 | 93.44 | 0.00 | 0.00 | 6.55 | 0.00 |
| 2000 | 5591.38 | 8028 | 693 | 91.41 | 91.41 | 91.85 | 91.39 | 0.87 | 0.80 | 7.79 | 0.00 |
| 2001 | 6105.26 | 8623 | 693 | 98.44 | 98.44 | 100.57 | 98.44 | 1.56 | 1.56 | 0.00 | 0.00 |
| 2002 | 5854.08 | 8369 | 693 | 95.55 | 95.55 | 96.43 | 95.54 | 0.17 | 0.16 | 4.28 | 0.00 |
| 2003 | 5562.48 | 8033 | 693 | 91.71 | 91.71 | 91.63 | 91.70 | 0.00 | 0.00 | 8.29 | 0.00 |
| 2004 | 6079.18 | 8662 | 693 | 98.62 | 98.62 | 99.87 | 98.61 | 1.38 | 1.38 | 0.00 | 0.00 |
| 2005 | 4240.96 | 6243 | 693 | 71.30 | 72.37 | 69.86 | 71.27 | 12.25 | 10.11 | 17.52 | 1.07 |
| 2006 | 5383.75 | 7669 | 693 | 87.56 | 87.56 | 88.68 | 87.55 | 1.07 | 0.95 | 11.49 | 0.00 |
| 2007 | 5148.80 | 8552 | 693 | 97.63 | 97.63 | 84.81 | 97.63 | 0.00 | 0.00 | 2.37 | 0.00 |
| 2008 | 5234.90 | 7415 | 693 | 84.43 | 85.15 | 86.00 | 84.41 | 0.40 | 0.34 | 14.50 | 0.72 |
| 2009 | 5435.35 | 7811 | 693 | 89.18 | 89.18 | 89.53 | 89.17 | 0.00 | 0.00 | 10.82 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|-----|--------|--------|--------|--------|------|------|-------|------|
| 2010 | 5949.82 | 8397 | 693 | 95.87 | 95.87 | 98.01 | 95.86 | 4.13 | 4.13 | 0.00 | 0.00 |
| 2011 | 5089.88 | 7202 | 693 | 82.24 | 82.24 | 83.84 | 82.21 | 0.00 | 0.00 | 17.76 | 0.00 |
| 2012 | 5235.36 | 7416 | 693 | 84.44 | 84.44 | 86.00 | 84.43 | 0.00 | 0.00 | 15.56 | 0.00 |
| 2013 | 4674.70 | 6156 | 802 | 73.43 | 73.43 | 68.84 | 70.27 | 0.65 | 0.48 | 26.09 | 0.00 |
| 2014 | 6149.85 | 7828 | 802 | 89.35 | 89.35 | 87.54 | 89.36 | 2.41 | 2.20 | 8.45 | 0.00 |
| 2015 | 7047.86 | 8623 | 802 | 98.44 | 98.44 | 100.32 | 98.44 | 0.61 | 0.61 | 0.96 | 0.00 |
| 2016 | 6559.29 | 8022 | 802 | 91.33 | 91.33 | 93.11 | 91.33 | 0.00 | 0.00 | 8.67 | 0.00 |
| 2017 | 6554.48 | 7956 | 802 | 90.82 | 90.82 | 93.30 | 90.82 | 1.74 | 1.61 | 7.57 | 0.00 |
| 2018 | 7292.15 | 8760 | 821 | 100.00 | 100.00 | 101.39 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 6608.74 | 8011 | 821 | 91.46 | 91.46 | 91.89 | 91.45 | 0.00 | 0.00 | 8.54 | 0.00 |
| 2020 | 6062.56 | 7338 | 821 | 83.54 | 83.54 | 84.07 | 83.54 | 4.60 | 4.03 | 12.43 | 0.00 |
| 2021 | 7571.21 | 8760 | 821 | 100.00 | 100.00 | 105.27 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 6908.00 | 7997 | 821 | 94.19 | 94.19 | 96.05 | 91.29 | 0.00 | 0.00 | 5.81 | 0.00 |
| 2023 | 6656.18 | 7715 | 821 | 87.92 | 87.92 | 92.55 | 88.07 | 0.38 | 0.33 | 11.75 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1973 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 24 | | | 286 | |
| B. Refuelling without maintenance | | | | 37 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1045 | | | 1087 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 220 | 57 | |
| E. Testing of plant systems or components | | | | 5 | 1 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 9 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 47 |
| Z. Other | | | | | 9 | |
| Subtotal | 1045 | 24 | | 1349 | 362 | 49 |
| Total | | 1069 | | | 1760 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1973 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | 24 | 63 |
| 12. Reactor I&C Systems | | 16 |
| 13. Reactor Auxiliary Systems | | 2 |
| 14. Safety Systems | | 4 |
| 15. Reactor Cooling Systems | | 71 |
| 16. Steam generation systems | | 75 |
| 31. Turbine and auxiliaries | | 49 |
| 32. Feedwater and Main Steam System | | 22 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 26 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 2 |
| 42. Electrical Power Supply Systems | | 39 |
| Total | 24 | 373 |

2023 Operating Experience

US-424

VOGTLE-1

UNITED STATES OF AMERICA

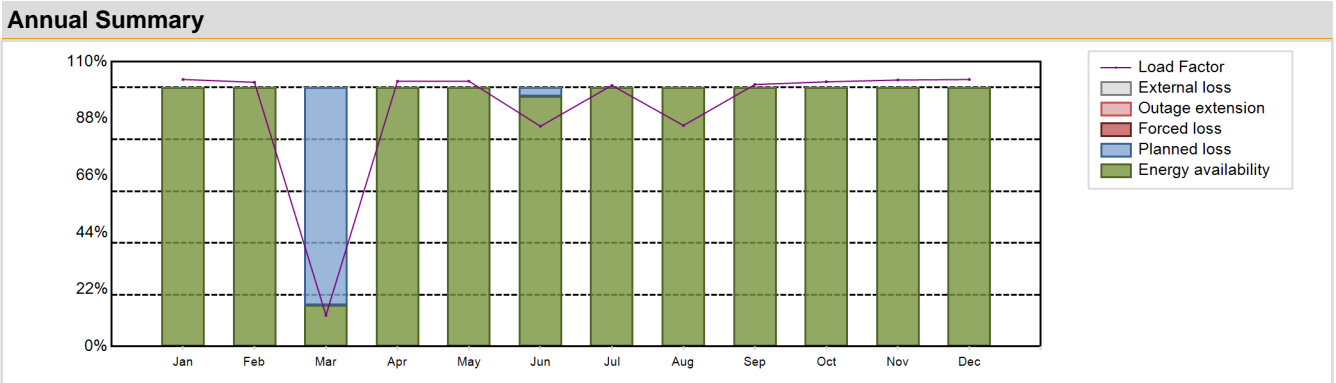
Status at end of year : **Operational**
 Operator : SOUTHERN (Southern Nuclear Operating Company, Inc.)
 Owner : GPCO (GEORGIA POWER CO.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-------------------------|--------------------|--------------|
| Reactor type and model | : PWR / WH 4LP (DRYAMB) | Construction Date | : 1976-08-01 |
| Thermal power | : 3626 MWth | Grid Date | : 1987-03-27 |
| Gross electrical power | : 1229 MWe | Commercial Date | : 1987-06-01 |
| Reference unit power (net) | : 1150 MWe | Age at end of year | : 36 years |

| Design Characteristics | | | |
|---|------------|--|------------------|
| Primary Systems | | Operating coolant pressure [MPa] | : 15.82 |
| Reactor vessel centreline orientation | : Vertical | Reactor outlet temperature [°C] | : 325 |
| Fuel material | : UO2 | Number of SG | : 4 |
| Refuelling type | : OFF-line | Containment type | : Single |
| Moderator material | : H2O | Containment design pressure [MPa] | : 0.365 |
| Average fuel enrichment [% of U235] | : - | Secondary systems | |
| Refuelling frequency [month] | : 18 | Number of turbine-generators per unit/reactor | : 1 |
| Part of the core refuelled [%] | : 33 | Turbine speed [rpm] | : 1800 |
| Average discharge burnup [MWd/t] | : 36400 | Number of LP cylinders per turbine | : - |
| Active core diameter [m] | : 3.4 | HP cylinder inlet steam pressure [MPa] | : 6.81 |
| Active core height/length [m] | : 3.66 | Output voltage [kV] | : - |
| Number of fissile fuel assemblies/bundles | : 193 | Primary means of condenser cooling | : Cooling Towers |
| Fuel linear heat generation rate [kW/m] | : 17.8 | Number of main condensate pumps | : - |
| Number of control rod assemblies | : 53 | Number of FW pumps for full power operation | : - |
| Number of external reactor coolant loops | : 4 | Number of on-site safety related diesel generators | : 2 |
| Coolant type | : H2O | Non-electrical applications | : none |

| Annual Production Results (2023) | | | |
|----------------------------------|-------------------|--|-------------|
| Net Energy Production | : 9244.23 GW(e).h | Forced Loss Rate (FLR) | : 0 % |
| Energy Availability Factor (EAF) | : 92.61 % | Unplanned Capability Loss Factor (UCL) | : 0 % |
| Unit Capability Factor (UCF) | : 92.61 % | Planned Unavailability Factor (PUF) | : 7.39 % |
| Load Factor (LF) | : 91.76 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 91.13 % | Total off-line time | : 777 hours |

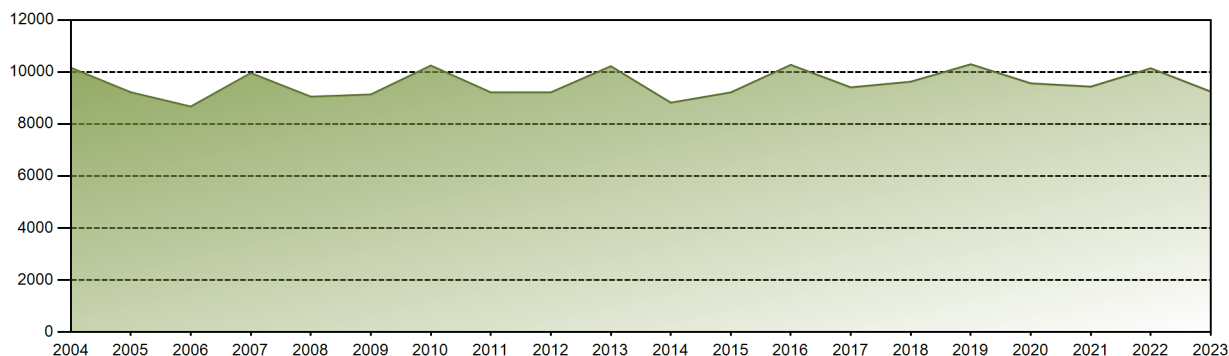


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 882.43 | 788.57 | 103.01 | 848.06 | 876.70 | 704.31 | 862.86 | 730.36 | 837.72 | 874.64 | 853.26 | 882.31 | 9244.23 |
| EAF [%] | 100.00 | 100.00 | 16.05 | 100.00 | 100.00 | 96.67 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.61 |
| UCF [%] | 100.00 | 100.00 | 16.05 | 100.00 | 100.00 | 96.67 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.61 |
| LF [%] | 103.14 | 102.04 | 12.06 | 102.42 | 102.47 | 85.06 | 100.85 | 85.36 | 101.17 | 102.23 | 102.91 | 103.12 | 91.76 |
| OF [%] | 100.00 | 100.00 | 16.02 | 100.00 | 100.00 | 85.14 | 100.00 | 93.82 | 100.00 | 100.00 | 100.00 | 100.00 | 91.13 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.00 | 0.00 | 83.95 | 0.00 | 0.00 | 3.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.39 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

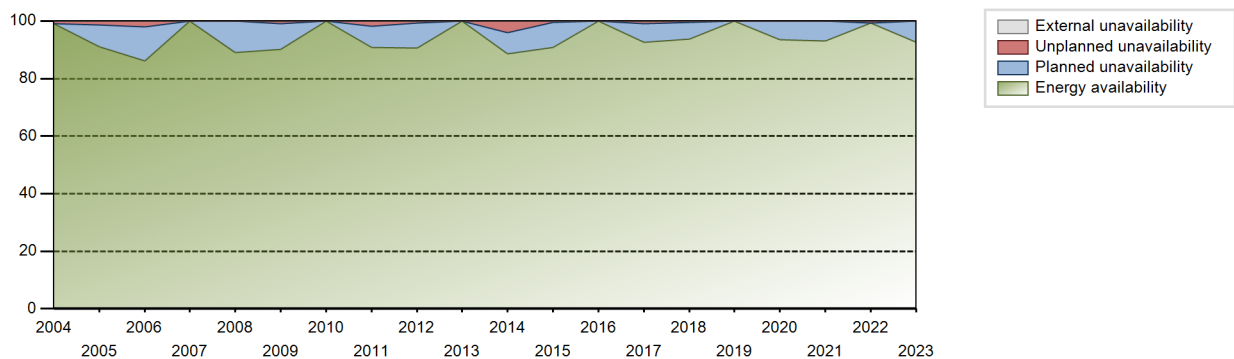
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 335626.18 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.49 % |
| Cumulative Energy Availability Factor (EAF) | : 91.74 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.39 % |
| Cumulative Unit Capability Factor (UCF) | : 91.76 % | Cumulative Planned Unavailability Factor (PUF) | : 6.85 % |
| Cumulative Load Factor (LF) | : 92.12 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 91.73 % | | |

Electricity Production (net) [GWh]

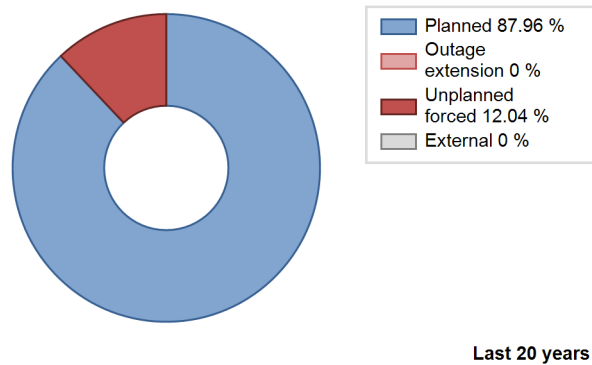
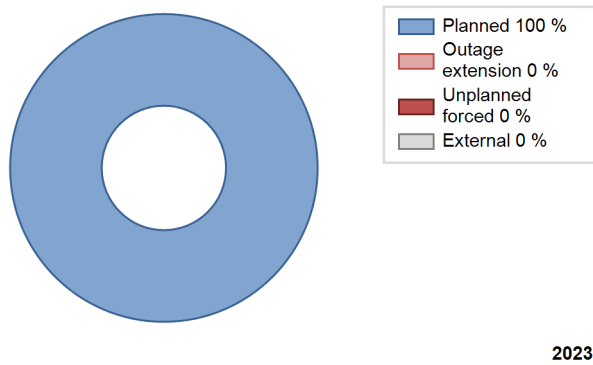


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1987 | | | | Data not provided | | | | | | | |
| 1988 | 6799.71 | 6569 | 1079 | 74.25 | 74.25 | 71.74 | 74.78 | 12.68 | 10.78 | 14.97 | 0.00 |
| 1989 | 8709.38 | 8275 | 1083 | 94.19 | 94.19 | 91.80 | 94.46 | 5.81 | 5.81 | 0.00 | 0.00 |
| 1990 | 7353.06 | 6980 | 1079 | 78.39 | 78.39 | 77.79 | 79.68 | 2.65 | 2.14 | 19.48 | 0.00 |
| 1991 | 7501.74 | 7016 | 1100 | 78.95 | 78.95 | 77.85 | 80.09 | 0.00 | 0.00 | 21.05 | 0.00 |
| 1992 | 9383.53 | 8523 | 1105 | 96.88 | 96.88 | 96.67 | 97.03 | 3.12 | 3.12 | 0.00 | 0.00 |
| 1993 | 8600.74 | 7577 | 1145 | 86.29 | 86.29 | 85.70 | 86.50 | 1.26 | 1.10 | 12.61 | 0.00 |
| 1994 | 8817.16 | 7847 | 1168 | 89.64 | 89.64 | 86.14 | 89.58 | 0.62 | 0.56 | 9.80 | 0.00 |
| 1995 | 9984.01 | 8621 | 1162 | 98.43 | 99.18 | 98.08 | 98.41 | 0.00 | 0.00 | 0.82 | 0.74 |
| 1996 | 8149.80 | 7162 | 1162 | 81.55 | 81.55 | 79.85 | 81.53 | 5.76 | 4.98 | 13.47 | 0.00 |
| 1997 | 8270.11 | 7167 | 1162 | 81.85 | 81.85 | 81.25 | 81.82 | 4.29 | 3.67 | 14.48 | 0.00 |
| 1998 | 10216.95 | 8738 | 1162 | 99.75 | 99.75 | 100.37 | 99.75 | 0.00 | 0.00 | 0.25 | 0.00 |
| 1999 | 9425.86 | 8108 | 1152 | 92.59 | 92.59 | 93.34 | 92.56 | 0.00 | 0.00 | 7.41 | 0.00 |
| 2000 | 9196.57 | 7963 | 1148 | 90.66 | 90.66 | 91.20 | 90.65 | 0.90 | 0.82 | 8.52 | 0.00 |
| 2001 | 10144.38 | 8665 | 1148 | 98.92 | 98.92 | 100.87 | 98.92 | 1.08 | 1.08 | 0.00 | 0.00 |
| 2002 | 8638.76 | 7469 | 1148 | 85.29 | 85.29 | 85.90 | 85.26 | 2.76 | 2.42 | 12.29 | 0.00 |
| 2003 | 9411.48 | 8097 | 1152 | 92.47 | 92.47 | 93.26 | 92.43 | 0.00 | 0.00 | 7.53 | 0.00 |
| 2004 | 10162.27 | 8694 | 1152 | 98.98 | 98.98 | 100.43 | 98.98 | 0.83 | 0.83 | 0.19 | 0.00 |
| 2005 | 9220.15 | 7964 | 1152 | 90.95 | 90.95 | 91.37 | 90.91 | 1.54 | 1.43 | 7.63 | 0.00 |
| 2006 | 8671.05 | 7536 | 1152 | 86.05 | 86.05 | 85.92 | 86.03 | 2.27 | 2.00 | 11.95 | 0.00 |
| 2007 | 9960.29 | 8760 | 1109 | 100.00 | 100.00 | 102.53 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 9050.43 | 7828 | 1109 | 89.12 | 89.12 | 92.91 | 89.12 | 0.00 | 0.00 | 10.88 | 0.00 |
| 2009 | 9135.00 | 7861 | 1150 | 90.12 | 90.12 | 90.68 | 89.74 | 1.10 | 1.00 | 8.88 | 0.00 |
| 2010 | 10247.42 | 8760 | 1150 | 100.00 | 100.00 | 101.72 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 9216.93 | 7954 | 1150 | 90.82 | 90.82 | 91.49 | 90.80 | 1.90 | 1.76 | 7.42 | 0.00 |
| 2012 | 9216.97 | 7961 | 1150 | 90.65 | 90.65 | 91.24 | 90.63 | 0.67 | 0.62 | 8.73 | 0.00 |
| 2013 | 10222.36 | 8760 | 1150 | 100.00 | 100.00 | 101.46 | 99.99 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 8820.19 | 7752 | 1150 | 88.50 | 88.50 | 87.55 | 88.49 | 4.45 | 4.12 | 7.39 | 0.00 |
| 2015 | 9215.78 | 7947 | 1150 | 90.72 | 90.72 | 91.48 | 90.72 | 0.45 | 0.41 | 8.87 | 0.00 |
| 2016 | 10273.15 | 8784 | 1150 | 100.00 | 100.00 | 101.70 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 9408.65 | 8109 | 1150 | 92.57 | 92.57 | 93.40 | 92.57 | 1.04 | 0.97 | 6.47 | 0.00 |
| 2018 | 9627.22 | 8216 | 1150 | 93.79 | 93.79 | 95.57 | 93.79 | 0.51 | 0.48 | 5.73 | 0.00 |
| 2019 | 10297.02 | 8760 | 1150 | 100.00 | 100.00 | 102.21 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 9562.45 | 8221 | 1150 | 93.60 | 93.60 | 94.66 | 93.59 | 0.00 | 0.00 | 6.40 | 0.00 |
| 2021 | 9436.79 | 8152 | 1150 | 93.06 | 93.06 | 93.67 | 93.06 | 0.00 | 0.00 | 6.94 | 0.00 |
| 2022 | 10141.46 | 8699 | 1150 | 99.30 | 99.30 | 100.67 | 99.30 | 0.70 | 0.70 | 0.00 | 0.00 |
| 2023 | 9244.23 | 7983 | 1150 | 92.61 | 92.61 | 91.76 | 91.13 | 0.00 | 0.00 | 7.39 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1987 to 2023 | | |
|---|------------|------------|----------|-------------------------------------|------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 106 | |
| B. Refuelling without maintenance | | | | 32 | | |
| C. Inspection, maintenance or repair combined with refuelling | 623 | | | 544 | | |
| D. Inspection, maintenance or repair without refuelling | 24 | | | 17 | | |
| E. Testing of plant systems or components | | | | 2 | 0 | |
| H. Nuclear regulatory requirements | | | | | 5 | |
| L. Human factor related | | | | | 8 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 1 |
| Z. Other | | | | 1 | 0 | 2 |
| Subtotal | 647 | | | 596 | 119 | 3 |
| Total | | 647 | | | 718 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1987 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 1 |
| 14. Safety Systems | | 21 |
| 15. Reactor Cooling Systems | | 22 |
| 16. Steam generation systems | | 4 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 6 |
| 31. Turbine and auxiliaries | | 4 |
| 32. Feedwater and Main Steam System | | 21 |
| 34. Miscellaneous Systems | | 0 |
| 35. All other I&C Systems | | 2 |
| 41. Main Generator Systems | | 19 |
| 42. Electrical Power Supply Systems | | 7 |
| Total | | 114 |

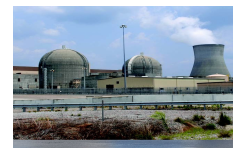
2023 Operating Experience

US-425

VOGTLE-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : SOUTHERN (Southern Nuclear Operating Company, Inc.)
 Owner : GPCO (GEORGIA POWER CO.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (DRYAMB)
 Thermal power : 3626 MWth
 Gross electrical power : 1229 MWe
 Reference unit power (net) : 1152 MWe

Key Dates

Construction Date : 1976-08-01
 Grid Date : 1989-04-10
 Commercial Date : 1989-05-20
 Age at end of year : 34 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : 18
 Part of the core refuelled [%] : 33
 Average discharge burnup [MWd/t] : 36400
 Active core diameter [m] : 3.4
 Active core height/length [m] : 3.66
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.8
 Number of control rod assemblies : 53
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.82
 Reactor outlet temperature [°C] : 325
 Number of SG : 4
 Containment type : Single
 Containment design pressure [MPa] : 0.365

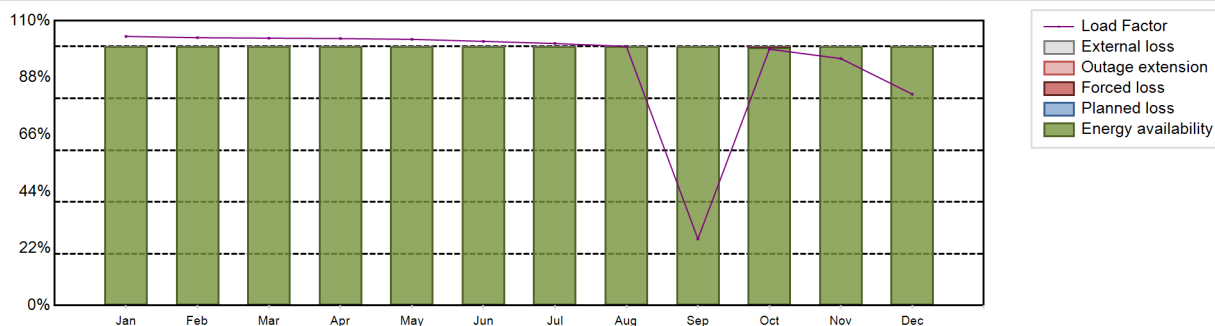
Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.81
 Output voltage [kV] : -
 Primary means of condenser cooling : Cooling Towers
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9436.09 GW(e).h
 Energy Availability Factor (EAF) : 99.98 %
 Unit Capability Factor (UCF) : 99.98 %
 Load Factor (LF) : 93.51 %
 Operating Factor (OF) : 94.24 %
 Forced Loss Rate (FLR) : 0.02 %
 Unplanned Capability Loss Factor (UCL) : 0.02 %
 Planned Unavailability Factor (PUF) : 0 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 505 hours

Annual Summary

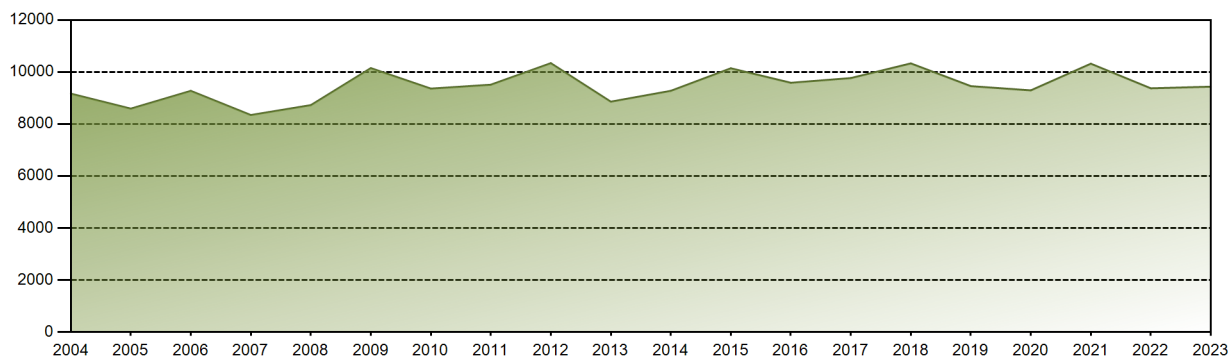


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 890.79 | 800.78 | 883.82 | 855.14 | 881.14 | 846.26 | 867.22 | 857.73 | 213.14 | 848.49 | 792.10 | 699.47 | 9436.09 |
| EAF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.71 | 100.00 | 100.00 | 99.98 |
| UCF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 99.71 | 100.00 | 100.00 | 99.98 |
| LF [%] | 103.93 | 103.44 | 103.26 | 103.10 | 102.81 | 102.03 | 101.18 | 100.07 | 25.70 | 99.00 | 95.37 | 81.61 | 93.51 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 30.00 | 99.87 | 100.00 | 100.00 | 94.24 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.00 | 0.00 | 0.02 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.00 | 0.00 | 0.02 |
| PUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

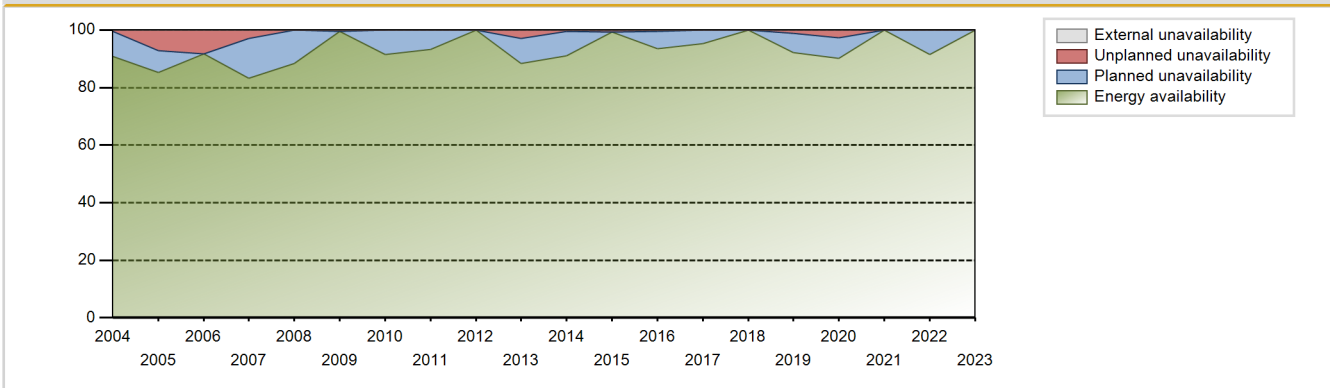
| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 320277.6 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 1.52 % |
| Cumulative Energy Availability Factor (EAF) | : 92.09 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 1.42 % |
| Cumulative Unit Capability Factor (UCF) | : 92.11 % | Cumulative Planned Unavailability Factor (PUF) | : 6.47 % |
| Cumulative Load Factor (LF) | : 92.13 % | Cumulative Externally cause unavailability (XUF) | : 0.01 % |
| Cumulative Operating Factor (OF) | : 91.95 % | | |

Electricity Production (net) [GWh]

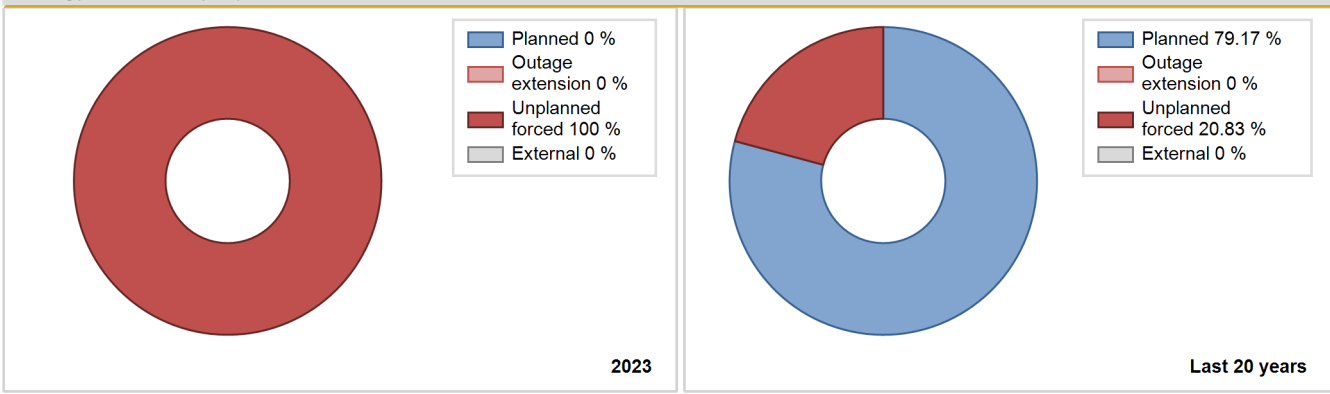


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|------|------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1989 | 5547.17 | 5104 | 1110 | 95.42 | 95.42 | 96.38 | 95.60 | 2.29 | 2.24 | 2.34 | 0.00 |
| 1990 | 6868.02 | 7125 | 1110 | 81.06 | 81.06 | 70.63 | 81.34 | 1.91 | 1.58 | 17.36 | 0.00 |
| 1991 | 8897.44 | 8375 | 1097 | 95.44 | 95.44 | 92.59 | 95.61 | 2.20 | 2.15 | 2.42 | 0.00 |
| 1992 | 7779.64 | 7175 | 1109 | 80.79 | 80.79 | 79.86 | 81.68 | 0.94 | 0.76 | 18.45 | 0.00 |
| 1993 | 8680.90 | 7737 | 1140 | 88.11 | 88.11 | 86.88 | 88.32 | 0.38 | 0.34 | 11.56 | 0.00 |
| 1994 | 9331.60 | 8062 | 1168 | 92.12 | 92.12 | 91.16 | 92.03 | 4.81 | 4.65 | 3.23 | 0.00 |
| 1995 | 9165.65 | 7908 | 1162 | 90.29 | 90.77 | 90.04 | 90.27 | 0.00 | 0.00 | 9.23 | 0.48 |
| 1996 | 9037.64 | 7899 | 1162 | 89.94 | 89.94 | 88.54 | 89.92 | 0.59 | 0.54 | 9.52 | 0.00 |
| 1997 | 10310.83 | 8760 | 1162 | 100.00 | 100.00 | 101.29 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1998 | 8388.61 | 7347 | 1162 | 83.89 | 83.89 | 82.38 | 83.87 | 4.82 | 4.25 | 11.87 | 0.00 |
| 1999 | 9022.63 | 7833 | 1156 | 89.47 | 89.47 | 89.09 | 89.42 | 0.57 | 0.51 | 10.02 | 0.00 |
| 2000 | 10337.82 | 8784 | 1149 | 100.00 | 100.00 | 102.39 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2001 | 9456.68 | 8112 | 1149 | 92.61 | 92.61 | 93.95 | 92.60 | 0.06 | 0.05 | 7.34 | 0.00 |
| 2002 | 8418.90 | 7328 | 1149 | 83.66 | 83.66 | 83.64 | 83.65 | 5.60 | 4.96 | 11.38 | 0.00 |
| 2003 | 9736.64 | 8401 | 1149 | 95.93 | 95.93 | 96.74 | 95.90 | 0.00 | 0.00 | 4.07 | 0.00 |
| 2004 | 9168.69 | 7970 | 1149 | 90.78 | 90.78 | 90.84 | 90.73 | 0.60 | 0.55 | 8.67 | 0.00 |
| 2005 | 8592.88 | 7464 | 1149 | 85.24 | 85.24 | 85.37 | 85.21 | 7.79 | 7.20 | 7.56 | 0.00 |
| 2006 | 9276.10 | 8024 | 1149 | 91.65 | 91.65 | 92.16 | 91.60 | 8.35 | 8.35 | 0.00 | 0.00 |
| 2007 | 8347.29 | 7323 | 1127 | 83.31 | 83.31 | 84.55 | 83.60 | 3.45 | 2.98 | 13.71 | 0.00 |
| 2008 | 8727.13 | 7767 | 1127 | 88.43 | 88.43 | 88.16 | 88.42 | 0.00 | 0.00 | 11.57 | 0.00 |
| 2009 | 10150.93 | 8710 | 1152 | 99.45 | 99.45 | 100.59 | 99.43 | 0.55 | 0.55 | 0.00 | 0.00 |
| 2010 | 9363.05 | 8011 | 1152 | 91.46 | 91.46 | 92.78 | 91.45 | 0.00 | 0.00 | 8.54 | 0.00 |
| 2011 | 9512.37 | 8163 | 1152 | 93.20 | 93.20 | 94.26 | 93.18 | 0.00 | 0.00 | 6.80 | 0.00 |
| 2012 | 10341.23 | 8784 | 1152 | 100.00 | 100.00 | 102.19 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 8860.32 | 7748 | 1152 | 88.45 | 88.45 | 87.79 | 88.44 | 3.14 | 2.86 | 8.68 | 0.00 |
| 2014 | 9276.53 | 7984 | 1152 | 91.13 | 91.13 | 91.92 | 91.14 | 0.58 | 0.53 | 8.34 | 0.00 |
| 2015 | 10144.14 | 8692 | 1152 | 99.22 | 99.22 | 100.52 | 99.22 | 0.78 | 0.78 | 0.00 | 0.00 |
| 2016 | 9586.97 | 8220 | 1152 | 93.57 | 93.57 | 94.74 | 93.58 | 0.43 | 0.40 | 6.03 | 0.00 |
| 2017 | 9767.38 | 8347 | 1152 | 95.28 | 95.28 | 96.79 | 95.29 | 0.00 | 0.00 | 4.72 | 0.00 |
| 2018 | 10331.91 | 8760 | 1152 | 100.00 | 100.00 | 102.38 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 9457.10 | 8076 | 1152 | 92.21 | 92.21 | 93.71 | 92.19 | 1.33 | 1.24 | 6.54 | 0.00 |
| 2020 | 9295.37 | 7913 | 1152 | 90.09 | 90.09 | 91.86 | 90.08 | 2.83 | 2.62 | 7.29 | 0.00 |
| 2021 | 10320.36 | 8760 | 1152 | 100.00 | 100.00 | 102.27 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 9373.75 | 8023 | 1152 | 91.59 | 91.59 | 92.89 | 91.59 | 0.00 | 0.00 | 8.41 | 0.00 |
| 2023 | 9436.09 | 8255 | 1152 | 99.98 | 99.98 | 93.51 | 94.24 | 0.02 | 0.02 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1989 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 91 | |
| B. Refuelling without maintenance | | | | 40 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 478 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 45 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| L. Human factor related | | | | | 22 | |
| Z. Other | | | | 2 | 13 | 1 |
| Subtotal | | | | 566 | 126 | 1 |
| Total | | 0 | | | 693 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1989 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 7 |
| 13. Reactor Auxiliary Systems | | 7 |
| 14. Safety Systems | | 9 |
| 15. Reactor Cooling Systems | | 22 |
| 16. Steam generation systems | | 2 |
| 31. Turbine and auxiliaries | | 1 |
| 32. Feedwater and Main Steam System | | 23 |
| 34. Miscellaneous Systems | | 2 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 14 |
| 42. Electrical Power Supply Systems | | 2 |
| Total | | 94 |

2023 Operating Experience

US-5025

VOGTLE-3

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : SOUTHERN (Southern Nuclear Operating Company, Inc.)
 Owner : GPCO (GEORGIA POWER CO.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : TOSHIBA (TOSHIBA CORPORATION)



| Reactor Unit Details | | Key Dates | |
|----------------------------|-----------------|--------------------|--------------|
| Reactor type and model | : PWR / AP-1000 | Construction Date | : 2013-03-02 |
| Thermal power | : 3400 MWth | Grid Date | : 2023-03-31 |
| Gross electrical power | : 1250 MWe | Commercial Date | : 2023-07-31 |
| Reference unit power (net) | : 1117 MWe | Age at end of year | : 0 years |

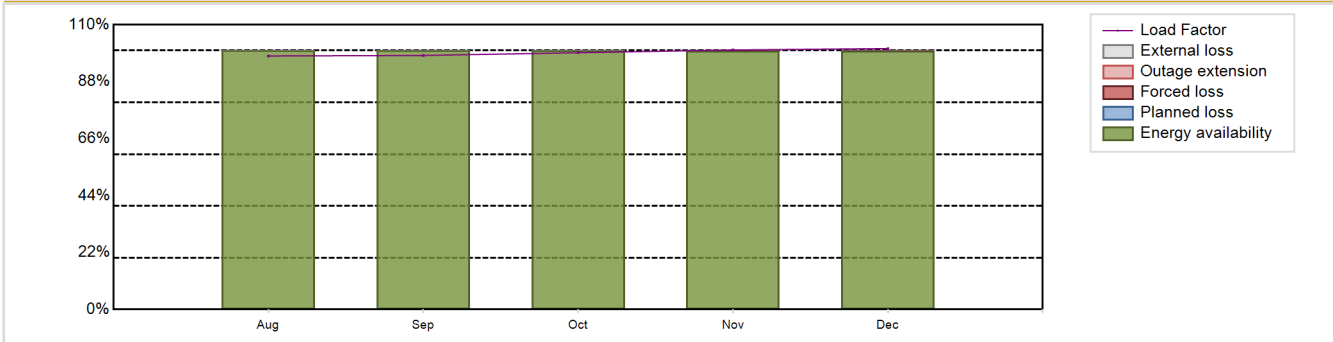
Design Characteristics

| Primary Systems | | Secondary systems | |
|---|-----|--|--------|
| Reactor vessel centreline orientation | : - | Operating coolant pressure [MPa] | : - |
| Fuel material | : - | Reactor outlet temperature [°C] | : - |
| Refuelling type | : - | Number of SG | : - |
| Moderator material | : - | Containment type | : - |
| Average fuel enrichment [% of U235] | : - | Containment design pressure [MPa] | : - |
| Refuelling frequency [month] | : - | Secondary systems | |
| Part of the core refuelled [%] | : - | Number of turbine-generators per unit/reactor | : - |
| Average discharge burnup [MWd/t] | : - | Turbine speed [rpm] | : - |
| Active core diameter [m] | : - | Number of LP cylinders per turbine | : - |
| Active core height/length [m] | : - | HP cylinder inlet steam pressure [MPa] | : - |
| Number of fissile fuel assemblies/bundles | : - | Output voltage [kV] | : - |
| Fuel linear heat generation rate [kW/m] | : - | Primary means of condenser cooling | : - |
| Number of control rod assemblies | : - | Number of main condensate pumps | : - |
| Number of external reactor coolant loops | : - | Number of FW pumps for full power operation | : - |
| Coolant type | : - | Number of on-site safety related diesel generators | : - |
| | | Non-electrical applications | : none |

Annual Production Results (2023)

| | | | |
|----------------------------------|-------------------|--|-----------|
| Net Energy Production | : 7369.68 GW(e).h | Forced Loss Rate (FLR) | : 0.02 % |
| Energy Availability Factor (EAF) | : 99.98 % | Unplanned Capability Loss Factor (UCL) | : 0.02 % |
| Unit Capability Factor (UCF) | : 99.98 % | Planned Unavailability Factor (PUF) | : 0 % |
| Load Factor (LF) | : 99.26 % | Externally cause unavailability (XUF) | : 0 % |
| Operating Factor (OF) | : 100 % | Total off-line time | : 0 hours |

Annual Summary

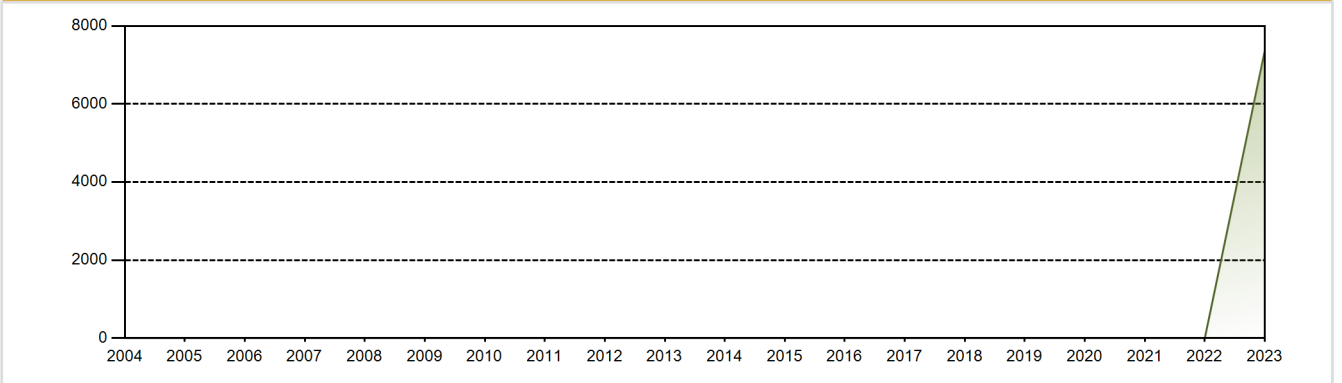


| | Jan | Feb | Mar | Apr | Jul | May | Jun | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|-----|-----|-----|-----|-----|-----|-----|--------|--------|--------|--------|--------|---------|
| GW(e)-h | | | | | | | | 813.91 | 789.14 | 824.33 | 807.32 | 837.60 | 4072.29 |
| EAF [%] | | | | | | | | 100.00 | 100.00 | 100.00 | 99.94 | 99.97 | 99.98 |
| UCF [%] | | | | | | | | 100.00 | 100.00 | 100.00 | 99.94 | 99.97 | 99.98 |
| LF [%] | | | | | | | | 97.94 | 98.12 | 99.19 | 100.24 | 100.79 | 99.26 |
| OF [%] | | | | | | | | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | | | | | | | | 0.00 | 0.00 | 0.00 | 0.06 | 0.03 | 0.02 |
| UCL [%] | | | | | | | | 0.00 | 0.00 | 0.00 | 0.06 | 0.03 | 0.02 |
| PUF [%] | | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| XUF [%] | | | | | | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|-------------------|---|----------|
| Lifetime energy generation | : 7369.68 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 0.02 % |
| Cumulative Energy Availability Factor (EAF) | : 99.98 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 0.02 % |
| Cumulative Unit Capability Factor (UCF) | : 99.98 % | Cumulative Planned Unavailability Factor (PUF) | : 0 % |
| Cumulative Load Factor (LF) | : 99.26 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 100 % | | |

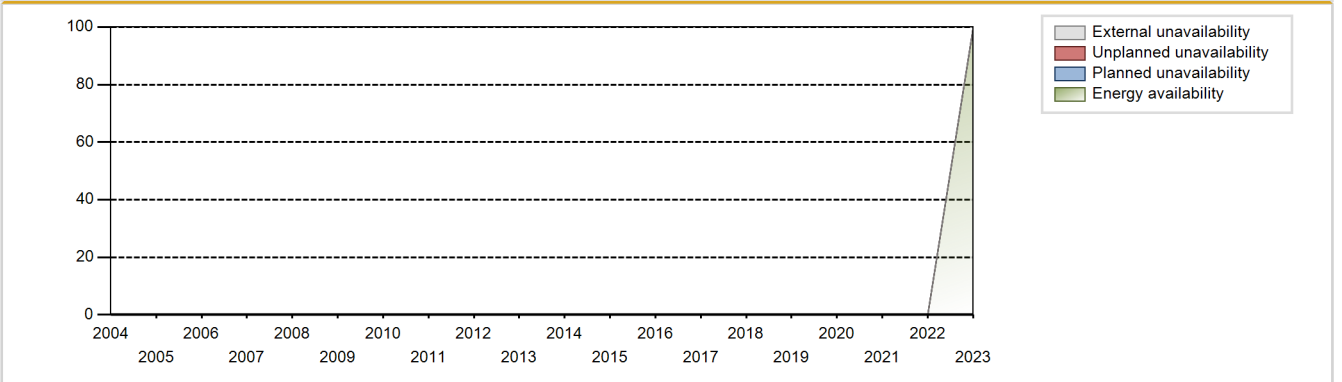
Electricity Production (net) [GWh]



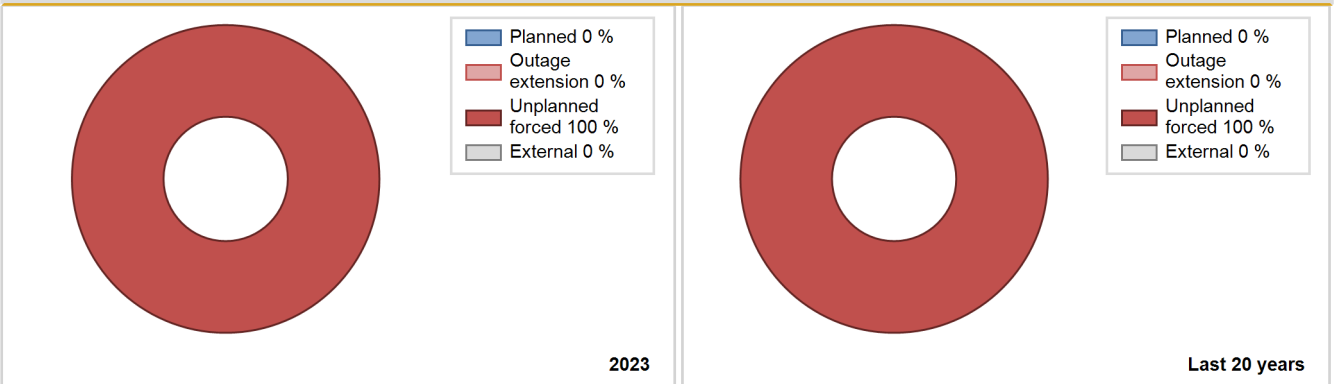
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|-------|-------|-------|--------|------|------|------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2023 | 7369.68 | 6625 | 1117 | 99.98 | 99.98 | 99.26 | 100.00 | 0.02 | 0.02 | 0.00 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2023 to 2023 | | |
|--------------|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| Subtotal | | | | | | |
| Total | | 0 | | | 0 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 2023 to 2023 |
|--------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| Total | | |

2023 Operating Experience

US-382

WATERFORD-3

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : ENERGY (Energy Nuclear Operations, Inc.)
 Owner : ENTLA (ENERGY LOUISIANA, INC.)
 Reactor Supplier : CE (COMBUSTION ENGINEERING CO.)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

| | | |
|----------------------------|---|-----------------------|
| Reactor type and model | : | PWR / CE 2LP (DRYAMB) |
| Thermal power | : | 3716 MWth |
| Gross electrical power | : | 1250 MWe |
| Reference unit power (net) | : | 1168 MWe |

Key Dates

| | | |
|--------------------|---|------------|
| Construction Date | : | 1974-11-14 |
| Grid Date | : | 1985-03-18 |
| Commercial Date | : | 1985-09-24 |
| Age at end of year | : | 38 years |

Design Characteristics

Primary Systems

| | | |
|---|---|----------|
| Reactor vessel centreline orientation | : | Vertical |
| Fuel material | : | UO2 |
| Refuelling type | : | OFF-line |
| Moderator material | : | H2O |
| Average fuel enrichment [% of U235] | : | - |
| Refuelling frequency [month] | : | 18 |
| Part of the core refuelled [%] | : | 33 |
| Average discharge burnup [MWd/t] | : | 33450 |
| Active core diameter [m] | : | 3.45 |
| Active core height/length [m] | : | 3.81 |
| Number of fissile fuel assemblies/bundles | : | 217 |
| Fuel linear heat generation rate [kW/m] | : | 17.52 |
| Number of control rod assemblies | : | 41 |
| Number of external reactor coolant loops | : | 2 |
| Coolant type | : | H2O |

| | | |
|-----------------------------------|---|-------|
| Operating coolant pressure [MPa] | : | 15.8 |
| Reactor outlet temperature [°C] | : | 322 |
| Number of SG | : | 2 |
| Containment type | : | - |
| Containment design pressure [MPa] | : | 0.309 |

Secondary systems

| | | |
|--|---|----------------------|
| Number of turbine-generators per unit/reactor | : | 1 |
| Turbine speed [rpm] | : | 1800 |
| Number of LP cylinders per turbine | : | - |
| HP cylinder inlet steam pressure [MPa] | : | 6.05 |
| Output voltage [kV] | : | - |
| Primary means of condenser cooling | : | River (once-through) |
| Number of main condensate pumps | : | - |
| Number of FW pumps for full power operation | : | - |
| Number of on-site safety related diesel generators | : | - |

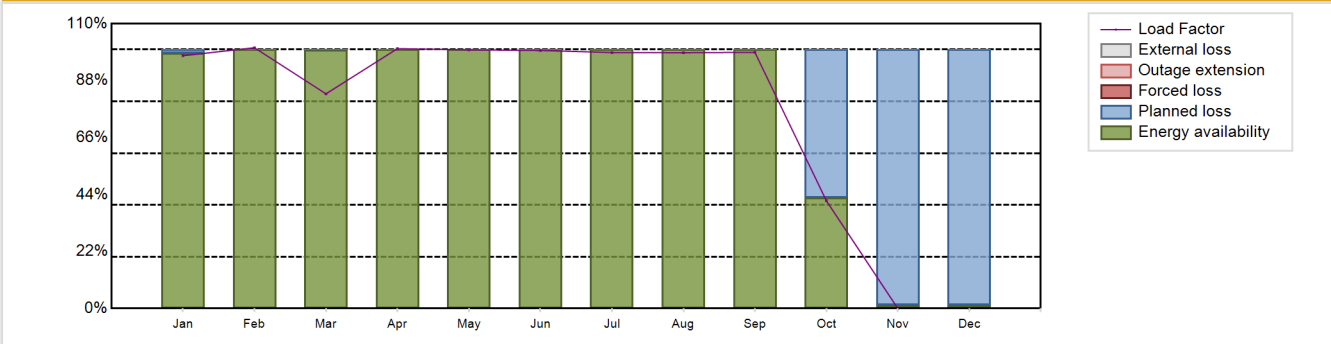
Non-electrical applications

| | | |
|--|---|------|
| | : | none |
|--|---|------|

Annual Production Results (2023)

| | | | | | |
|----------------------------------|---|-----------------|--|---|------------|
| Net Energy Production | : | 7820.38 GW(e).h | Forced Loss Rate (FLR) | : | 0 % |
| Energy Availability Factor (EAF) | : | 78.49 % | Unplanned Capability Loss Factor (UCL) | : | 0 % |
| Unit Capability Factor (UCF) | : | 78.49 % | Planned Unavailability Factor (PUF) | : | 21.51 % |
| Load Factor (LF) | : | 76.44 % | Externally cause unavailability (XUF) | : | 0 % |
| Operating Factor (OF) | : | 77.09 % | Total off-line time | : | 2007 hours |

Annual Summary

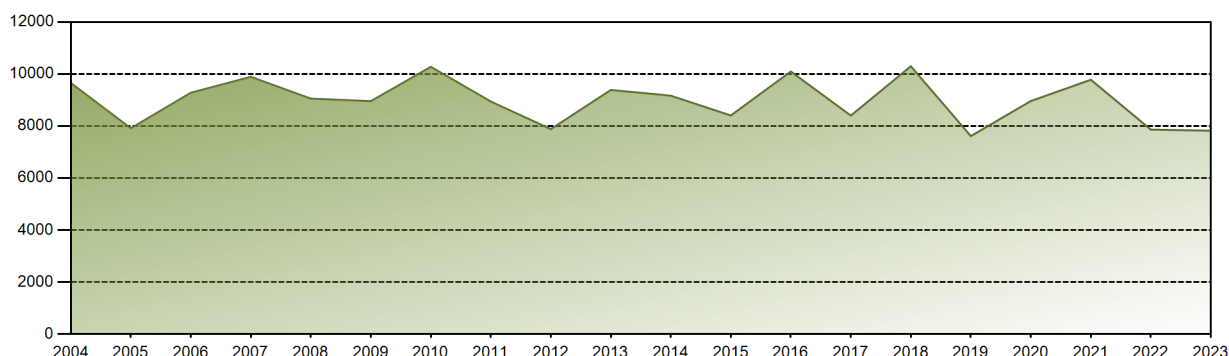


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|---------|
| GW(e)-h | 848.50 | 790.52 | 719.58 | 844.05 | 868.14 | 838.23 | 859.10 | 858.59 | 832.05 | 361.63 | 0.00 | 0.00 | 7820.38 |
| EAF [%] | 98.50 | 100.00 | 99.75 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 42.74 | 1.23 | 1.37 | 78.49 |
| UCF [%] | 98.50 | 100.00 | 99.75 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 42.74 | 1.23 | 1.37 | 78.49 |
| LF [%] | 97.64 | 100.72 | 82.92 | 100.37 | 99.90 | 99.68 | 98.86 | 98.80 | 98.94 | 41.61 | 0.00 | 0.00 | 76.44 |
| OF [%] | 100.00 | 100.00 | 85.06 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 41.94 | 0.00 | 0.00 | 77.09 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 1.50 | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 57.26 | 98.77 | 98.63 | 21.51 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 325739.44 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.63 % |
| Cumulative Energy Availability Factor (EAF) | : 87.34 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.36 % |
| Cumulative Unit Capability Factor (UCF) | : 87.57 % | Cumulative Planned Unavailability Factor (PUF) | : 10.06 % |
| Cumulative Load Factor (LF) | : 86.77 % | Cumulative Externally cause unavailability (XUF) | : 0.23 % |
| Cumulative Operating Factor (OF) | : 87.09 % | | |

Electricity Production (net) [GWh]

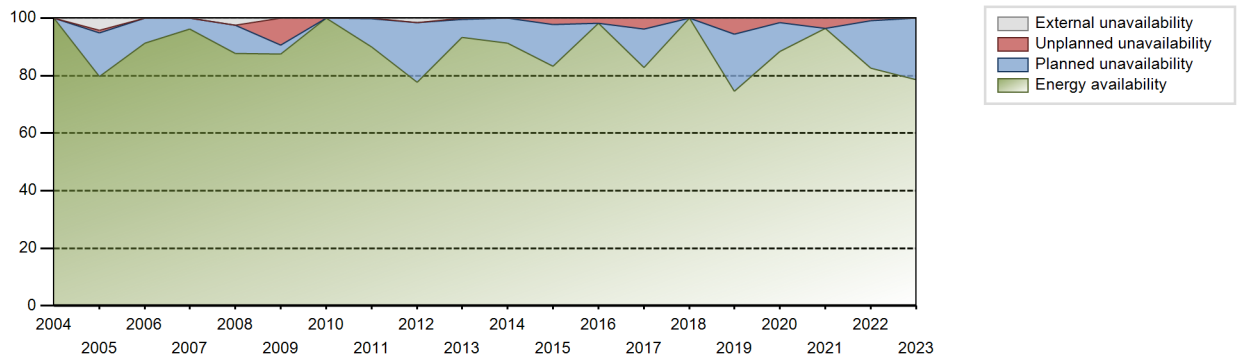


Performance for Years of Commercial Operation

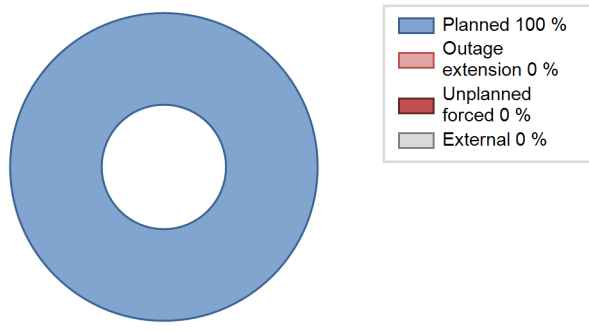
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 2773.07 | 3372 | 1099 | 75.85 | 75.85 | 69.71 | 75.51 | 23.80 | 23.69 | 0.46 | 0.00 |
| 1986 | 7308.38 | 6921 | 1096 | 79.47 | 79.47 | 76.07 | 79.01 | 5.80 | 4.90 | 15.64 | 0.00 |
| 1987 | 7434.08 | 7085 | 1075 | 80.93 | 80.93 | 78.94 | 80.88 | 9.29 | 8.29 | 10.79 | 0.00 |
| 1988 | 6548.41 | 6468 | 1075 | 73.70 | 73.70 | 69.35 | 73.63 | 2.86 | 2.17 | 24.13 | 0.00 |
| 1989 | 7609.43 | 7136 | 1075 | 81.51 | 81.51 | 80.81 | 81.46 | 2.84 | 2.38 | 16.11 | 0.00 |
| 1990 | 8604.23 | 8079 | 1075 | 92.25 | 92.25 | 91.37 | 92.23 | 1.51 | 1.42 | 6.34 | 0.00 |
| 1991 | 7274.94 | 6869 | 1075 | 78.46 | 78.88 | 77.25 | 78.41 | 1.26 | 1.00 | 20.11 | 0.42 |
| 1992 | 7622.16 | 7213 | 1075 | 82.14 | 82.14 | 80.72 | 82.12 | 1.72 | 1.43 | 16.43 | 0.00 |
| 1993 | 9138.83 | 8691 | 1075 | 99.22 | 99.22 | 97.05 | 99.21 | 0.78 | 0.78 | 0.00 | 0.00 |
| 1994 | 7931.92 | 7555 | 1075 | 86.28 | 86.28 | 84.23 | 86.24 | 0.41 | 0.35 | 13.37 | 0.00 |
| 1995 | 7763.45 | 7241 | 1075 | 82.68 | 82.68 | 82.44 | 82.66 | 6.01 | 5.29 | 12.03 | 0.00 |
| 1996 | 8926.85 | 8237 | 1075 | 93.81 | 93.81 | 94.54 | 93.77 | 6.19 | 6.19 | 0.00 | 0.00 |
| 1997 | 6720.68 | 6161 | 1075 | 70.35 | 70.35 | 71.37 | 70.33 | 0.00 | 0.00 | 29.65 | 0.00 |
| 1998 | 8620.78 | 7966 | 1075 | 90.96 | 90.96 | 91.54 | 90.94 | 8.54 | 8.50 | 0.54 | 0.00 |
| 1999 | 7441.74 | 6905 | 1075 | 78.87 | 78.87 | 79.02 | 78.82 | 10.89 | 9.64 | 11.50 | 0.00 |
| 2000 | 8477.38 | 7743 | 1075 | 88.17 | 88.17 | 89.78 | 88.15 | 0.61 | 0.55 | 11.29 | 0.00 |
| 2001 | 9539.06 | 8718 | 1075 | 99.52 | 99.52 | 101.30 | 99.52 | 0.48 | 0.48 | 0.00 | 0.00 |
| 2002 | 8847.93 | 8136 | 1075 | 92.78 | 92.78 | 93.96 | 92.88 | 0.00 | 0.00 | 7.22 | 0.00 |
| 2003 | 8503.13 | 7865 | 1075 | 89.66 | 89.66 | 90.30 | 89.78 | 1.25 | 1.13 | 9.21 | 0.00 |
| 2004 | 9654.42 | 8771 | 1075 | 99.86 | 99.86 | 102.24 | 99.85 | 0.14 | 0.14 | 0.00 | 0.00 |
| 2005 | 7913.75 | 6975 | 1089 | 79.65 | 84.02 | 82.95 | 79.61 | 0.85 | 0.72 | 15.26 | 4.37 |
| 2006 | 9279.81 | 7996 | 1158 | 91.30 | 91.30 | 91.48 | 91.28 | 0.00 | 0.00 | 8.70 | 0.00 |
| 2007 | 9893.00 | 8423 | 1157 | 96.18 | 96.18 | 97.61 | 96.15 | 0.00 | 0.00 | 3.82 | 0.00 |
| 2008 | 9053.98 | 7703 | 1157 | 87.73 | 90.27 | 89.09 | 87.69 | 0.06 | 0.05 | 9.68 | 2.53 |
| 2009 | 8956.07 | 7648 | 1176 | 87.52 | 87.52 | 86.94 | 87.31 | 9.80 | 9.51 | 2.97 | 0.00 |
| 2010 | 10276.18 | 8760 | 1168 | 100.00 | 100.00 | 100.43 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 8942.35 | 7876 | 1168 | 89.93 | 89.93 | 87.40 | 89.91 | 0.18 | 0.17 | 9.91 | 0.00 |
| 2012 | 7880.31 | 6820 | 1168 | 77.68 | 79.22 | 76.81 | 77.64 | 0.00 | 0.00 | 20.78 | 1.55 |
| 2013 | 9386.86 | 8176 | 1168 | 93.33 | 93.33 | 91.73 | 93.32 | 0.59 | 0.55 | 6.12 | 0.00 |
| 2014 | 9166.31 | 7999 | 1168 | 91.32 | 91.32 | 89.59 | 91.31 | 0.00 | 0.00 | 8.68 | 0.00 |
| 2015 | 8405.17 | 7300 | 1168 | 83.33 | 83.33 | 82.15 | 83.33 | 2.54 | 2.17 | 14.50 | 0.00 |
| 2016 | 10095.50 | 8622 | 1168 | 98.16 | 98.16 | 98.40 | 98.16 | 1.84 | 1.84 | 0.00 | 0.00 |
| 2017 | 8401.72 | 7248 | 1168 | 82.75 | 82.75 | 82.11 | 82.74 | 4.54 | 3.94 | 13.32 | 0.00 |
| 2018 | 10298.11 | 8760 | 1168 | 100.00 | 100.00 | 100.65 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 7612.50 | 6528 | 1168 | 74.54 | 74.54 | 74.40 | 74.52 | 6.88 | 5.51 | 19.95 | 0.00 |
| 2020 | 8961.22 | 7767 | 1168 | 88.42 | 88.42 | 87.34 | 88.42 | 1.72 | 1.55 | 10.03 | 0.00 |
| 2021 | 9779.29 | 8445 | 1168 | 96.41 | 96.41 | 95.58 | 96.40 | 3.59 | 3.59 | 0.00 | 0.00 |

| | | | | | | | | | | | |
|------|---------|------|------|-------|-------|-------|-------|------|------|-------|------|
| 2022 | 7863.02 | 6777 | 1168 | 82.62 | 82.62 | 76.85 | 77.36 | 1.13 | 0.94 | 16.43 | 0.00 |
| 2023 | 7820.38 | 6752 | 1168 | 78.49 | 78.49 | 76.44 | 77.09 | 0.00 | 0.00 | 21.51 | 0.00 |

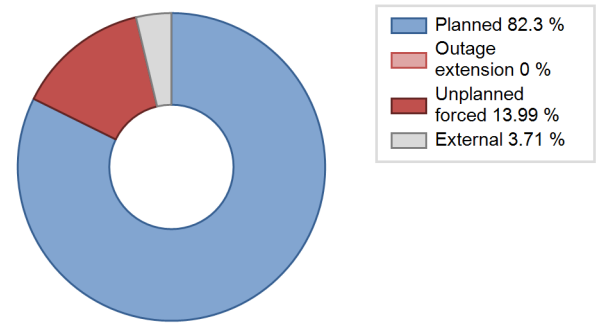
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|-------------|-------------|----------|-------------------------------------|-------------|-----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 185 | |
| B. Refuelling without maintenance | | | | 73 | | |
| C. Inspection, maintenance or repair combined with refuelling | 3768 | | | 802 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 71 | | |
| E. Testing of plant systems or components | | | | 1 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 1 |
| L. Human factor related | | | | | 8 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 22 |
| Z. Other | | | | | 14 | |
| Subtotal | 3768 | | | 947 | 207 | 23 |
| Total | | 3768 | | | 1177 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 13 |
| 13. Reactor Auxiliary Systems | | 8 |
| 14. Safety Systems | | 2 |
| 15. Reactor Cooling Systems | | 60 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 22 |
| 31. Turbine and auxiliaries | | 37 |
| 32. Feedwater and Main Steam System | | 19 |
| 33. Circulating Water System | | 2 |
| 34. Miscellaneous Systems | | 3 |
| 35. All other I&C Systems | | 12 |
| 41. Main Generator Systems | | 12 |
| 42. Electrical Power Supply Systems | | 3 |
| Total | | 193 |

2023 Operating Experience

US-390

WATTS BAR-1

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : TVA (Tennessee Valley Authority)
 Owner : TVA (Tennessee Valley Authority)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

| | | |
|----------------------------|---|-----------------------|
| Reactor type and model | : | PWR / WH 4LP (ICECND) |
| Thermal power | : | 3459 MWth |
| Gross electrical power | : | 1210 MWe |
| Reference unit power (net) | : | 1157 MWe |

Key Dates

| | | |
|--------------------|---|------------|
| Construction Date | : | 1973-07-20 |
| Grid Date | : | 1996-02-06 |
| Commercial Date | : | 1996-05-27 |
| Age at end of year | : | 27 years |

Design Characteristics

Primary Systems

| | | |
|---|---|----------|
| Reactor vessel centreline orientation | : | Vertical |
| Fuel material | : | UO2 |
| Refuelling type | : | OFF-line |
| Moderator material | : | H2O |
| Average fuel enrichment [% of U235] | : | - |
| Refuelling frequency [month] | : | 18 |
| Part of the core refuelled [%] | : | 32 |
| Average discharge burnup [MWd/t] | : | 36000 |
| Active core diameter [m] | : | 3.37 |
| Active core height/length [m] | : | 3.65 |
| Number of fissile fuel assemblies/bundles | : | 193 |
| Fuel linear heat generation rate [kW/m] | : | 17.88 |
| Number of control rod assemblies | : | 33 |
| Number of external reactor coolant loops | : | 4 |
| Coolant type | : | H2O |

| | | |
|-----------------------------------|---|-------|
| Operating coolant pressure [MPa] | : | 15.71 |
| Reactor outlet temperature [°C] | : | 326 |
| Number of SG | : | 4 |
| Containment type | : | - |
| Containment design pressure [MPa] | : | 0.105 |

Secondary systems

| | | |
|--|---|----------------|
| Number of turbine-generators per unit/reactor | : | 1 |
| Turbine speed [rpm] | : | 1800 |
| Number of LP cylinders per turbine | : | - |
| HP cylinder inlet steam pressure [MPa] | : | 6.85 |
| Output voltage [kV] | : | - |
| Primary means of condenser cooling | : | Cooling Towers |
| Number of main condensate pumps | : | - |
| Number of FW pumps for full power operation | : | - |
| Number of on-site safety related diesel generators | : | - |

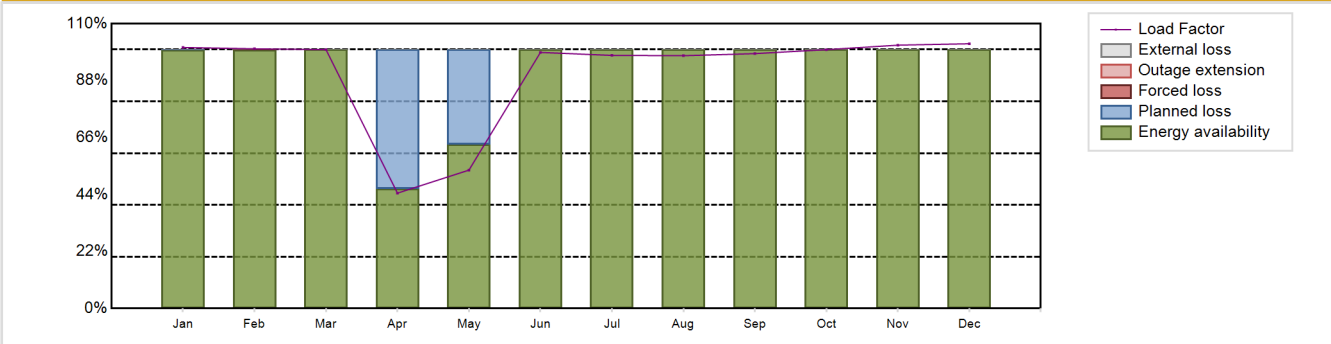
Non-electrical applications

| | | |
|--|---|------|
| | : | none |
|--|---|------|

Annual Production Results (2023)

| | | | | | |
|----------------------------------|---|-----------------|--|---|-----------|
| Net Energy Production | : | 9253.94 GW(e).h | Forced Loss Rate (FLR) | : | 0 % |
| Energy Availability Factor (EAF) | : | 92.44 % | Unplanned Capability Loss Factor (UCL) | : | 0 % |
| Unit Capability Factor (UCF) | : | 92.44 % | Planned Unavailability Factor (PUF) | : | 7.55 % |
| Load Factor (LF) | : | 91.3 % | Externally cause unavailability (XUF) | : | 0 % |
| Operating Factor (OF) | : | 92.47 % | Total off-line time | : | 660 hours |

Annual Summary

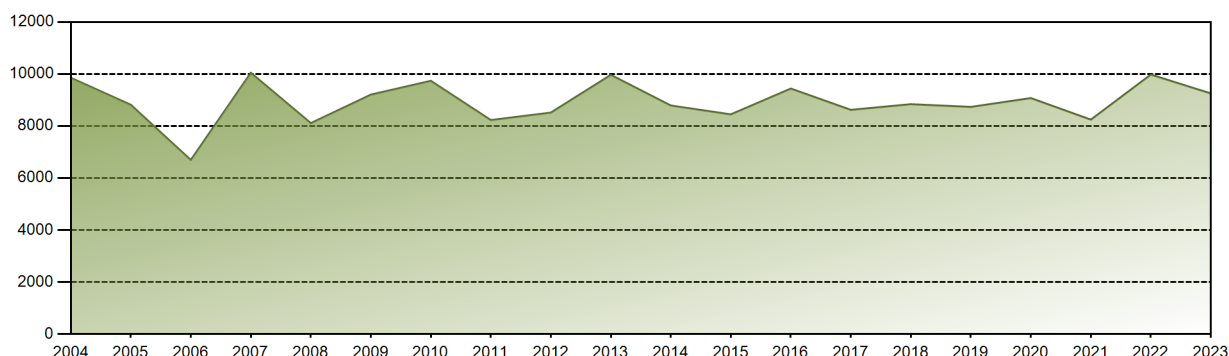


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 867.86 | 779.89 | 859.61 | 371.22 | 460.12 | 823.92 | 841.52 | 840.49 | 820.02 | 860.59 | 848.45 | 880.25 | 9253.94 |
| EAF [%] | 99.74 | 99.96 | 100.00 | 46.25 | 63.34 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.44 |
| UCF [%] | 99.74 | 99.96 | 100.00 | 46.25 | 63.34 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.44 |
| LF [%] | 100.82 | 100.31 | 100.00 | 44.56 | 53.45 | 98.91 | 97.76 | 97.64 | 98.44 | 99.97 | 101.71 | 102.26 | 91.30 |
| OF [%] | 100.00 | 100.00 | 100.00 | 46.25 | 63.31 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.47 |
| FLR [%] | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PUF [%] | 0.26 | 0.00 | 0.00 | 53.75 | 36.66 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.55 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

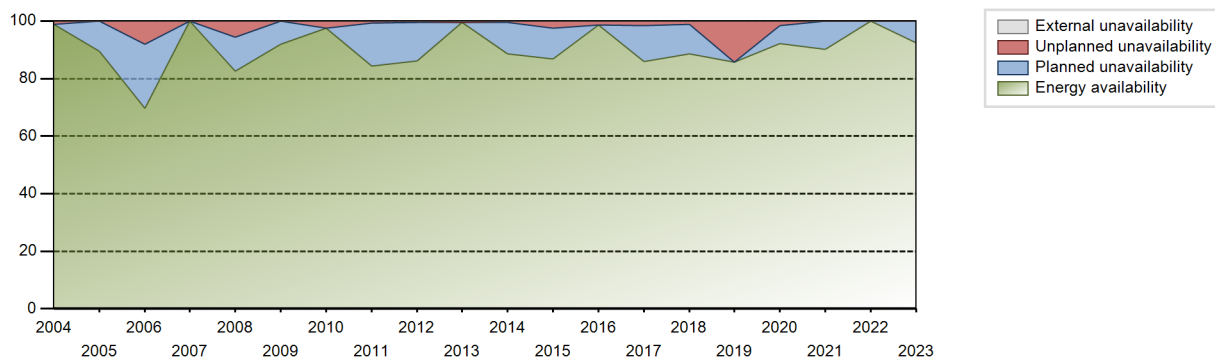
| | | | |
|---|---------------------|---|----------|
| Lifetime energy generation | : 245687.87 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 2.27 % |
| Cumulative Energy Availability Factor (EAF) | : 90.5 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 2.1 % |
| Cumulative Unit Capability Factor (UCF) | : 90.52 % | Cumulative Planned Unavailability Factor (PUF) | : 7.38 % |
| Cumulative Load Factor (LF) | : 89.93 % | Cumulative Externally cause unavailability (XUF) | : 0.02 % |
| Cumulative Operating Factor (OF) | : 90.43 % | | |

Electricity Production (net) [GWh]

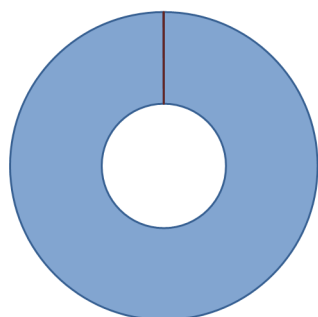


| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1996 | 5544.23 | 5491 | 1109 | 90.65 | 90.65 | 88.78 | 91.16 | 0.21 | 0.19 | 9.17 | 0.00 |
| 1997 | 7600.09 | 7269 | 1117 | 82.27 | 82.27 | 77.67 | 82.98 | 5.73 | 5.00 | 12.73 | 0.00 |
| 1998 | 9680.98 | 8672 | 1117 | 98.96 | 98.96 | 98.93 | 99.00 | 1.04 | 1.04 | 0.00 | 0.00 |
| 1999 | 8267.43 | 7606 | 1118 | 86.84 | 86.84 | 84.42 | 86.83 | 0.00 | 0.00 | 13.16 | 0.00 |
| 2000 | 9076.39 | 8124 | 1118 | 92.50 | 92.50 | 92.42 | 92.49 | 0.00 | 0.00 | 7.50 | 0.00 |
| 2001 | 9626.58 | 8419 | 1125 | 96.13 | 96.13 | 97.52 | 96.11 | 3.87 | 3.87 | 0.00 | 0.00 |
| 2002 | 9079.35 | 7998 | 1125 | 91.30 | 91.30 | 92.13 | 91.30 | 2.10 | 1.95 | 6.74 | 0.00 |
| 2003 | 8549.61 | 7551 | 1121 | 86.16 | 86.16 | 86.91 | 86.20 | 4.65 | 4.20 | 9.64 | 0.00 |
| 2004 | 9856.92 | 8680 | 1121 | 98.82 | 98.82 | 100.10 | 98.82 | 1.18 | 1.18 | 0.00 | 0.00 |
| 2005 | 8816.42 | 7841 | 1121 | 89.52 | 89.52 | 89.77 | 89.50 | 0.00 | 0.00 | 10.48 | 0.00 |
| 2006 | 6697.05 | 6099 | 1121 | 69.66 | 69.66 | 68.20 | 69.62 | 10.49 | 8.16 | 22.18 | 0.00 |
| 2007 | 10049.69 | 8760 | 1123 | 100.00 | 100.00 | 102.16 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 8112.31 | 7247 | 1123 | 82.53 | 82.53 | 82.24 | 82.50 | 6.44 | 5.68 | 11.79 | 0.00 |
| 2009 | 9207.46 | 8055 | 1123 | 91.96 | 91.96 | 93.60 | 91.95 | 0.00 | 0.00 | 8.04 | 0.00 |
| 2010 | 9738.46 | 8544 | 1123 | 97.55 | 97.55 | 98.99 | 97.53 | 2.45 | 2.45 | 0.00 | 0.00 |
| 2011 | 8230.98 | 7386 | 1123 | 84.33 | 84.33 | 83.67 | 84.32 | 0.93 | 0.79 | 14.88 | 0.00 |
| 2012 | 8516.47 | 7557 | 1123 | 86.04 | 86.04 | 86.34 | 86.03 | 0.62 | 0.53 | 13.42 | 0.00 |
| 2013 | 9967.80 | 8709 | 1123 | 99.42 | 100.00 | 101.31 | 99.41 | 0.00 | 0.00 | 0.00 | 0.58 |
| 2014 | 8789.69 | 7769 | 1123 | 88.69 | 88.69 | 89.35 | 88.69 | 0.51 | 0.45 | 10.85 | 0.00 |
| 2015 | 8449.15 | 7609 | 1123 | 86.86 | 86.86 | 85.89 | 86.86 | 2.79 | 2.49 | 10.65 | 0.00 |
| 2016 | 9441.96 | 8656 | 1123 | 98.54 | 98.54 | 95.72 | 98.54 | 1.46 | 1.46 | 0.00 | 0.00 |
| 2017 | 8622.85 | 7529 | 1123 | 85.94 | 85.94 | 87.65 | 85.95 | 1.87 | 1.64 | 12.41 | 0.00 |
| 2018 | 8840.45 | 7637 | 1157 | 88.51 | 88.51 | 87.22 | 87.18 | 1.24 | 1.11 | 10.38 | 0.00 |
| 2019 | 8735.99 | 7514 | 1157 | 85.79 | 85.79 | 86.19 | 85.78 | 14.21 | 14.21 | 0.00 | 0.00 |
| 2020 | 9075.10 | 7996 | 1157 | 92.16 | 92.16 | 89.29 | 91.03 | 1.63 | 1.52 | 6.32 | 0.00 |
| 2021 | 8246.82 | 7900 | 1157 | 90.18 | 90.18 | 81.37 | 90.18 | 0.00 | 0.00 | 9.82 | 0.00 |
| 2022 | 9979.10 | 8760 | 1157 | 100.00 | 100.00 | 98.46 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 9253.94 | 8100 | 1157 | 92.44 | 92.44 | 91.30 | 92.47 | 0.00 | 0.00 | 7.55 | 0.00 |

Key Factors in Last 20 Years [%]

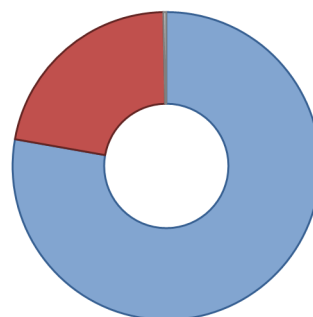


Energy Losses by Type



Planned 99.96 %
 Outage extension 0 %
 Unplanned forced 0.04 %
 External 0 %

2023



Planned 77.78 %
 Outage extension 0 %
 Unplanned forced 21.92 %
 External 0.3 %

Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1996 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 141 | |
| B. Refuelling without maintenance | | | | 24 | | |
| C. Inspection, maintenance or repair combined with refuelling | 1512 | | | 600 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 53 | | |
| E. Testing of plant systems or components | | | | 26 | | |
| J. Grid limitation, failure or grid unavailability | | | | | | 2 |
| L. Human factor related | | | | | 14 | |
| P. Fire | | | | | 1 | |
| Z. Other | | | | 45 | 11 | |
| Subtotal | 1512 | | | 748 | 167 | 2 |
| Total | | 1512 | | | 917 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1996 to 2023 |
|-------------------------------------|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 12. Reactor I&C Systems | | 2 |
| 14. Safety Systems | | 7 |
| 15. Reactor Cooling Systems | | 17 |
| 16. Steam generation systems | | 2 |
| 31. Turbine and auxiliaries | | 50 |
| 32. Feedwater and Main Steam System | | 34 |
| 33. Circulating Water System | | 9 |
| 35. All other I&C Systems | | 1 |
| 41. Main Generator Systems | | 12 |
| 42. Electrical Power Supply Systems | | 12 |
| Total | | 146 |

2023 Operating Experience

US-391

WATTS BAR-2

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : TVA (Tennessee Valley Authority)
 Owner : TVA (Tennessee Valley Authority)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model : PWR / WH 4LP (ICECND)
 Thermal power : 3411 MWth
 Gross electrical power : 1218 MWe
 Reference unit power (net) : 1164 MWe

Key Dates

Construction Date : 1973-09-01
 Grid Date : 2016-06-03
 Commercial Date : 2016-10-19
 Age at end of year : 7 years

Design Characteristics

Primary Systems

Reactor vessel centreline orientation : Vertical
 Fuel material : UO2
 Refuelling type : OFF-line
 Moderator material : H2O
 Average fuel enrichment [% of U235] : -
 Refuelling frequency [month] : -
 Part of the core refuelled [%] : -
 Average discharge burnup [MWd/t] : -
 Active core diameter [m] : 3.37
 Active core height/length [m] : 3.65
 Number of fissile fuel assemblies/bundles : 193
 Fuel linear heat generation rate [kW/m] : 17.88
 Number of control rod assemblies : 33
 Number of external reactor coolant loops : 4
 Coolant type : H2O

Operating coolant pressure [MPa] : 15.71
 Reactor outlet temperature [°C] : 326
 Number of SG : 4
 Containment type : Double
 Containment design pressure [MPa] : 1.05

Secondary systems

Number of turbine-generators per unit/reactor : 1
 Turbine speed [rpm] : 1800
 Number of LP cylinders per turbine : -
 HP cylinder inlet steam pressure [MPa] : 6.85
 Output voltage [kV] : -
 Primary means of condenser cooling : -
 Number of main condensate pumps : -
 Number of FW pumps for full power operation : -
 Number of on-site safety related diesel generators : -

Non-electrical applications

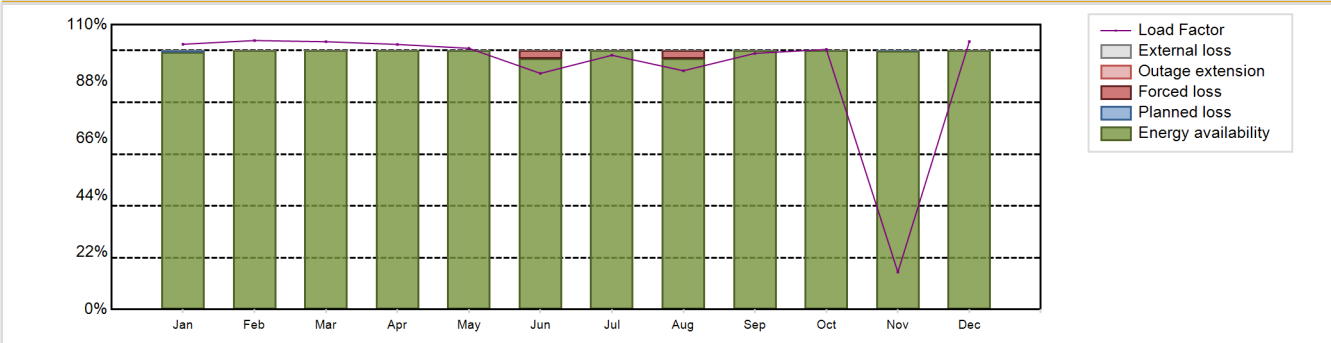
Non-electrical applications : none

Annual Production Results (2023)

Net Energy Production : 9455.43 GW(e).h
 Energy Availability Factor (EAF) : 99.41 %
 Unit Capability Factor (UCF) : 99.41 %
 Load Factor (LF) : 92.73 %
 Operating Factor (OF) : 92.44 %

Forced Loss Rate (FLR) : 0.53 %
 Unplanned Capability Loss Factor (UCL) : 0.53 %
 Planned Unavailability Factor (PUF) : 0.07 %
 Externally cause unavailability (XUF) : 0 %
 Total off-line time : 662 hours

Annual Summary

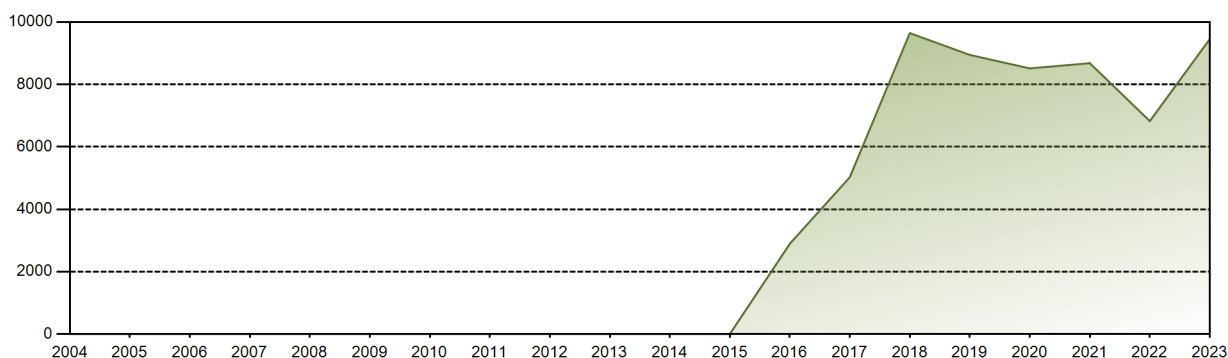


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| GW(e)-h | 887.15 | 812.61 | 894.47 | 858.07 | 873.59 | 764.23 | 850.49 | 798.58 | 829.12 | 869.80 | 121.14 | 896.19 | 9455.43 |
| EAF [%] | 99.38 | 100.00 | 100.00 | 100.00 | 100.00 | 96.79 | 100.00 | 96.89 | 100.00 | 100.00 | 99.84 | 100.00 | 99.41 |
| UCF [%] | 99.38 | 100.00 | 100.00 | 100.00 | 100.00 | 96.79 | 100.00 | 96.89 | 100.00 | 100.00 | 99.84 | 100.00 | 99.41 |
| LF [%] | 102.44 | 103.89 | 103.42 | 102.39 | 100.87 | 91.19 | 98.21 | 92.21 | 98.93 | 100.44 | 14.43 | 103.48 | 92.73 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 92.64 | 100.00 | 95.56 | 100.00 | 100.00 | 20.11 | 100.00 | 92.44 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.21 | 0.00 | 3.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.53 |
| UCL [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.21 | 0.00 | 3.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.53 |
| PUF [%] | 0.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | 0.07 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|--------------------|---|----------|
| Lifetime energy generation | : 58895.96 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 7.83 % |
| Cumulative Energy Availability Factor (EAF) | : 84.28 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 7.16 % |
| Cumulative Unit Capability Factor (UCF) | : 84.28 % | Cumulative Planned Unavailability Factor (PUF) | : 8.56 % |
| Cumulative Load Factor (LF) | : 80.44 % | Cumulative Externally cause unavailability (XUF) | : 0 % |
| Cumulative Operating Factor (OF) | : 82.51 % | | |

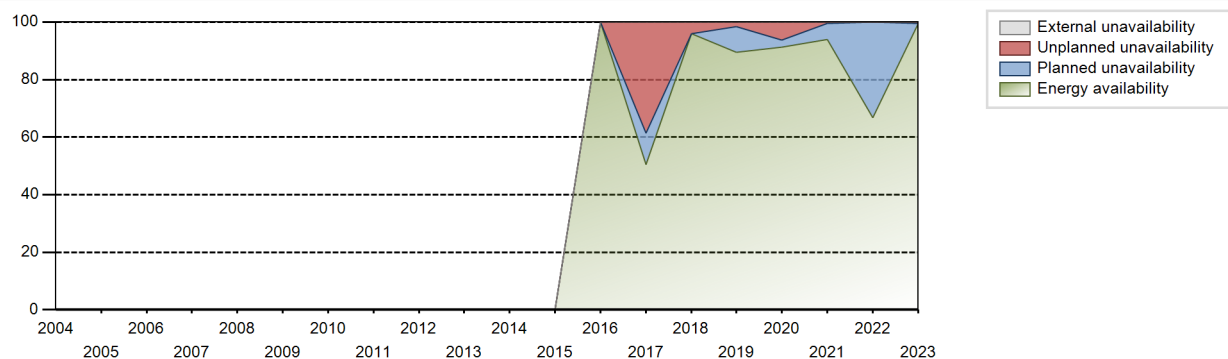
Electricity Production (net) [GWh]



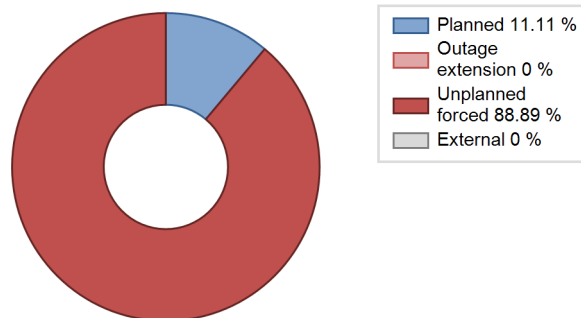
Performance for Years of Commercial Operation

| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
|------|------------------|---------------------------|---------------------------------|--------|--------|--------|--------|-------|-------|-------|------|
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 2016 | 2893.72 | 2593 | 1165 | 100.00 | 100.00 | 101.05 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 5026.65 | 4421 | 1165 | 50.46 | 50.46 | 49.25 | 50.47 | 43.34 | 38.59 | 10.95 | 0.00 |
| 2018 | 9644.14 | 8397 | 1164 | 95.97 | 95.97 | 94.58 | 95.86 | 4.03 | 4.03 | 0.00 | 0.00 |
| 2019 | 8944.95 | 7820 | 1164 | 89.55 | 89.55 | 87.72 | 89.27 | 1.72 | 1.57 | 8.88 | 0.00 |
| 2020 | 8513.91 | 7548 | 1164 | 91.31 | 91.31 | 83.27 | 85.93 | 6.33 | 6.17 | 2.52 | 0.00 |
| 2021 | 8680.09 | 8227 | 1164 | 93.92 | 93.92 | 85.13 | 93.92 | 0.46 | 0.43 | 5.65 | 0.00 |
| 2022 | 6824.42 | 5845 | 1164 | 66.72 | 66.72 | 66.93 | 66.72 | 0.00 | 0.00 | 33.28 | 0.00 |
| 2023 | 9455.43 | 8098 | 1164 | 99.41 | 99.41 | 92.73 | 92.44 | 0.53 | 0.53 | 0.07 | 0.00 |

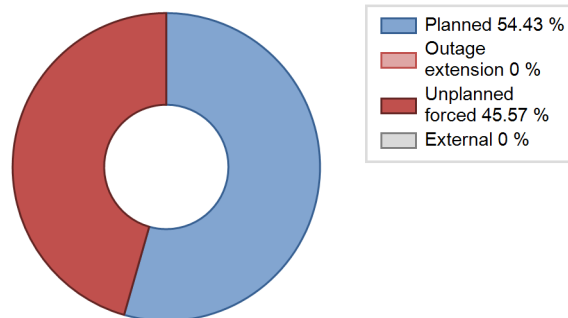
Key Factors in Last 20 Years [%]



Energy Losses by Type



2023



Last 20 years

Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 2016 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-----------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | 72 | | | 573 | |
| B. Refuelling without maintenance | | | | 567 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 245 | | |
| D. Inspection, maintenance or repair without refuelling | | | | 4 | | |
| L. Human factor related | | | | | 9 | |
| Z. Other | | | | | 83 | |
| Subtotal | | 72 | | 816 | 665 | |
| Total | | 72 | | | 1481 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | | 2016 to 2023 | |
|-------------------------------------|------------|----|-------------------------------------|-----|
| | Hours Lost | | Average hours lost per reactor-year | |
| 11. Reactor and Accessories | | 72 | | 9 |
| 12. Reactor I&C Systems | | | | 12 |
| 15. Reactor Cooling Systems | | | | 6 |
| 31. Turbine and auxiliaries | | | | 65 |
| 32. Feedwater and Main Steam System | | | | 429 |
| 34. Miscellaneous Systems | | | | 28 |
| Total | | 72 | | 549 |

2023 Operating Experience

US-482

WOLF CREEK

UNITED STATES OF AMERICA

Status at end of year : **Operational**
 Operator : WCNOC (WOLF CREEK NUCLEAR OPERATING CORP.)
 Owner : KCP&L (Kansas City Power & Light Co.)
 Reactor Supplier : WH (WESTINGHOUSE ELECTRIC CORPORATION)
 Turbine Supplier : GE (GENERAL ELECTRIC CO.)



Reactor Unit Details

| | | |
|----------------------------|---|-----------------------|
| Reactor type and model | : | PWR / WH 4LP (DRYAMB) |
| Thermal power | : | 3565 MWth |
| Gross electrical power | : | 1285 MWe |
| Reference unit power (net) | : | 1200 MWe |

Key Dates

| | | |
|--------------------|---|------------|
| Construction Date | : | 1977-05-31 |
| Grid Date | : | 1985-06-12 |
| Commercial Date | : | 1985-09-03 |
| Age at end of year | : | 38 years |

Design Characteristics

Primary Systems

| | | |
|---|---|----------|
| Reactor vessel centreline orientation | : | Vertical |
| Fuel material | : | UO2 |
| Refuelling type | : | OFF-line |
| Moderator material | : | H2O |
| Average fuel enrichment [% of U235] | : | - |
| Refuelling frequency [month] | : | 18 |
| Part of the core refuelled [%] | : | 33.3 |
| Average discharge burnup [MWd/t] | : | 33000 |
| Active core diameter [m] | : | 6.3 |
| Active core height/length [m] | : | 5.94 |
| Number of fissile fuel assemblies/bundles | : | 22 |
| Fuel linear heat generation rate [kW/m] | : | 17.85 |
| Number of control rod assemblies | : | 53 |
| Number of external reactor coolant loops | : | 4 |
| Coolant type | : | H2O |

| | | |
|-----------------------------------|---|------|
| Operating coolant pressure [MPa] | : | 15.8 |
| Reactor outlet temperature [°C] | : | 326 |
| Number of SG | : | 4 |
| Containment type | : | - |
| Containment design pressure [MPa] | : | 0.42 |

Secondary systems

| | | |
|--|---|-----------------------------|
| Number of turbine-generators per unit/reactor | : | 1 |
| Turbine speed [rpm] | : | 1800 |
| Number of LP cylinders per turbine | : | - |
| HP cylinder inlet steam pressure [MPa] | : | 6.86 |
| Output voltage [kV] | : | - |
| Primary means of condenser cooling | : | Cooling Pond (closed-cycle) |
| Number of main condensate pumps | : | - |
| Number of FW pumps for full power operation | : | - |
| Number of on-site safety related diesel generators | : | - |

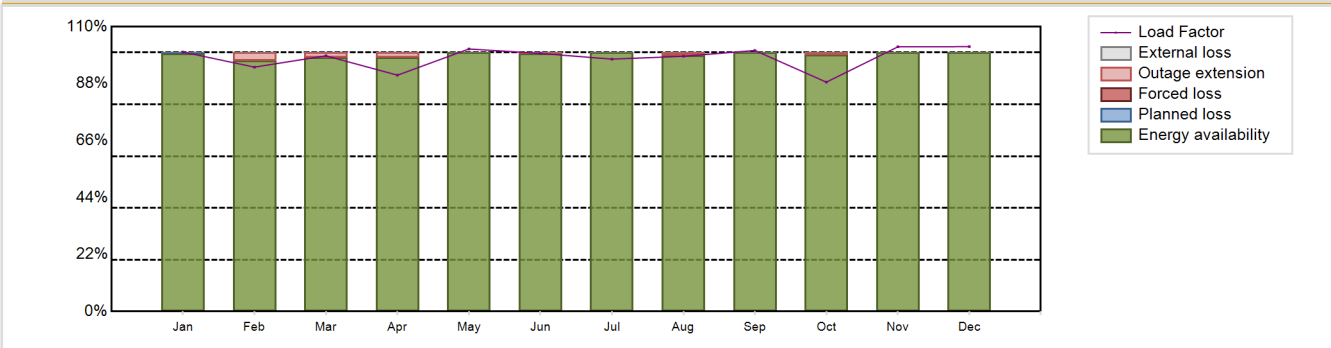
Non-electrical applications

| | | |
|-----------------------------|---|------|
| Non-electrical applications | : | none |
|-----------------------------|---|------|

Annual Production Results (2023)

| | | | | | |
|----------------------------------|---|------------------|--|---|---------|
| Net Energy Production | : | 10301.86 GW(e).h | Forced Loss Rate (FLR) | : | 0 % |
| Energy Availability Factor (EAF) | : | 99.2 % | Unplanned Capability Loss Factor (UCL) | : | 0.76 % |
| Unit Capability Factor (UCF) | : | 99.2 % | Planned Unavailability Factor (PUF) | : | 0.04 % |
| Load Factor (LF) | : | 98 % | Externally cause unavailability (XUF) | : | 0 % |
| Operating Factor (OF) | : | 100 % | Total off-line time | : | 0 hours |

Annual Summary

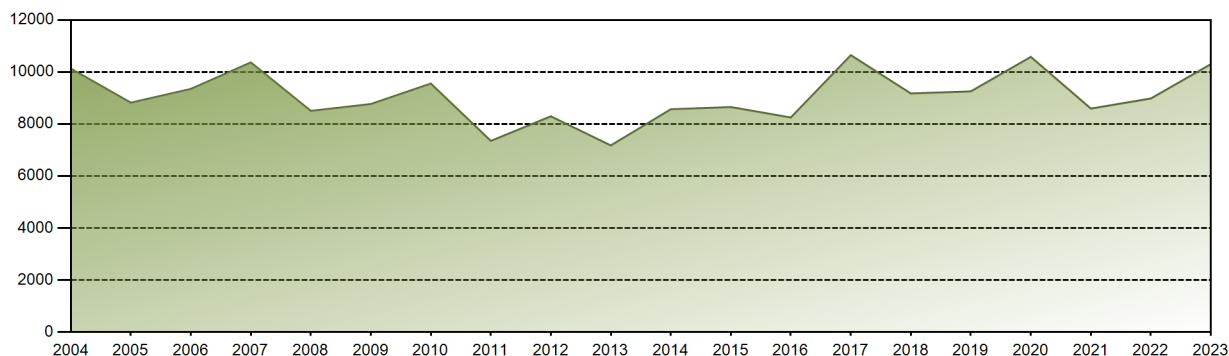


| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| GW(e)-h | 894.77 | 761.17 | 880.58 | 788.67 | 905.31 | 861.25 | 870.31 | 879.99 | 871.04 | 790.90 | 884.45 | 913.42 | 10301.86 |
| EAF [%] | 99.53 | 96.95 | 98.21 | 98.06 | 100.00 | 99.58 | 100.00 | 98.84 | 100.00 | 99.06 | 100.00 | 100.00 | 99.20 |
| UCF [%] | 99.53 | 96.95 | 98.21 | 98.06 | 100.00 | 99.58 | 100.00 | 98.84 | 100.00 | 99.06 | 100.00 | 100.00 | 99.20 |
| LF [%] | 100.22 | 94.39 | 98.76 | 91.28 | 101.40 | 99.68 | 97.48 | 98.56 | 100.81 | 88.59 | 102.22 | 102.31 | 98.00 |
| OF [%] | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| FLR [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| UCL [%] | 0.00 | 3.05 | 1.79 | 1.94 | 0.00 | 0.42 | 0.00 | 1.16 | 0.00 | 0.94 | 0.00 | 0.00 | 0.76 |
| PUF [%] | 0.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| XUF [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Historical Summary

| | | | |
|---|---------------------|---|-----------|
| Lifetime energy generation | : 336348.77 GW(e).h | Cumulative Forced Loss Rate (FLR) | : 3.63 % |
| Cumulative Energy Availability Factor (EAF) | : 86.15 % | Cumulative Unplanned Capability Loss Factor (UCL) | : 3.27 % |
| Cumulative Unit Capability Factor (UCF) | : 86.19 % | Cumulative Planned Unavailability Factor (PUF) | : 10.54 % |
| Cumulative Load Factor (LF) | : 85.74 % | Cumulative Externally cause unavailability (XUF) | : 0.04 % |
| Cumulative Operating Factor (OF) | : 86.16 % | | |

Electricity Production (net) [GWh]

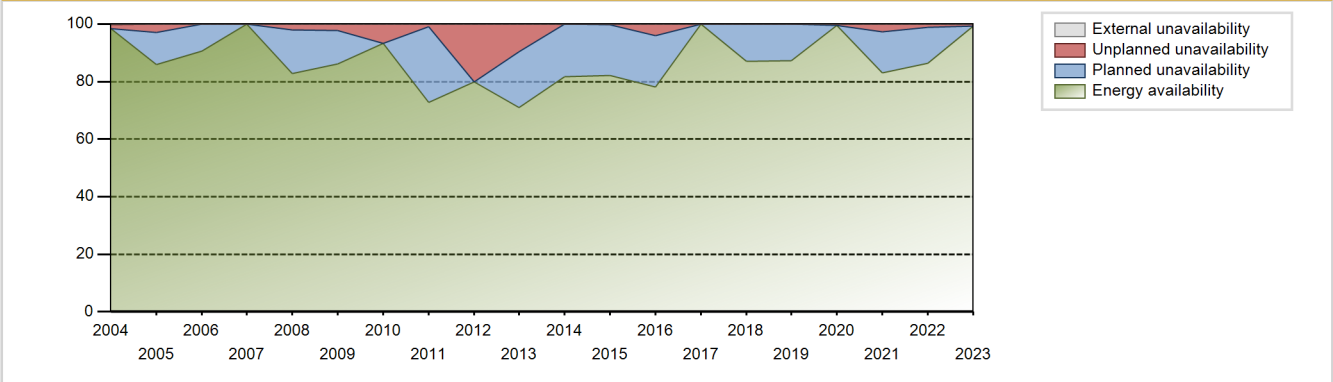


Performance for Years of Commercial Operation

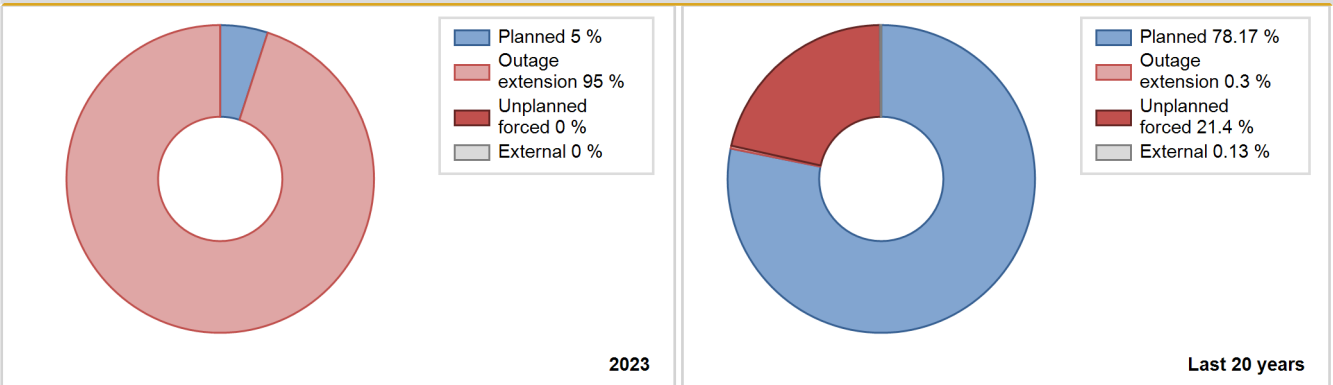
| Year | Energy [GW-h] | Time Online [Hours] | Reference Unit Power [MW] | Performance for Years of Commercial Operation | | | | | | | |
|------|------------------|---------------------------|---------------------------------|---|--------|--------|--------|-------|-------|-------|------|
| | | | | EAF | UCF | LF | OF | FLR | UCL | PUF | XUF |
| | | | | [%] | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| 1985 | 3814.03 | 4350 | 1144 | 100.00 | 100.00 | 90.60 | 96.21 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1986 | 6966.06 | 6416 | 1128 | 73.01 | 73.01 | 70.50 | 73.24 | 9.92 | 8.04 | 18.95 | 0.00 |
| 1987 | 6504.14 | 6009 | 1128 | 68.59 | 68.59 | 65.82 | 68.60 | 30.99 | 30.81 | 0.61 | 0.00 |
| 1988 | 6676.39 | 5963 | 1128 | 66.80 | 66.80 | 67.38 | 67.88 | 10.14 | 7.54 | 25.66 | 0.00 |
| 1989 | 9709.26 | 8618 | 1135 | 98.35 | 98.35 | 97.65 | 98.38 | 0.61 | 0.60 | 1.05 | 0.00 |
| 1990 | 7889.14 | 7036 | 1135 | 79.75 | 79.75 | 79.35 | 80.32 | 1.78 | 1.44 | 18.80 | 0.00 |
| 1991 | 5891.38 | 6288 | 1135 | 70.99 | 70.99 | 59.25 | 71.78 | 0.00 | 0.00 | 29.01 | 0.00 |
| 1992 | 8490.66 | 7538 | 1131 | 85.38 | 85.38 | 85.46 | 85.82 | 14.62 | 14.62 | 0.00 | 0.00 |
| 1993 | 7908.61 | 7000 | 1132 | 79.32 | 79.32 | 79.74 | 79.91 | 0.00 | 0.00 | 20.68 | 0.00 |
| 1994 | 8545.97 | 7500 | 1149 | 85.42 | 85.42 | 84.89 | 85.62 | 0.79 | 0.68 | 13.90 | 0.00 |
| 1995 | 10062.18 | 8625 | 1163 | 98.47 | 98.47 | 98.70 | 98.46 | 1.53 | 1.53 | 0.00 | 0.00 |
| 1996 | 8233.68 | 7078 | 1165 | 80.59 | 81.84 | 80.41 | 80.58 | 0.68 | 0.56 | 17.60 | 1.25 |
| 1997 | 8447.47 | 7255 | 1163 | 82.80 | 82.80 | 82.92 | 82.82 | 1.43 | 1.20 | 16.00 | 0.00 |
| 1998 | 10400.72 | 8760 | 1163 | 100.00 | 100.00 | 102.09 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1999 | 9156.62 | 7847 | 1163 | 89.58 | 89.58 | 89.88 | 89.58 | 0.32 | 0.28 | 10.13 | 0.00 |
| 2000 | 9071.40 | 7795 | 1170 | 88.75 | 88.75 | 88.31 | 88.74 | 0.93 | 0.83 | 10.41 | 0.00 |
| 2001 | 10346.66 | 8731 | 1170 | 99.68 | 99.68 | 100.95 | 99.67 | 0.00 | 0.00 | 0.32 | 0.00 |
| 2002 | 9041.70 | 7695 | 1165 | 87.83 | 87.83 | 88.44 | 87.84 | 2.51 | 2.26 | 9.91 | 0.00 |
| 2003 | 8902.46 | 7594 | 1167 | 86.70 | 86.70 | 87.15 | 86.69 | 0.89 | 0.78 | 12.52 | 0.00 |
| 2004 | 10132.74 | 8650 | 1166 | 98.48 | 98.81 | 98.93 | 98.47 | 1.19 | 1.19 | 0.00 | 0.33 |
| 2005 | 8820.95 | 7528 | 1165 | 85.97 | 85.97 | 86.42 | 85.93 | 3.36 | 2.99 | 11.04 | 0.00 |
| 2006 | 9350.27 | 7935 | 1166 | 90.59 | 90.59 | 91.54 | 90.58 | 0.00 | 0.00 | 9.41 | 0.00 |
| 2007 | 10369.14 | 8760 | 1166 | 100.00 | 100.00 | 101.52 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2008 | 8505.89 | 7271 | 1166 | 82.78 | 82.78 | 83.05 | 82.78 | 2.51 | 2.13 | 15.09 | 0.00 |
| 2009 | 8768.55 | 7541 | 1160 | 86.04 | 86.04 | 86.29 | 86.08 | 2.52 | 2.22 | 11.74 | 0.00 |
| 2010 | 9555.71 | 8163 | 1160 | 93.20 | 93.20 | 94.04 | 93.18 | 6.80 | 6.80 | 0.00 | 0.00 |
| 2011 | 7350.65 | 6333 | 1195 | 72.79 | 72.79 | 71.08 | 72.29 | 1.26 | 0.93 | 26.28 | 0.00 |
| 2012 | 8295.93 | 7014 | 1195 | 79.86 | 79.86 | 79.03 | 79.85 | 20.14 | 20.14 | 0.00 | 0.00 |
| 2013 | 7175.89 | 6210 | 1195 | 70.89 | 70.89 | 68.54 | 70.88 | 11.95 | 9.62 | 19.50 | 0.00 |
| 2014 | 8569.17 | 7161 | 1195 | 81.74 | 81.74 | 81.86 | 81.75 | 0.00 | 0.00 | 18.26 | 0.00 |
| 2015 | 8653.66 | 7194 | 1200 | 82.18 | 82.18 | 82.32 | 82.12 | 0.34 | 0.28 | 17.54 | 0.00 |
| 2016 | 8251.51 | 6867 | 1200 | 78.17 | 78.17 | 78.28 | 78.18 | 4.82 | 3.96 | 17.87 | 0.00 |
| 2017 | 10648.17 | 8760 | 1200 | 100.00 | 100.00 | 101.30 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 9176.04 | 7597 | 1200 | 87.12 | 87.12 | 87.29 | 86.72 | 0.00 | 0.00 | 12.88 | 0.00 |
| 2019 | 9255.42 | 7643 | 1200 | 87.25 | 87.25 | 88.05 | 87.25 | 0.00 | 0.00 | 12.75 | 0.00 |
| 2020 | 10582.48 | 8743 | 1200 | 99.55 | 99.55 | 100.40 | 99.53 | 0.45 | 0.45 | 0.00 | 0.00 |
| 2021 | 8594.06 | 7274 | 1200 | 83.04 | 83.04 | 81.75 | 83.04 | 3.26 | 2.80 | 14.17 | 0.00 |

| | | | | | | | | | | | |
|------|----------|------|------|-------|-------|-------|--------|------|------|-------|------|
| 2022 | 8981.96 | 7565 | 1200 | 86.36 | 86.36 | 85.44 | 86.36 | 1.20 | 1.04 | 12.60 | 0.00 |
| 2023 | 10301.86 | 8760 | 1200 | 99.20 | 99.20 | 98.00 | 100.00 | 0.00 | 0.76 | 0.04 | 0.00 |

Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

| Outage Cause | 2023 | | | 1985 to 2023 | | |
|---|------------|-----------|----------|-------------------------------------|-------------|----------|
| | Hours Lost | | | Average hours lost per reactor-year | | |
| | Planned | Unplanned | External | Planned | Unplanned | External |
| A. Plant equipment problem/failure | | | | | 186 | |
| B. Refuelling without maintenance | | | | 62 | | |
| C. Inspection, maintenance or repair combined with refuelling | | | | 819 | 9 | |
| D. Inspection, maintenance or repair without refuelling | | | | 48 | | |
| E. Testing of plant systems or components | | | | 0 | 1 | |
| H. Nuclear regulatory requirements | | | | | 2 | |
| J. Grid limitation, failure or grid unavailability | | | | | | 3 |
| L. Human factor related | | | | | 73 | |
| N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.) | | | | | | 4 |
| Z. Other | | | | | 13 | |
| Subtotal | | | | 929 | 284 | 7 |
| Total | | 0 | | | 1220 | |

Equipment Related Unplanned Full Outages, Analysis by System

| System | 2023 | 1985 to 2023 |
|--|------------|-------------------------------------|
| | Hours Lost | Average hours lost per reactor-year |
| 11. Reactor and Accessories | | 18 |
| 12. Reactor I&C Systems | | 9 |
| 15. Reactor Cooling Systems | | 10 |
| 16. Steam generation systems | | 26 |
| 17. Safety I&C Systems (excluding reactor I&C) | | 4 |
| 31. Turbine and auxiliaries | | 3 |
| 32. Feedwater and Main Steam System | | 45 |
| 33. Circulating Water System | | 3 |
| 34. Miscellaneous Systems | | 9 |
| 35. All other I&C Systems | | 5 |
| 41. Main Generator Systems | | 57 |
| 42. Electrical Power Supply Systems | | 5 |
| Total | | 194 |

6. NON-ELECTRIC APPLICATION OF NUCLEAR ENERGY IN MEMBER STATES

Table 6: Energy produced from Non-Electric Applications in 2023

| | | | | | Number of reactors | RUP [MWe] | Total Heat [GCal] | Electrical equivalent of heat [GWh] | | |
|---------|-------------|------|-----------------|------------------------------|------------------------------|---------------------------------|--|---|---------------------------------|---|
| | | | | | 45 | 33 440 | 4 467 206.55 | 2 045.95 | | |
| Country | Unit | Type | Model | District Heating | Process Heating | Desalination | | | Total Heat | |
| | | | | PDH Thermal energy [GCal] | PPH Thermal energy [GCal] | PDI Thermal energy [GCal] | Electrical energy for Reverse Osmosis [GWh] | Water production [m3] | Total Heat (PDH + PPH + PDI) | Electrical equivalent of heat [GWh] |
| BG | KOZLODUY-5 | PWR | VVER V-320 | 110.72 | | | | | 110.72 | 38.50 |
| BG | KOZLODUY-6 | PWR | VVER V-320 | 12.81 | | | | | 12.81 | 4.50 |
| CH | BEZNAU-1 | PWR | WH 2LP | 141.75 | | | | | 141.75 | 49.33 |
| CH | BEZNAU-2 | PWR | WH 2LP | 8.12 | | | | | 8.12 | 2.83 |
| CH | GOESGEN | PWR | PWR 3 Loop | | 65.25 | | | | 65.25 | 22.72 |
| CN | HAIYANG-1 | PWR | AP-1000 | 488.85 | | | | | 488.85 | 565.80 |
| CN | HAIYANG-2 | PWR | AP-1000 | 139.71 | | | | | 139.71 | 161.70 |
| CZ | TEMELIN-1 | PWR | VVER V-320 | 13.58 | | | | | 13.58 | 4.72 |
| CZ | TEMELIN-2 | PWR | VVER V-320 | 167.45 | | | | | 167.45 | 58.27 |
| HU | PAKS-2 | PWR | VVER V-213 | 0.06 | | | | | 0.06 | 0.02 |
| HU | PAKS-3 | PWR | VVER V-213 | 16.40 | | | | | 16.40 | 4.62 |
| HU | PAKS-4 | PWR | VVER V-213 | 24.30 | | | | | 24.30 | 5.82 |
| IN | MADRAS-2 | PHWR | Horizontal Pres | | | 7.28 | 0.00 | 0.00 | 7.28 | 2.53 |
| IN | RAJASTHAN-2 | PHWR | Horizontal Pres | | 5.24 | | | | 5.24 | 1.83 |
| IN | RAJASTHAN-4 | PHWR | Horizontal Pres | | 537.96 | | | | 537.96 | 187.21 |
| JP | GENKAI-3 | PWR | M (4-loop) | | | 13.33 | 0.00 | 168.15 | 13.33 | 4.64 |
| JP | GENKAI-4 | PWR | M (4-loop) | | | 2.33 | 0.00 | 26.71 | 2.33 | 0.81 |
| JP | IKATA-3 | PWR | M (3-loop) | | | 0.00 | 1.57 | 0.00 | 0.00 | 1.57 |
| JP | OHI-3 | PWR | M (4-loop) | | | 0.00 | 0.00 | 647.21 | 16.83 | 16.83 |
| JP | TAKAHAMA-3 | PWR | M (3-loop) | | | 0.00 | 0.00 | 333.31 | 8.67 | 8.67 |

| Country | Unit | Type | Model | District Heating | | Desalination | | | Total Heat | |
|---------|----------------|------|------------|---------------------------|---------------------------|---------------------------|---|-----------------------|------------------------------|-------------------------------------|
| | | | | PDH Thermal energy [GCal] | PPH Thermal energy [GCal] | PDI Thermal energy [GCal] | Electrical energy for Reverse Osmosis [GWh] | Water production [m3] | Total Heat (PDH + PPH + PDI) | Electrical equivalent of heat [GWh] |
| RU | BALAKOVO-1 | PWR | VVER V-320 | 15.25 | 0.00 | | | | 15.25 | 5.31 |
| RU | BALAKOVO-2 | PWR | VVER V-320 | 13.71 | 0.00 | | | | 13.71 | 4.77 |
| RU | BALAKOVO-3 | PWR | VVER V-320 | 12.12 | 0.00 | | | | 12.12 | 4.22 |
| RU | BALAKOVO-4 | PWR | VVER V-320 | 11.39 | 0.00 | | | | 11.39 | 3.96 |
| RU | BELOYARSK-3 | FBR | BN-600 | 151.17 | 0.00 | | | | 151.17 | 52.61 |
| RU | BILIBINO-2 | LWGR | EGP-6 | 38.36 | | | | | 38.36 | 13.35 |
| RU | BILIBINO-3 | LWGR | EGP-6 | 68.36 | | | | | 68.36 | 23.79 |
| RU | BILIBINO-4 | LWGR | EGP-6 | 61.94 | | | | | 61.94 | 21.56 |
| RU | KALININ-1 | PWR | VVER V-338 | 98.02 | 0.00 | | | | 98.02 | 34.11 |
| RU | KALININ-2 | PWR | VVER V-338 | 123.86 | 0.00 | | | | 123.86 | 43.10 |
| RU | KALININ-3 | PWR | VVER V-320 | 88.34 | 0.00 | | | | 88.34 | 30.74 |
| RU | KALININ-4 | PWR | VVER V-320 | 44.12 | 0.00 | | | | 44.12 | 15.36 |
| RU | KURSK-2 | LWGR | RBMK-1000 | 140.10 | 0.00 | | | | 140.10 | 48.75 |
| RU | KURSK-3 | LWGR | RBMK-1000 | 111.31 | 0.00 | | | | 111.31 | 38.74 |
| RU | KURSK-4 | LWGR | RBMK-1000 | 182.81 | 0.00 | | | | 182.81 | 63.62 |
| RU | LENINGRAD-3 | LWGR | RBMK-1000 | 198.83 | 0.00 | | | | 198.83 | 69.19 |
| RU | LENINGRAD-4 | LWGR | RBMK-1000 | 173.92 | 0.00 | | | | 173.92 | 60.52 |
| RU | NOVOVORONEZH-4 | PWR | VVER V-179 | 209.97 | 0.00 | | | | 209.97 | 73.07 |
| RU | SMOLENSK-1 | LWGR | RBMK-1000 | 183.00 | 0.00 | | | | 183.00 | 63.68 |
| RU | SMOLENSK-2 | LWGR | RBMK-1000 | 167.51 | 0.00 | | | | 167.51 | 58.29 |
| RU | SMOLENSK-3 | LWGR | RBMK-1000 | 135.87 | 0.00 | | | | 135.87 | 47.28 |
| SK | BOHUNICE-3 | PWR | VVER V-213 | 183.19 | 0.00 | | | | 183.19 | 46.78 |
| SK | BOHUNICE-4 | PWR | VVER V-213 | 185.90 | 0.00 | | | | 185.90 | 49.76 |

The non-electric applications table does not include data from Ukrainian reactor units as operational data were not submitted for the year 2023 by the time of publication.